South African Journal of Animal Science

Official Journal of the South African Society for Animal Science

(ISSN 0375-1589)

Scope of the Journal

The South African Journal of Animal Science is a peer-reviewed journal for publication of original scientific articles and reviews in the field of animal science. The scope of the journal includes reports of research dealing with farm livestock species (cattle, sheep, goats, pigs, horses, poultry and ostriches), as well as pertinent aspects of research on aquatic and wildlife species. The main disciplines covered are nutrition, genetics and physiology. Papers dealing with animal products and sociological aspects of well-defined livestock production systems are also invited, provided that they are scientific by nature and have been carried out in a systematic way.

Publication information

The South African Journal of Animal Science is published in paper format and electronically at **http://www.sasas.co.za/Sajas.html**. Four issues are published annually. The journal does not discriminate against short communications of complete research. Details of requirements for different categories of manuscripts and of the peer-review process are given in the Instructions to Authors which may be downloaded from the website address given above. In cases where the first author is not a member of the South African Society for Animal Science, a fee of SA Rand 220.00 / US$ 50.00 (for 2004) per article will be levied upon publication. Prospective authors should adhere strictly to the guidelines detailed in the Instructions to Authors, as manuscripts that do not fully comply with the style and format of the journal will not be accepted for review. Manuscripts should be submitted electronically to the editor-in-chief (editor@sasas.co.za). In all cases, submissions should represent **original** contributions to current scientific knowledge of the **principles** of the **application of principles** governing the functioning of animals and their relationship to the social or physical environment. Once accepted, papers become the copyright of the South African Society for Animal Science and may be reprinted only on written permission of the Council of the Society.

The South African Society for Animal Science

Mission

Our mission is to advance animal science and promote viable animal production systems, while sustaining natural resources and the environment, and thereby to serve in the interests of human welfare.

Objectives

The objectives of the Society are to promote animal science by:

- Ensuring that high standards of education, research, technology and science-based public policy are upheld with regard to animal production and animal products.
- Upholding professional integrity and ethical codes.
- Fostering the scientific interests and professional status of members.
- Organizing symposia on a regular basis.
- Publishing a scientific journal.
- Serving as mouthpiece on all matters relating to animal production and animal products in compliance with public welfare and general interest.
- Liaison with other societies with similar or related interests.

Membership

Membership is open to individuals in possession of a bachelor degree or a diploma in animal science/production or a related biological science field, whose activities may contribute to the scientific knowledge of animal production or to its application to agriculture. Applications for membership may be submitted electronically from the Society website: http://www.sasas.co.za

Members of Council: May 2002 – June 2004

- **President:** C.W. Cruywagen (e-mail: cwc@sun.ac.za)
- **Vice-President:** P. Bevan (portfolio: finances; e-mail: paul@centralvet.co.za)
-
- **Honorary President:** A.G. Paterson (e-mail: ingridm@stockowners.co.za)
- **Honorary Secretary:** J.B.J. van Ryssen (e-mail: secretary@sasas.co.za)
- **Other members:**

  L. Bergh (portfolio: marketing; e-mail: leslie@irene.agric.za)

  T.J. Dugmore (portfolio: constitution, branches and interest groups; e-mail: dugmoret@dae.kzntl.gov.za)

  A.V. Ferreira (portfolio: student affairs, promotion, marketing; e-mail: avf@sun.ac.za)

  J.P.C. Greyling (portfolio: medals, bursaries; e-mail: greylijp@sci.uovs.ac.za)

  H.E. Theron (portfolio: marketing; e-mail: helena@irene.agric.za)

  E.C. Webb (portfolio: journal, marketing; e-mail: edward.webb@up.ac.za)

South African Journal of Animal Science

Official Journal of the South African Society for Animal Science

(ISSN 0375-1589)

Contents:Volume 34 (Supplement 1)

Peer-reviewed papers: 8th International Conference on Goats

Peer-reviewed paper: 8th International Conference on Goats

Preliminary assessment of Boer and Kiko does as maternal lines for kid performance under humid, subtropical conditions

R. Browning, Jr.#, S.H. Kebe and M. Byars
Institute of Agricultural and Environmental Research, Tennessee State University, 3500 John A. Merritt Blvd., Nashville, TN 37209, USA

Abstract

Thirty Boer and 27 Kiko does were exposed to Spanish bucks and evaluated for doe reproduction, pre-weaning kid growth, and production efficiency in the humid, subtropical south-eastern United States. Does of each breed were represented by at least seven seed stock farms and eight sires. Twenty-five Boer and 23 Kiko does gave birth to at least one live kid. Body weights at parturition were heavier for Boer than Kiko dams. Litter size and litter weight were similar at birth for Boer (1.92 ± 0.12 kids, 6.05 ± 0.31 kg) and Kiko dams (1.82 ± 0.12 kids, 5.90 ± 0.33 kg). Birth weights were similar between 46 Boer and 42 Kiko F_1 kids. Birth weights were heavier for single than for twin kids; twin kids were heavier at birth than triplet kids. Bucks were heavier than does at birth. At least one kid was reared to weaning by 20 Boer and 21 Kiko dams. Body weights at weaning were similar for dam breeds. Litter size, litter weight, and litter weight to doe weight ratio were significantly greater for Kiko (1.85 ± 0.09 kids, 31.73 ± 1.52 kg, 78.1 ± 4%) compared with Boer dams (1.58 ± 0.09 kids, 26.48 ± 1.51 kg, 63.9 ± 4%) at weaning. Pre-weaning growth rates and weaning weights were greater for 38 Kiko compared with 32 Boer F_1 kids and were greater for bucks than for does. Kiko F_1 kids had significantly lower attrition rates (9.5%) and Kiko does had significantly fewer episodes of lameness (1.60 ± 0.33 episodes/doe) compared with Boer (34.8%, 3.31 ± 0.31 episodes/doe). Kiko dams tended to wean a higher kid crop percentage and weaned higher litter weights per doe exposed compared with Boer dams. Significant variation existed between Boer and Kiko as maternal breeds for performance, efficiency, and fitness under these research conditions.

Keywords: Meat goats, breeds, reproduction, pre-weaning growth, fitness, doe productivity
#Corresponding author. E-mail: rbrowning@tnstate.edu

Introduction

In the United States, goat production is characterized as a non-traditional, alternative agricultural enterprise. The meat goat is an emerging class of livestock offering U.S. farmers a new option for on-farm income. Major determinants of profitability in a meat goat enterprise are reproductive and maternal abilities of the doe herd. Genetic composition of does may affect the performance of progeny. The improved Boer goat from South Africa (Casey & Van Niekerk, 1988; Campbell, 2003) is a breed developed for meat production that evolved from selection pressures placed on common goats of the region by farmers. Exportation of Boer goats to the U.S. in the mid-1990s helped to stimulate interest in meat goat production. No goat breeds in the U.S. had been developed specifically for meat production; milk, fibre, and brush control were the primary reasons of raising goat with meat being a by-product. The Kiko from New Zealand (Batten, 1987) is another goat breed exported to the U.S. in the mid-1990s that was developed for meat production. The Kiko breed developed from the systematic breeding of selected New Zealand feral does with dairy bucks, further crossbreeding and interbreeding at the F2 and F3 generations, and breed establishment at the fourth generation (Batten, 1987). Exportations of Boer and Kiko goats have created an opportunity for goat producers internationally to introduce the germplasm of new meat breeds into their breeding programs.

Reproduction and maternal ability are important economic traits to consider when evaluating the strengths and weaknesses of a new breed. When assessing new breeds for genetic merit in meat animal production systems, the maternal side is often overlooked. Breed of dam genetics can influence the performance of any sire's progeny. Meat goat dam breeds likely differ for general production efficiency in a given production environment as documented in sheep (Bourfia & Touchberry, 1993; Bunge *et al.*, 1995; Dimsoski *et al.*, 1999). Maternal breed has not received much attention in the area of meat goat production. Breed of dam has been shown to affect body weight, growth from birth through the post-weaning period and carcass traits for the progeny of Boer sires and dairy breed sires (Ruvuna *et al.*, 1992; Waldron *et al.*, 1996; Goonewardene *et al.*, 1998; Ward *et al.*, 1998). Percentage Boer does did not outperform Spanish does under

Peer-reviewed paper: 8th International Conference on Goats

range conditions (Ward *et al.*, 1998). Studies involving Kiko-influenced does have not been published to date in the scientific literature. The reported breed of dam effects on kid performance were largely based on absolute weights and not adjusted for dam weight to measure production efficiency. Reproductive and maternal merits should be considered when making breed of dam choices. The semi-arid origin of the Boer and humid origin of the Kiko are distinctions that may influence the merits of these breeds in a given environment. This project focused on reproductive and maternal abilities of Boer and Kiko does under the humid, subtropical climatic conditions of the southeastern United States.

Materials and Methods

In the autumn, 30 Boer and 27 Kiko does were exposed to three Spanish bucks in single-sire breeding groups to begin evaluating meat goat breeds of doe for reproductive rates, pre-weaning kid growth, and production efficiency. Each breed of doe was represented by at least seven seedstock farms and eight sires. Does were nulliparous or primiparous purebreds under two years old with age and parity balanced across breeds. All goats were managed on the Tennessee State University research station in Nashville, Tennessee, USA (36°17'N, 86°81'W). Nashville is 183 m above sea level and receives an annual rainfall of 1222 mm. The 12-month rainfall during the study (September, 2002 to August, 2003) was 1552 mm.

Does were managed in pastures that provided tall fescue (*Festuca arundinacea*) for limited grazing supplemented with orchardgrass hay (*Dactylis glomerata*; 110 g CP/kg, 50% TDN, estimated as-fed) for *ad libitum* consumption and 682 g/d of a commercial concentrate (160 g CP/kg, 69% TDN, as-fed) medicated with monensin. Does kidded on pasture without intervention. The spring-born kids were not creep-fed and bucks were not castrated before weaning. Dams and kids were weighed at birth and at weaning (14 wk). Animal weights, litter size, production efficiencies and hoof care for lameness were statistically tested by analysis of variance. Kid crop percent was determined by litter size at weaning divided by number of does exposed. Individual doe health records were maintained, from which cases of lameness and subsequent hoof treatments were obtained. Kid attrition was analysed by chi-square. Kid attrition included pre-weaning kid mortality, excluding stillborns, and kids orphaned due to dam mortality.

Results and Discussion

At kidding, 25 Boer and 23 Kiko does produced at least one live kid. Stillborns were not included in birthing datasets. Boer dams at kidding were heavier ($P = 0.06$) than Kiko dams (48.49 ± 1.25 *vs.* 45.04 ± 1.32 kg). Litter size and litter weight at birth did not differ ($P > 0.5$) between Boer (1.92 ± 0.12 kids, 6.05 ± 0.31 kg) and Kiko dams (1.82 ± 0.12 kids, 5.90 ± 0.33 kg). Kid birth weights were similar ($P = 0.43$) between 46 Boer and 42 Kiko F_1 kids (3.21 ± 0.09 *vs.* 3.29 ± 0.08 kg). Each litter type differed ($P < 0.001$) for kid birth weights (singles = 3.84 ± 0.14, twins = 3.23 ± 0.06, triplets = 2.67 ± 0.13 kg). Bucks at birth were heavier ($P < 0.01$) than does (3.40 ± 0.08 *vs.* 3.10 ± 0.09 kg). Birth traits were generally similar for the dam breeds.

Pre-weaning growth rates and weaning weights were greater ($P = 0.04$) for 38 Kiko F_1 kids (140.4 ± 4.61 g/d, 16.81 ± 0.51 kg) compared with 32 Boer F_1 kids (126.5 ± 5.97 g/d, 15.29 ± 0.65 kg). Bucks had higher ($P < 0.01$) pre-weaning growth rate and weaning weights (145.2 ± 4.3 g/d, 17.29 ± 0.47 kg) than does (121.7 ± 6 g/d, 14.81 ± 0.66 kg). Kids orphaned before weaning were not included in the weaning kid dataset. Kid attrition rates before weaning were higher ($P < 0.01$) for Boer than for Kiko (34.8 *vs.* 9.5%). These data indicate that Kiko dams enhanced pre-weaning performance of the Spanish-sired kids.

Twenty Boer and 21 Kiko dams reared at least one kid to weaning. Boer and Kiko dam body weights at weaning did not differ ($P = 0.35$; 42.42 *vs.* 40.75 ± 1.25 kg). Weaning litter size was smaller ($P = 0.05$) and litter weaning weight was lower ($P = 0.02$) for Boer (1.58 ± 0.09 kids, 26.48 ± 1.51 kg) than for Kiko dams (1.85 ± 0.09 kids, 31.73 ± 1.52 kg). The ratio of litter weight weaned to doe weight at weaning was greater ($P = 0.01$) for Kiko compared with Boer dams (78.1 *vs.* 63.9 ± 4%). In terms of overall herd efficiency, Kiko does tended ($P = 0.10$) to wean a higher kid crop percent and weaned a heavier ($P = 0.07$) litter weight per doe exposed (125 ± 19%, 21.55 ± 3.05 kg) compared with Boer does (86 ± 19%, 14.77 ± 2.96 kg). During the 12-month period, Boer does had more ($P < 0.001$) episodes of lameness requiring hoof care than Kiko does (3.31 ± 0.31 *vs.* 1.60 ± 0.33 episodes/doe). Performance comparisons appeared to favour the Kiko does under these research conditions.

Boer goats have been used extensively in the U.S. over the last 10 years for crossbreeding with the goal of enhancing growth and conformation of market kids. In the process, the Boer influence has become

pronounced in U.S. commercial herds as Boer-cross does are retained as replacements. The substantial numbers of Boer-cross does in commercial herds and purebred Boer does raised in the seedstock and commercial operations necessitate an evaluation of this breed for maternal ability under U.S. production conditions. In simulation work of Blackburn (1995), the production environment determined if Spanish or Boer does were more productive and efficient as genetic × environment interactions existed. Unlike the Boer goat that evolved under semi-arid to arid conditions, the Kiko goat was developed in a humid environment. Environmental adaptations of the Kiko goat are speculated as contributing to its fitness and performance at this research location which is situated in the humid, subtropical climate zone of the south-eastern United States. Comparatively higher pre-weaning kid attrition rates and greater hoof care requirements of the Boer further suggest that the Boer may be less adapted to a humid environment. Poor environmental adaptation could negatively influence performance. The evaluation of various doe breeds for performance within unique environmental settings are warranted.

Conclusions

This project was designed to evaluate Boer and Kiko does for economically important production traits under the humid, subtropical conditions of the south-eastern United States. The Kiko exhibited greater performance levels and efficiencies compared with the Boer for doe-kid performance. These initial results suggest that Kiko does would be a viable breed option to enhance doe-kid performance in commercial meat goat production systems of the humid subtropics. The reader is cautioned, however, that the current dataset is based on a rather small sample, thus is preliminary in character at this stage of the study. Nevertheless, results highlight the need to evaluate new breeds under unique environmental conditions for doe fitness, reproductive and maternal traits that are important to commercial meat goat production.

References

Batten, G.J., 1987. A new meat goat breed. In: Proc. 4th Int. Conf. on Goats. Brasilia, Brazil. Vol. 2, pp. 1330-1336.

Blackburn, H.D., 1995. Comparison of performance of Boer and Spanish goats in two U.S. locations. J. Anim. Sci. 73, 302-309.

Bourfia, M. & Touchberry, R.W., 1993. Diallel cross of three Moroccan breeds of sheep: I. Lamb growth and carcass traits. J. Anim. Sci. 71, 870-881.

Bunge, R., Thomas, D.L. & Nash, T.G., 1995. Performance of hair breeds and prolific wool breeds of sheep in southern Illinois: lamb production of F1 adult ewes. J. Anim. Sci. 73, 1602-1608.

Campbell, Q.P., 2003. The origin and description of southern Africa's indigenous goats. S. Afr. Soc. Anim. Sci. Popular Scientific Papers. Vol. 4, pp. 18-22. http://www.sasas.co.za/scientific/campbell.pdf

Casey, N.H. & Van Niekerk, W.A., 1988. The Boer Goat I. Origin, adaptability, performance testing, reproduction and milk production. Small Rumin. Res. 1, 291-302.

Dimsoski, P., Tosh, J.J., Clay, J.C. & Irvin, K.M., 1999. Influence of management system on litter size, lamb growth, and carcass characteristics in sheep. J. Anim. Sci. 77, 1037-1043.

Goonewardene, L.A., Day, P.A., Patrick, N., Scheer, H.D., Patrick, D. & Suleiman, A., 1998. A preliminary evaluation of growth and carcass traits in Alpine and Boer goat crosses. Can. J. Anim. Sci. 78, 229-232.

Ruvuna, F., Taylor, J.F., Okeyo, M., Wanyoike, M. & Ahuya, C., 1992. Effects of breed and castration on slaughter weight and carcass composition of goats. Small Rumin. Res. 7, 175-183.

Waldron, D.F., Willingham, T.D. & Thompson, P.V., 1996. A comparison of Angora and Spanish does for producing crossbred goats for slaughter: effects on growth rate and feed efficiency. Combined Research Reports: Sheep and Goat, Wool and Mohair, 1996. CPR 5257. Texas Agricultural Experiment Station, College Station, TX, USA.

Ward, B.J., Waldron, D.F., Willingham, T.D., Hallum, C.R. & Casey, J.E., 1998. Factors affecting birth weight and weaning weight in kids of Spanish and Boer-Spanish does. J. Anim. Sci. 76 (Suppl. 1), 77 (Abstr.).

Peer-reviewed paper: 8th International Conference on Goats

A comparison of the OFDA2000 with conventional mid-side testing of mohair

M.B. Ferguson# and G. Kearney
PIRVic (Primary Industries Research Victoria), Department of Primary Industries, Private Bag 105, Hamilton, Victoria, 3300, Australia

Abstract

The portable fibre-testing instrument OFDA2000 has applications in the mohair industry for both fibre classing and animal selection. A comparison was completed between single-staple mid-side testing using an OFDA2000 and conventional laboratory mid-side testing using an OFDA100. Mid-side mohair samples (n=504) were collected from two consecutive shearings of a mixed sex group of Angora kids at 6 and 12 months of age. The samples were at the fine end (average 20.9 μm) of the mean fibre diameter range of mohair. There was a bias between the estimates of mean fibre diameter at both shearings. The other traits studied also had biases between measurement methods. The regression analyses results of mean fibre diameter from the two test methods accounted for 91% and 88% of the variance for first and second shearings, respectively. Regression analyses between test methods for standard deviation, coefficient of variation of fibre diameter and fibre curvature accounted for less variance than the regressions of mean fibre diameter results. The results indicate OFDA2000 is suitable for estimation of mean fibre diameter of greasy kid mohair staples and is therefore useful for both mohair classing and Angora selection.

Keywords: Fibre diameter, correlation, bias, portable fibre-testing
#Corresponding author. E-mail: mark.ferguson@dpi.vic.gov.au

Introduction

The OFDA2000 is a portable fibre-testing device developed to measure the properties of greasy fibres for both animal selection and fibre classing (Brims *et al*., 1999) and is widely used in the Australian wool industry. Further information regarding the OFDA2000 can be obtained from the manufacturers website (www.ofda.com). The OFDA2000 and similar portable testing devices have advantages over conventional laboratory based testing in being able to provide real-time data allowing timely management decisions. The mean fibre diameter (MFD) results from the OFDA2000 are closely correlated to conventional mid-side testing across a wide range of fibre diameters in wool (Behrendt *et al*., 2002). The technology has potential uses in the mohair industry for fibre classing prior to sale and for animal selection and breeding. Although there have been several studies completed testing the OFDA2000 measuring wool samples there is little published data on the performance of the instrument when used in mohair. This study presents a comparison of the OFDA2000 and the conventional laboratory based Optical Fibre Diameter Analyser 100 (OFDA100) when used to measure mean fibre diameter (MFD), standard deviation of fibre diameter (SD) co-efficient of variation of fibre diameter (CVD) and fibre curvature (FC) of kid mohair.

Materials and Methods

This study used mohair mid-side samples from Angora goats that were grazed at Horsham (36º43'00"S, 142º14'30"E) in north-western Victoria, Australia. The mid-side samples were collected prior to shearing at 6 and 12 months of age. Samples (n=504) consisted of 259 and 245 samples from the first and second shearings respectively. A grease correction factor (GCF) is used by the OFDA2000 to account for grease (wax and suint) on the outside of the fibre, and as the level of grease is proportional to MFD, a GCF slope is used to determine a GCF for each sample. A mohair specific GCF slope was calculated prior to this study utilising 151 mohair samples (average 28.3 μm; range 18.8 to 40.2 μm), from three flocks. A staple was randomly removed from each sample and a portion of this staple was tested on an OFDA2000 in a greasy state with the GCF set to zero. The remaining part of each staple was scoured in a sonicator for 1 minute in a solution of 20% isopropanol in industrial grade hexane. After allowing the sample to dry in fan-forced air it was measured on an OFDA2000 with the GCF set to zero. A regression analysis was then completed between clean and greasy MFD results to calculate the GCF slope of 1.06. For each shearing a staple was removed from each of 20 randomly selected mid-side samples. A portion of each staple was

Peer-reviewed paper: 8th International Conference on Goats

measured on the OFDA2000 in a greasy state and again in a scoured state following the method previously described. The difference between the greasy and clean results was then utilised to calculate a GCF (GCF 0.4 μm and 1.0 μm for first and second shearings respectively). A randomly selected staple from each mid-side sample was then measured on an OFDA2000 that was operated using the calculated GCF and a wool calibration with the calculated mohair specific GCF slope.

The mid-side samples were mini-cored, washed with sonication in a series of detergent solutions at 60 ºC, dried and conditioned for 24 hours and measured utilising an OFDA100 calibrated using mohair top supplied by CSIR, Port Elizabeth, South Africa, and following the IWTO-47-98 standard.

Regression was used to determine the relationship between the test methods at each shearing for MFD, SD, CVD and FC and a paired T-test was used to determine any bias that existed using GenStat 5.42 (GenStat Committee 2000).

Results and Discussion

The samples used were at the fine end of the MFD range for mohair (Table 1), finer than would normally be expected for Angora kids at that age (Snyman, 2002). The MFD results from the two test methods were closely aligned (Figure 1) and the regression models (Table 2) accounted for 91% and 88% of the variance at the first and second shearings respectively, which compared favourably to that reported for wool (Behrendt *et al*., 2002). Compared to the OFDA100, the OFDA2000 under-estimated ($P < 0.001$) MFD by 0.3 μm at the first shearing and over-estimated ($P < 0.001$) MFD by 0.4 μm at the second shearing (Table 1). These biases are likely to be related to GCF calculation used with OFDA2000. The appropriate GCF will vary for each sample depending on the level of wax and suint of that sample. Using an average GCF for all samples across a shearing with varied genotypes, will lead to some errors.

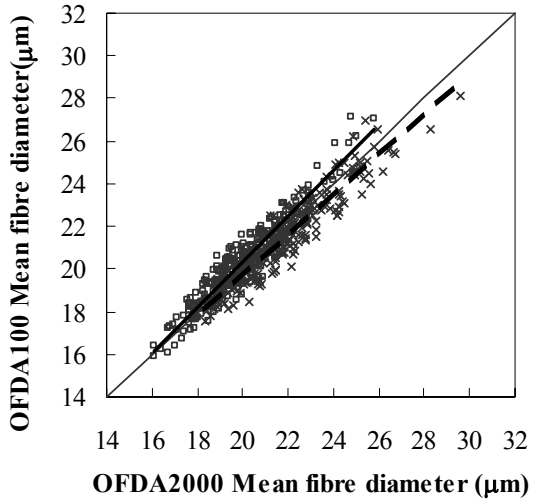


Figure 1 The relationship between OFDA100 and OFDA2000 for mean fibre diameter for first (□) and second (×) shearings, including regression lines for first (——) and second (— —) shearings

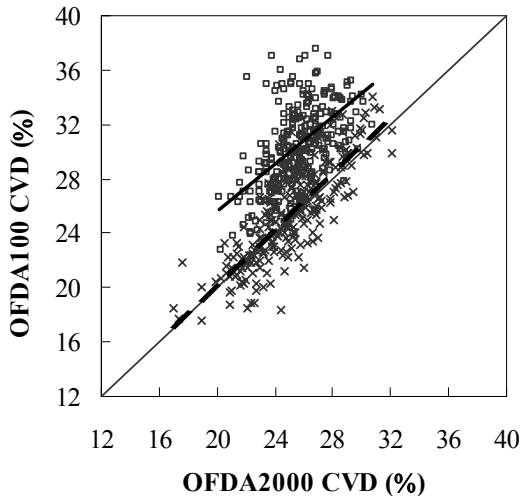


Figure 2 The relationship between OFDA100 and OFDA2000 for coefficient of variation of diameter for first (□) and second (×) shearings, including regression lines for first (——) and second (— —) shearings

The regression between test-methods for SD, CVD and FC accounted for less of the variation. For SD and CVD, this is again consistent with that found for wool (Behrendt *et al*., 2002), and would be associated with differences between methods and number of fibres measured. The regressions between test methods for SD accounted for 70% of the variance at the second shearing compared to 56% of the variance at the first shearing. SD results measured by OFDA2000 were 1.1 μm lower ($P < 0.001$) than those from the OFDA100 for the first shearing and did not differ ($P > 0.05$) at the second shearing.

The regressions of CVD results from the two test methods accounted for 32% and 68% of the variance for first and second shearings respectively. The OFDA2000 under estimated CVD at the first ($P < 0.01$) and second ($P < 0.001$) shearings (Table 1). The first shearing CVD results were higher and more variable than

Peer-reviewed paper: 8th International Conference on Goats

those for the second shearing (Figure 2), due to the presence of coarser birth coat fibre in the first fleece. At both shearings the OFDA2000 was operated with a distribution-trimming algorithm switched on, which trims measurements more than 4 standard deviations above the sample mean (Baxter, 2001). This may have affected the CVD results at the first shearing and would have lowered the CVD of some highly variable samples, this may explain the difference in regression results between shearings.

The regressions between test methods for FC accounted for 32% and 56% of the variance for first and second shearings respectively. These low results are likely to be associated with the very low curvature of mohair and the method of sample preparation used on the OFDA2000.

Table 1 Mean (±s.e.) of results from OFDA2000 single-staple mid-side testing and OFDA100 conventional mid-side testing for measured traits at the first (1st) and second (2nd) shearings

Test Method	Mean fibre diameter (μm)		Standard deviation (μm)		Coefficient of variation (%)		Fibre Curvature (°/mm)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
OFDA2000	19.9 (0.11)	21.9 (0.12)	5.1 (0.04)	5.5 (0.04)	25.6 (0.12)	25.1 (0.17)	16.1 (0.12)	18.8 (0.19)
OFDA100	20.2 (0.12)	21.5 (0.12)	6.2 (0.05)	5.5 (0.05)	30.5 (0.18)	25.4 (0.22)	19.0 (0.19)	17.9 (0.21)
Significance	***	***	***	Ns	**	***	***	***

*** values differ (P < 0.001); ** values differ (P < 0.01); ns values do not differ (P > 0.05)

Table 2 Intercept (±s.e.), slope (±s.e.), percentage of variance accounted for (% var. acc.) and residual standard deviation (r.s.d.) from regression analysis of OFDA100 *versus* OFDA2000 for mean fibre diameter (MFD), standard deviation of fibre diameter (SD), coefficient of variation of fibre diameter (CVD) and fibre curvature (FC) for first and second shearing results

	First Shearing				Second Shearing			
	MFD μm	SD μm	CVD %	FC °/mm	MFD μm	SD μm	CVD %	FC °/mm
Intercept	-1.08(0.42)	1.66(0.25)	8.71(1.96)	4.86(1.29)	0.61 (0.50)	-0.37(0.24)	-0.80(1.16)	2.35(0.88)
Slope	1.07(0.02)	0.88(0.05)	0.85 (0.08)	0.88 (0.08)	0.95 (0.02)	1.06(0.04)	1.05(0.05)	0.82(0.05)
% var. acc.*	91	56	32	32	88	70	68	56
r.s.d.	0.57	0.48	2.43	2.49	0.67	0.44	1.95	2.19

* Adjusted R^2

Our work shows that MFD results from single-staple OFDA2000 testing are similar to laboratory-based mid-side testing when used in mohair. Compared to MFD less variation is accounted for by regression analyses between test methods for SD, CVD and FC, reflecting the reduced precision when testing for these traits. Results from regression analyses completed in this study suggest there may be level dependent biases for some traits and further work is required to better define the grease correction factor and distribution trimming algorithm used for OFDA2000 measurement of mohair to reduce these biases. This study did not attempt to estimate the precision of the OFDA2000 when used to test mohair and repeatability between shearings for the two methods and future work will investigate these areas.

Acknowledgement

This research was jointly funded by Rural Industries Research and Development Corporation and the Victorian Department of Primary Industries. The authors gratefully acknowledge the assistance from R. & J. Liddy, R. Doyle, sire owners, M. Murray, B. McGregor, D. Gordon and J. Bennett.

Peer-reviewed paper: 8th International Conference on Goats

References

Baxter, P., 2001. On-farm classing of animals and fleeces with the OFDA2000. Wool. Tech. Sheep Breed. 49, 133-155.

Behrendt, R., Konstantinov, K., Brien, F., Ferguson, M. & Gloag, C., 2002. A comparison of estimates of mean fibre diameter, variation in fibre diameter and fibre curvature between OFDA2000 and conventional laboratory-based fibre testing. Wool Technol. Sheep Breed. 50, 780-786.

Brims, M.A., Peterson, A.D. & Gherardi, S.G., 1999. IWTO Tech. Rep. RWG04, Florence.

GenStat Committee, 2000. GenStat for Windows. Release 4.2. Fifth Edition. VSN International Ltd., Oxford.

IWTO-47-98, 1998. The Woolmark Company, Ilkley, West Yorkshire.

Snyman, M.A., 2002. Evaluation of a genetically fine mohair producing herd. Small Rumin. Res. 43, 105-113.

Peer-reviewed paper: 8th International Conference on Goats

An evaluation of Angora sires through progeny testing - A progress report

M.B. Ferguson[1#] and B.A. McGregor[2]

[1]PIRVic (Primary Industries Research Victoria), Department of Primary Industries, Private Bag 105, Hamilton, Victoria, 3300, Australia.

[2]PIRVic (Primary Industries Research Victoria) Department of Primary Industries, 475 Mickleham Rd, Attwood, Victoria, 3049, Australia

Abstract

Genetic improvement is a key to future increases in productivity in the Australian Mohair industry. Accurate identification of superior sires is part of this process. A progeny test was established to evaluate some prominent sires in use within the Australian Mohair industry. Angora does (n=511) were mated to 11 Angora sires using artificial insemination in April, 2002. A total of 270 progeny was evaluated at their first shearing at 6 months of age and 246 were evaluated at the second shearing at 12 months of age. The project site experienced a severe drought for the 2002 season resulting in lower than expected kidding performance, average clean fleece weights (0.70 and 0.95 kg) and fibre diameters (20.3 and 21.2 μm) at first and second shearings respectively. Progeny sex and birth type had effects on greasy fleece weight and clean fleece weights at both shearings, on mean fibre diameter at the first shearing, birth weight and live weight at 3, 5, 11 and 15 months of age. The effect of the age of dam was evident for greasy fleece weight, clean fleece weight and medullation at the first shearing; clean fleece weight and yield at the second shearing; birth weight and live weight at 3, 5, 11 and 15 months of age. Differences between sires were small but apparent for the majority of fibre quality traits as well as live weight at 15 months of age. The third shearing, and a genetic analysis utilising dam pedigree, will expand results further and is likely to reveal larger differences between sires.

Keywords: Genetics, mohair, birth type, fibre diameter, fleece weight
[#]Corresponding author. E-mail: mark.ferguson@dpi.vic.gov.au.

Introduction

The Mohair industry has existed in Australia for over 100 years and is worth A$3 million annually, but the industry is yet to realise the full potential of superior genetics imported from Africa and North America during the last 15 years. There is the potential to increase the productivity of the Angora goats in Australia through increasing or maintaining fleece weight while reducing the mean fibre diameter and medullation, increasing staple length, and improving reproductive traits (Stapleton, 1997).

There is currently very little objective information on which sire selection can be based, and it is impossible to identify the genetically superior animals that exist within the national flock. A performance recording system known as MOPLAN was established in 1992 (Lollback & Stapleton, 1995). However, this system was not adopted by industry. A central progeny test site was established in 2002 to determine the genetic variation that existed between prominent sires in use in the industry and to demonstrate the usefulness of modern genetic techniques in identifying elite individuals. The project was designed to evaluate the progeny of the selected sires at their first three shearings. This paper reports on preliminary data from the first two shearings.

Materials and Methods

The project site was established near Horsham (36º43'00"S, 142º14'30"E), in the north-west of Victoria, Australia. The selected group of 11 sires included South African, Texan and interbred sires and was representative of the genetics available in Australia. A group of mixed age Angora does (n=511) were mated using artificial insemination with frozen semen over four days in April 2002. The does were separated into age groups and randomly assigned to each sire within the age group. The average kidding date was 11th September 2002. A total of 345 progeny was born with large numbers of multiple births. At birth all progeny were tagged and their dam, birth weight and birth type (single, twin, triplet or quad) were recorded. All male progeny were castrated at 3 months of age and all progeny were weaned at 5 months of age. Animals were weighed at 3 months (LW3), 5 months (LW5), 11 months (LW11) and 15 months

(LW15) of age. Animals were shorn at six months of age and again at 12 months of age. Prior to each shearing, a midside sample was removed from all animals. A randomly selected staple from the midside staple was manually measured for length (SL). The midside samples were measured for mean fibre diameter (MFD), standard deviation of fibre diameter (SD), coefficient of variation of fibre diameter (CVD), fibre curvature (FC) and percentage of medullated fibres (MED). The testing was carried out utilising an Optical Fibre Diameter Analyser 100 (OFDA100) using a mohair calibration developed from mohair top supplied by CSIR, Port Elizabeth, South Africa, and following standards IWTO-47-98 and IWTO-57-98. The samples were then tested for clean washing yield (YLD). At shearing, greasy fleece weight (GFW) was recorded, and this was later multiplied by YLD to determine clean fleece weight (CFW).

Birth type was converted to include only single or multiple births (i.e. twins, triplets and quads were bulked into one category). A REML variance components analysis was completed, the fixed model included birth type, dam age, sex and sire. There was no random model specified. Dam age was included in the analysis to account for both maternal environment and genetic differences. All traits were analysed separately and all interactions were included in the initial analysis. For all traits there were no interactions ($P > 0.05$). The analysis was undertaken using GenStat 5.42 (GenStat Committee, 2000).

Results and Discussion

Angora goat growth and fibre production traits are closely linked to animal nutrition (McGregor 1998). The site experienced a severe drought for the 2002 season, and despite considerable supplementary feeding there was a reduction in doe kidding performance and in progeny growth and fibre production. The predicted means for fleece traits (Table 1) and live weight traits (Table 2) are lower than expected.

Table 1 Means (±s.e.) of fleece traits at the first and second shearings for mean fibre diameter (MFD), standard deviation of fibre diameter (SD), coefficient of variation of fibre diameter (CVD), fibre curvature (FC), percentage of fibres displaying medullation (MED), clean washing yield (YLD), greasy fleece weight (GFW), clean fleece weight (CFW) and mid-side staple length (SL)

		MFD µm	SD µm	CVD %	FC °/mm	MED %	YLD %	GFW kg	CFW kg	SL cm
First Shearing	**Mean**	20.3	6.3	31.0	19.2	1.3	80.5	0.87	0.70	14.1
(n=270)	**s.e.**	0.3	0.1	0.5	0.4	0.1	0.7	0.03	0.02	0.3
Second Shearing	**Mean**	21.2	5.4	25.3	18.5	0.6	81.6	1.17	0.95	11.6
(n=246)	**s.e.**	0.3	0.1	0.5	0.5	0.1	0.7	0.03	0.03	0.3

Table 2 Means (±s.e.) and the predicted means of birth type effects (single=1 and multiple=2) including the standard error of difference (s.e.d.) and predicted mean of sex effects including the s.e.d. of birthweight (BWT) and live weight at 3 (LW3), 5 (LW5), 11 (LW11) and 15 (LW15) months of age, greasy fleece weight at first (GFW1) and second (GFW2) shearings, clean fleece weight at first (CFW1) and second shearings (CFW2) and mean fibre diameter at the first shearing (MFD1)

Trait	Unit	Overall			Birth type category means			Sex category means		
		n	Mean	s.e.	1	2	s.e.d.	Female	Male	s.e.d.
BWT	kg	345	2.7	0.06	3.0	2.4	0.06*	2.6	2.8	0.05*
LW3	kg	281	12.4	0.44	14.3	10.4	0.39*	11.4	13.3	0.35*
LW5	kg	271	14.3	0.51	16.4	12.2	0.47*	13.3	15.3	0.41*
LW11	kg	246	15.7	0.39	16.7	14.7	0.39*	14.8	16.6	0.33*
LW15	kg	239	23.0	0.56	23.8	22.1	0.55*	21.7	24.2	0.47*
GFW1	kg	270	0.87	0.03	1.01	0.74	0.03*	0.82	0.93	0.03*
GFW2	kg	246	1.17	0.03	1.20	1.13	0.03*	1.12	1.22	0.02*
CFW1	kg	270	0.70	0.02	0.80	0.60	0.02*	0.65	0.74	0.02*
CFW2	kg	246	0.95	0.03	0.98	0.92	0.02*	0.91	0.99	0.02*
MFD1	µm	270	20.3	0.27	21.1	19.5	0.25*	-	-	

* Difference is significant ($P < 0.001$)

There were differences ($P < 0.001$) between birth types and between sexes for all live weight traits and some fleece traits (Table 2). Female progeny were smaller and produced lighter fleeces than the male

Peer-reviewed paper: 8th International Conference on Goats

progeny. Single born progeny were heavier on average, producing more mohair than multiple born progeny. The effects of sex and birth type were similar to those reported by Nicoll *et al.* (1989).

The drought conditions may have reduced the variation between sires, however, differences ($P < 0.05$) were evident for many of the fleece traits (Table 3). The only time where there was a difference ($P < 0.05$) between sires in live weight was LW15, this weight was taken following a period of rapid growth.

Table 3 Predicted sire means, standard error of differences (s.e.d.) and the significance level (Sig.) at the first (1st) and second (2nd) shearings for mean fibre diameter (MFD), coefficient of variation of fibre diameter (CVD), fibre curvature (FC), percentage of medullated fibres (MED), washing yield (YLD) clean fleece weight (CFW) and live weight at 15 months of age (LW15)

					Sire										
	Trait		**Sig.**	**s.e.d.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1st	MFD	µm	P < 0.001	0.53	20.3	21.0	19.6	21.4	19.6	20.6	20.3	21.2	20.1	20.0	19.6
	CVD	%	P < 0.05	0.86	31.9	30.7	32.0	30.9	31.0	29.3	31.7	31.5	31.2	29.8	30.5
	FC	°/mm	P < 0.001	0.82	20.9	18.9	19.0	17.8	20.9	17.0	18.9	18.8	19.8	19.4	20.0
	MED	%	P < 0.01	0.16	1.3	1.4	1.4	1.2	1.1	1.4	1.6	1.5	1.1	1.5	1.1
	YLD	%	P < 0.001	1.37	79.7	76.6	82.6	82.5	80.6	83.1	79.3	79.7	80.9	80.4	80.2
	CFW	kg	ns	0.05	0.71	0.70	0.63	0.69	0.69	0.70	0.68	0.77	0.76	0.67	0.68
2nd	MFD	µm	P < 0.001	0.58	21.2	22.0	20.7	22.2	20.1	21.2	21.9	22.1	20.5	20.8	20.3
	CVD	%	P < 0.05	1.08	26.5	25.5	25.8	25.0	25.6	23.6	24.5	23.9	26.1	25.4	26.6
	FC	°/mm	P < 0.001	1.00	20.8	18.3	17.8	17.8	19.9	16.4	18.3	16.4	19.5	18.3	19.7
	MED	%	P < 0.05	0.10	0.4	0.7	0.6	0.6	0.6	0.5	0.6	0.8	0.5	0.5	0.6
	YLD	%	P < 0.001	1.43	79.3	83.1	80.2	83.5	81.6	83.8	82.1	79.1	82.8	82.6	79.2
	CFW	kg	ns	0.05	0.95	0.99	0.89	0.92	0.92	0.95	1.04	0.95	0.93	0.97	0.94
	LW15	kg	P < 0.05	1.13	22.3	23.3	23.5	23.0	23.0	20.9	24.8	23.9	21.6	23.5	22.8

MFD is the most important mohair property for processing and it is closely associated with greasy mohair price (Hunter, 1993). The maximum difference between sires for MFD was 1.8 µm at the first shearing and 2.1 µm at the second shearing. These differences in MFD are evident without an associated reduction in fleece weight ($P > 0.05$) and for some sires without a reduction in live weight, which is promising for industry genetic improvement. Due to better seasonal conditions in 2003 it is expected that the third shearing will allow the progeny to better express their genetic potential and much larger differences will be evident. Widespread industry use of the most profitable sires identified in this project will result in an increase in profitability of Australian mohair production enterprises. The evaluation of further sires, with links to the current data would substantially enhance the value of this information, and result in more efficient identification and use of superior sires in the industry.

Acknowledgment

This research is funded by Rural Industries Research and Development Corporation and the Victorian Department of Primary Industries. The authors gratefully acknowledge the assistance from R. & J. Liddy, R. Doyle, sire owners, D. Gordon, M. Murray and J. Bennett.

References

GenStat Committee, 2000. GenStat for Windows. Release 4.2. Fifth Edition. VSN International Ltd., Oxford.

Hunter, L., 1993. Mohair: a review of its properties, processing and applications. (CSIR: Port Elizabeth).

IWTO-47-98, 1998. The Woolmark Company, Ilkley, West Yorkshire.

IWTO-57-98, 1998. The Woolmark Company, Ilkley, West Yorkshire.

Lollback, M.W. & Stapleton, D.L., 1995. MOPLAN-A national performance recording scheme for Angora goats. Proc. Aust. Assoc. Anim. Breed. Genet. 11, 678-681.

McGregor, B.A., 1998. Nutrition, management and other environmental influences on the quality and production of mohair and cashmere with particular reference to Mediterranean and annual temperate climatic zones: A review. Small Rumin. Res. 28, 199-215.

Nicoll, G.B., Bigham, M.L. & Alderton, M.J., 1989. Estimates of environmental effects and genetic parameters for liveweights and fleece traits of Angora goats. Proc. N.Z. Soc. Anim. Prod. 49, 183-189.

Stapleton, D.L., 1997. Breeding Angora goats for mohair production. Proc. Assoc. Advmt. Anim. Breed. Genet. 12, 377-381.

Peer-reviewed paper: 8th International Conference on Goats

A genetic profile of the Kalahari Red goat breed from Southern Africa

A. Kotze[1] H. Swart[1], J.P. Grobler[2] and A. Nemaangani[1]
[1]ARC Animal Improvement Institute, Private Bag X2, Irene 0062, South Africa
[2]Biodiversity, School of Molecular and Life Sciences, University of the North, P/Bag X1106, Sovenga 0727, South Africa

Abstract

The erosion of the Kalahari Red with red Boer goats is a major concern among breeders. Little empiric information is available with no comprehensive system of monitoring special characteristics. Eighteen mircosatellite markers were applied to investigate the genetic diversity of the breed and to set up a molecular inventory. The results provide genetic characterization information, which forms the bases for future management of the Kalahari Red.

Keywords: Kalahari Red, indigenous, microsatellite markers, heterozygosity
#Corresponding author. E-mail: akotze@idpi.agric.za

Introduction

The Kalahari Red is regarded as an indigenous goat breed originating from southern Africa. Records indicate that the goats have been selected from lop-eared animals that migrated with tribes to the southern part of Africa more than 2000 years ago (Epstein, 1971). Breeders from the Northern Cape Province in South Africa and the southern part of Namibia, specifically the Kalahari Desert area, selected animals slightly smaller than the red and white improved Boer goat, but with uniform red pigmentation. The Kalahari Red was recognized as a landrace breed in 1998 with the establishment of a breeder's organization. Today this goat breed is an important meat-producing breed in South Africa with characteristics such as adaptation to arid and semi arid savannah, good foraging abilities and excellent mothering abilities. It is regarded as a "minimum care / maximum profit" breed (Ramsay *et al*., 2001).

The purpose of this study was to optimize microsatellite markers for goats at the ARC Irene laboratory; to use the Kalahari Red goat as an example to investigate the genetic diversity of markers within a population; and to commence with a molecular inventory describing the distinctiveness of the Kalahari Red goat breed.

Material and Methods

A total of 214 hair samples was collected from goats of six breeders identified by the breeders association from different geographical regions: the Northern Cape Province (Kuruman 61, Prieska 75, Douglas 22) and Limpopo Province (Tsipise 34) in South Africa; and from Namibia (Maltahohe 15).

DNA was extracted from the hair roots using a modified Proteinase K digestion method (Higuchi *et al.*,1988). Microsatellite loci were selected for exploratory screening based on the degree of polymorphism and genome coverage of these loci (Arevalo *et al.*, 1994; Bhebhe *et al*., 1994; Barker *et al*., 2001). These microsatellite markers are listed on the FAO and ISAG recommended list and adhere to international standards.

PCR reactions were performed in a Perkin Elmer Thermal Cycler. Genotyping was carried out on an automated ABI 377 DNA sequencer (Perkin Elmer, Foster City, USA), with fragments separated using 0.5% polyacrylamide gels. The data was captured using GeneScan 2.1 Software and initial data analysis was carried out using Genotyper 2.0 to determine the fragment sizes in base pairs. Data were then analysed using POPGENE software to determine the heterogeneity of the markers used and the extent of genetic differentiation among populations.

Results and Discussion

Eighteen microsatellite markers were optimised for PCR and successfully divided into four multiplexes based on their product size and dye label (Table 1). The difference in size between two adjacent markers was at least 20 bp to allow for the identification of new alleles outside the known fragment ranges. Not all the criteria have been fulfilled in the case of each marker, primarily in an effort to tie this list in with

Peer-reviewed paper: 8th International Conference on Goats

existing screening efforts. In some cases more than one marker has been selected from one chromosome. This was not foreseen as problematic in population genetic studies if there is no linkage.

Table 1 Standardization of selected microsatellite markers and plexus

Multiplex:	**Microsatellite loci:**
PLEX 1	SRCRSP24, SRCRSP5, SRCRSP8
PLEX 2	MCM527, INRA2, BM1329, OARFCB20, CSRD247, ILST87, SRCRSP23
PLEX 3	OARFCB11, ILST002, RM004, INRA63
PLEX 4	INRA006, BM1818, MAF65, CSSM36, BM1258

The mean number of alleles and the expected heterozygosities detected are good indicators of the genetic polymorphism within the breed. Generally the mean number of alleles is highly dependent on the sample size because of the presence of unique alleles in populations, which occur in low frequencies and also because the number of observed alleles tends to increase with increases in population size. The number of alleles scored for each marker is an invaluable indicator of the future usefulness of the marker for genetic screening.

Table 2 Variability of the microsatellite markers used

	Pooled populations:	**Individual populations:**
Mean number of alleles	7.77	3.83-6.89
Average heterozygosity	0.63	0.56-0.68

The average number of 7.77 alleles per locus, with even the most monomorphic locus having 3.83, is promising for future application of these markers (Luikart *et al*., 1999). It should be noted that the number of 7.77 is the mean across 18 loci, and specific loci provided up to 12 alleles per locus.

The genetic relationships between the different populations within the Kalahari Red breed were measured by determining the genetic distance (Nei, 1978) between populations. Genetic distance values were small and ranged from 0.072 to 0.171. A dendrogram based on these genetic distances revealed no specific link with geographic distance.

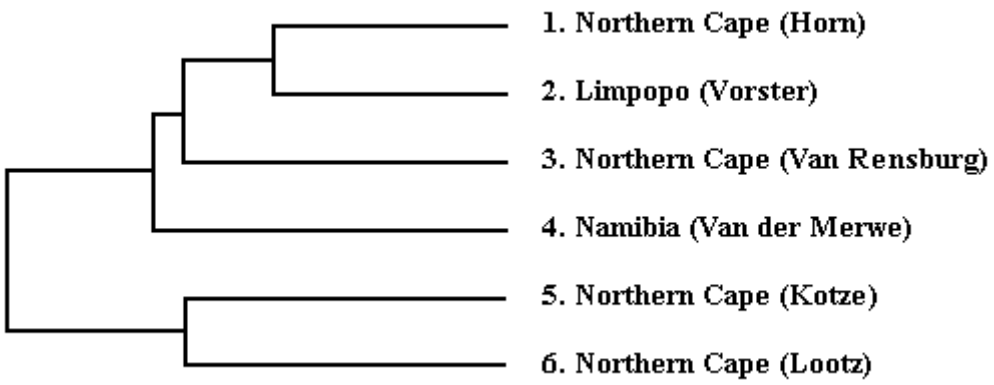


Figure 1 **Dendrogram depicting the relationships between six Kalahari Red populations**

The results indicate no differentiation between the different populations that can be linked to geographical separation. Note that various populations of Northern Cape origin fall into two distinct clusters, overlapping divergence between these groups and populations from the Limpopo Province and Namibia. This indicates uniformity within the breed. The limited differences that do exist among populations may suggest local selection / adaptation, and the presence of such possible ecotypes in distinct environments should be further investigated (Tunon *et al*., 1989; Saitbekova *et al*., 1999; Yang *et al*., 1999; Watts *et al*., 2001). Possible ecotypes should not be forfeited but should be used to their full potential to

benefit livestock production in their respective areas. Crossbreeding with other breeds should be done with discrimination as to preserve this important farm animal genetic resource.

Conclusion

Microsatellite DNA is currently the most useful marker of choice for a wide range of molecular genetic studies such as population structure, population differentiation and reconstruction of phylogenetic relationships among populations. The criteria for the markers were that a common PCR program could amplify them, have a minimum of five alleles and were easily scored for PCR products. The primers evaluated and optimised in this study met the criteria set, and can now contribute to standardization for genetic characterization studies of Kalahari Red populations within the SADC region, be used for parentage determination and for forensic analyses.

The results provide characterization information that forms the basis for future management of the Kalahari Red goat breed. This study has also provided a DNA repository for the Kalahari Red breed and detailed genetic data applicable to future research and development. Establishing the profile of the Kalahari Red breed through survey, monitoring population status and descriptive qualities is the essential first steps in better understanding, developing and utilizing this animal genetic resource.

References

Arevalo, E., Holder, D.A., Der, J.N., Bhebhe, E., Linn,R.A., Ruvuna, F., Davis, S.K. & Taylor, J.N., 1994. Caprine microsatellite dinucleotide repeat polymorphisms at SR-CRSP-1, SR-CRSP-2, SR-CRSP-3, SR-CRSP-4, SR-CRSP-5 loci. Anim. Genet. 25, 202.

Barker, J.S.F., Tan, S.G., Moore, S.S., Mukherjee, T.K., Matheson, J-L. & Selvara, O.S., 2001. Genetic variation within and relationships among populations of Asian goats (*Capra hircus*). J. Anim. Breed. Genet. 118, 213-233.

Bhebhe, E., Kogi, J., Holder, D.A., Arevalo, E., Derr, J.N., Linn, R.A., Ruvuna, F., Davis, S.K. & Taylor, J.F., 1994. Caprine microsatellite dinucleotide repeat polymorphisms at SR-CRSP-7, SR-CRSP-8, SR-CRSP-9 and SR-CRSP-10 loci. Anim. Genet. 25, 203.

Epstein, H., 1971. The origin of the domestic animals of Africa. Volume II. Africana Publishing Corporation.

Higuchi, R. & Bradley, D., 1998. DNA typing from single hairs. Nature 332, 543-546.

Luikart, G., Biju-Duval, M-P., Ertugrul, O., Zagdsuren, Y., Maudet, C. & Taberlet, P., 1999. Power of 22 microsatellite markers in fluorescent multiplex for parentage testing in goats (*Capra hircus*). Anim. Genet. 30, 431-438.

Nei, M., 1978. Estimation of average heterozygosity and genetic distance from a small number of individuals. Genetics 89, 583-592.

POPGENE version 1.31 - Francis Yeh, & Rong-caiYang, University of Alberta; and Tim Boyle, International Forest Research

Ramsay, K., Harris, L. & Kotze, A., 2001. Landrace Breeds: South Africa's Indigenous and Locally developed Farm Animals. Publication Farm Animal Conservation Trust, ISBN: 0-620-25493-9.

Saitbekova, N., Gaillard, C., Obexer-Ruff, G. & Dolf, G., 1999. Genetic diversity in Swiss goat breeds based on microsatellite analysis. Anim. Genet. 30, 36–41.

Tuñón, M.J., Gonzalez, P. & Vallejo, M., 1989. Genetic relationships between 14 native Spanish goat breeds. Anim. Genet. 20, 205-212.

Yang, L., Zhao, K.L., Peng, Z.Z. & Montgomery, G.W., 1999. Determination of genetic relationships among five indigenous Chinese goat breeds with six microsatellite markers. Anim. Genet. 30, 452-455.

Watts, P.C., Chenyambuga, S.W., Hirbo, J., Gwakisa, P.S., Kifaro, G.C., Kemp, S.J., Rege, J.E.O. & Hanotte, O., 2001. Study of genetic diversity of sub-Saharan goat populations using microsatellite loci. ILRI publication. DO87.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Genetic assay of CAE in the Hungarian goat herd

Sz. Kusza[1#], Zs. Bősze[2], S. Kukovics[3] and A. Jávor[1]

[1] University of Debrecen, Centre of Agricultural Sciences, Dept. of Animal Breeding and Nutrition 4032, Debrecen, Böszörményi st. 138., Hungary

[2] Agricultural Biotechnology Center, Dept. for Animal Biology 2100 Gödöllő, P.O. Box 411, Hungary

[3] Research Institute for Animal Breeding and Nutrition 2053 Herceghalom, Gesztenyés st. 1., Hungary

Abstract

Caprine arthritis encephalitis (CAE) is a retroviral infection of goats. CAEV is closely related to the virus which causes Maedi- Visna in sheep and AIDS in humans. The first survey of the seroprevalence of CAEV in Hungarian goats was performed. Parallel with it we tried to reveal whether there is any association between either the susceptibility of CAE or the appearance of clinical symptoms in infected individuals and MHC II DRBP1 microsatellite polymorphism. Our aim was to encourage control measures before the infection can spread rapidly. The experiments were launched in 2003. Hungarian Milking Goats (White, Brown, Multicolour) and Saanen were selected for this initial study. Blood samples were taken for DNA extraction. Serological data showed that 30% of the Hungarian goat population was infected with Caprine Arthritis Encephalitis Virus (CAEV). Microsatellite polymorphism located within the DRBP1 MHC class II candidate gene was analysed. The genotypes of 130 animals were determined out of the 2000 animals which are planned to be examined untill the end of 2004. A significant association between serological results and DRBP1 genotypes was not detected using Chi-square test (at level 5%).

Keywords: CAE susceptibility, DRBP1, goat
[#]Corresponding author. Email: kusza@helios.date.hu

Introduction

The nervous disease first reported in 1974, was named Viral Leukoencephalitis of Goats (VLG). When it was found that arthritis could also result from the same virus infection, the name of the disease was changed to Caprine Arthritis Encephalitis Syndrome (Sherman, 1992). Body excretions, which contain white blood cells are potential sources of the virus infection to other goats in the herd. CAEV may lead to chronic disease of the joints and in rare cases encephalitis in goat kids younger than six months of age (Sherman, 1992). Some infected animals, which can transmit the disease, may never show clinical symptoms. The best protection against disease is the prevention. This disease is widely distributed in the dairy goat populations (Contreras *et al*., 1998) in those countries where modern dairy technologies has been introduced for several years (Adams *et al*., 1982). Presence of the virus is not detectable in goat kids younger than six months of age. Therefore, linkage studies were initiated in Switzerland, Spain and France to reveal the background of the disease. Goats imported from other European countries (France, Switzerland, Netherland) have a high prevalence of the disease and they might have introduced the disease into the Hungarian goat population.

CAEV infections are detected in two ways:

- by demonstrating the presence of antibodies to CAEV in goat serum (Adams, 1982; 1986)
- by using a polymerase chain reaction (PCR), which detects the virus's genome in the white blood cells (Vander Schale, 1994).

Dolf & Ruff (1994) demonstrated that a DNA fingerprint band is associated with susceptibility of CAE in Saanen goats. Another DNA fingerprint band was present in clinically healthy animals of the Toggenburg breed. However, DNA fingerprint experiments were not continued because the low reproducibility of the technique.

The MHC II molecules are dimeric glycoproteins which are expressed on the surface of B lymphocytes, macrophages and other antigen presenting cells (Andersson, 1990). There are different kinds of MHC class II molecules, but DQ and DR subtypes are the most polymorhic in human and domestic animals, and probably play a major role in the development of MHC restricted immune responses (Groenen *et al*., 1990, Van de Poel *et al*., 1990). In goats there are 22 different alleles of the DRB gene (Schwaiger *et al*., 1993).

Peer-reviewed paper: 8th International Conference on Goats

Association studies was perfomed by Ruff *et al*. (Personal communication, 2003) using candidate microsatellite loci of the MHC class II DRBP1 gene to reveal possible association with CAE susceptibility. The Be1 serologically defined MHC class I allele segregated with disease development and a higher viral load in Swiss Saanen breed and it was associated with a 213bp allele of the DRBP1 microsatellite locus. The MHC I allele Be7 associated with another II DRBP1 allele (196bp) in which case the clinical symptoms did not appear in CAEV infected Swiss Saanen and Alpine breed.

According to our recent survey (Kukovics *et al*., 2003a, b and c) 30% of the Hungarian goats is infected by CAEV. The first infected animals could be traced back to the end of the 1990s and those supposedly arrived with imported goats and spread with their offspring. The extent of infection is different in the Hungarian breeds. It is most frequent observed in purebred and crossbred Saanen as well as in crossbred Alpine flocks. Generally the presence of the infection has a negative influence on production traits. However, its effect depends on the breed. Our results revealed that the semen quality of seropositive individuals was weaker than of seronegative bucks (Kukovics *et al*., 2003a, b and c). The ratio of infected animals has increased with the size of herds in Hungary. Moreover, significant differences were found between the countries regarding the herds contracting the CAEV infection.

Materials and Methods

Three imported (Alpine, Saanen, Boer) and four local goat breeds (Hungarian Improved Goat, Hungarian Milking White Goat, Hungarian Milking Brown Goat, Hungarian Milking Multicolour Goat) are represented on Hungarian goat farms. Up to date a total of 56 Saanen and 74 Hungarian Milking Goats was examined with both a serological analysis and a microsatellite analysis. Out of them 50% was seropositive.

CAEV specific ELISA and AGID tests were performed at the Central Veterinary Institute based on the method published by Heckert *et al*. (1992). A DRBP1 microsatellite analysis was performed as published by Ruff *et al*. (1988). Genomic DNA was extracted from blood samples by standard protocol as published earlier (Bősze *et al*., 2000). PCR was performed in a 25 μL reaction mixture consisting of 100 ng goat genomic DNA, 0.38 μM Ready Mix (Sigma), 0.04 μM of each primer (MWG-Biotech AG). The following primers were used:

F: 5'-GGA-CAC-GTT-CTT-GCA-GAT-ACA-ACT-AC-3'

R: 5'-GAA-CTC-TCC-TTA-AGC-ATA-CTT-GCT-C-3'

Thermal cycling conditions were: a denaturation step of 95 ^{o}C for 5 min., 34 cycles of 95 ^{o}C for 40 sec, 58 ^{o}C for 40 sec and 72 ^{o}C for 40 sec, followed by a final extension at 72 ^{o}C for 4 sec. Genotype analysis was carried out on an automated DNA sequencer (Alf II). Internal standards were 142, 164, 252, 275 bp, while external standards were 142, 164, 252, 275, 206 and 309 bp long. Detailed serological data of the CAEV ELISA and AGID tests from 2000 sampled goats have been presented by Kukovics *et al*. (2003 b).

The frequency of genotypes was calculated using the following formula:

$P_i = N_i/n$

Where: P_i = frequency of the i^{th} genotype

N_i = number of the „i" genotype animals

n = total number of animals

Statistical analysis were performed using SPSS for Windows 11.0 and Microsoft Excell (SPSS InC., 2001; Microsoft Corporation, 2002).

Results and Discussion

The DRBP1 MHCII microsatellite analysis revealed eight bp intervallums which were the following: 197-201 bp- A allele, 202-208 bp- B allele, 209-213 bp- C allele, 214-215 bp- D allele, 216-219 bp- E allele, 220-222 bp- F allele, 226-229 bp- G allele, 230- bp- H allele. In the Saanen breed most of the individuals was heterozygous (54%). However, in case of the Hungarian Milking breed the rate of homozygous was higher (homozygous: 62%; heterozygous: 38%). Among Saanen goats the CC genotype had the hoighest frequency (Table 1). The FF genotype was found only in the Hungarian Milking breed and the GG genotype only in the Saanen breed.

In the Hungarian Milking breed the frequency of the E allele was the highest. The DNA samples from Swiss reference animals were homozygous for the MHC II DRBP1 213 and 196 bp allelic variants and

(kindly donated by G. Ruff) were included in the microsatellite analysis in order to establish which are the corresponding variants in the Hungarian samples. The results are presented in Table 2.

Table 1 Frequences of MHC II DRBP1 microsatellite lengths in the examined breeds

		Alleles							
	n	A	B	C	D	E	F	G	H
Saanen	56	0.232	0.027	0.455	0.054	0.098	-	0.134	0.009
Milking				0.203	0.038	0.38	0.051	-	
Hungarian	74	0.259	0.057						-

Table 2 Tentative allele frequency values corrected to the control sample

	a	Be1	Be7	B
Milking				
Hungarian	0.24	0.52	0.24	
Saanen	0.39	0.25	0.22	0.14

In the Saanen breed the 205-211 bp long interval microsatellite's lengths were the most frequent, while in the Hungarian Milking breed the 212- 222 bp long interval were microsatellite's lengths were the most frequent. A significant difference was not detected in the allele frequency between seropositive and seronegative goats. A significant association were not detected in the examined populations between serological results (virus infected/non infected) and MHC II DRBP1 genotypes ($P < 0.05$).

Conclusions

The microsatellite polymorhism is a powerful tool to differentiate between goat breeds and was successfully adapted in association studies with infectious caprine diseases. Unfortunately a reliable assay has not been developed yet for determining the susceptibility to CAE at birth. Based on our results the following further experiments will be necessary and are planned:

- To confirm the serological results with CAEV specific PCR, since serological results are strongly influenced by age and physiological status of goats;
- To reveal if there is any correlation between clinical symptoms and DRBP1 genotypes;
- To use Swiss DNA samples to determine whether Be1 MHC I cosegregates with the 213bp allele of DRBP1 in Hungarian breeds. MHC haplotypes can change between breeds and populations and it is not known how close the Hungarian Saanen is to the Swiss Saanen;
- To evaluate the correlation between MHC II DRBP1 genotypes and the development of clinical symptoms with the help of a pyrosequencing approach.

Acknowledgements

We wish to thank G. Obexer-Ruff at University of Bern, Switzerland for her valuable help and discussions. This research is financially supported by a fellowship from the Ministry of Education. The authors express their sincere thanks to the farmers for their cooperation.

References

Adams, D.S., 1982. The meaning of the agar gel immunodiffusion test (AGID) for antibody against caprine arthritis encephalitis virus (CAEV). Dairy J. 60, 17.

Adams, D.S.& Gorham, J.R., 1986. The gp 135 of caprine arthritis encephalitis virus affords greater sensitivity than the p28 in immunodiffusion serology. Res.Vet. Sci. 40, 157.

Andersson, L., 1990. Major histocompatibility genes in cattle and their significante for immune response and disease susceptibility. In: Genome analysis in domestic animals. Eds. Geldermann, H. & Ellendorff. F., VCH, Weinheim, Germany. pp. 213-223.

Bősze, Z., Hiripi, L., Virág, G., Toth. S., Makovic, S., Fontaine, M.L. & Devinoy, E., 2000. Polymorphism of the rabbit kappa casein gene and its influence on performance traits. Pflugers Arch. 439 (3 Suppl), R2-3.

Contreras, A., Corrales, J.C., Sanchez. A., Aduriz, J.J., Gonzalez, L. & Marco, J., 1998. Caprine Arthritis – encephalitis in an indigenous Spanish breed of dairy goat. Vet. Rec. 142, 140-142.

Dolf, G. & Ruff, G., 1994. A DNA fingerprinting band associated with the susceptibility to CAE virus-induced arthritis in goats. Br. Vet. J. 150, 349-353.

Groenen, M.A.M., Van der Poel, J.J., Dijkhof, R.J.M. & Giphart, M.J., 1990. The nucleotide sequence of bovine MHC class II DQB and DRB genes. Immunogenetics 31, 37-44.

Heckert, R., McNab, W.B., Richardson, S.M. & Briscoe, M.R., 1992. Evaluation of an enzyme linked Immunosorbent assay for the detection of antibodies to Caprine Arthritis Encephalitis virus in goat serum. Can. J. Vet. Res. 56, 237-241.

Kukovics, S., Molnár, A., Ábrahám, M., Dani, Z., Kusza, Sz. & Fülöp, Gy., 2003a. The presence of CAE in the Hungarian goat breeds. EU konform mezőgazdaság és élelmiszerbiztonság. Gödöllő. pp. 219-228.

Kukovics, S., Molnár, A., Ábrahám, M., Dani, Z., Kusza, Sz. & Fülöp, Gy., 2003b. Presence of CAEV infection in Hungarian goat industry as an effect of livestock import. In: Book of Abstracts; 54th Annual Meeting of EAAP, Rome, Italy 31 August-03. Sept., 2003; No.9. 320 p.

Kukovics, S., Molnár, A., Ábrahám, M., Dani, Z., Kusza, Sz. & Fülöp, Gy., 2003c. Presence of CAEV infection in the Hungarian goat industry as an effect of livestock import. In: Buletinul, Universitatii de Stiinte Agricole Si Medicina Veterinara, Seria Zootechnie si Biotechnologii, ISSN 1454-2382, Vol. 59, 42-48 p.

Ruff, G. & Lazary, S., 1988. Evidence for linkage between the caprine leucocyte antigen (CLA) system and susceptibility to CAE virus induced arthritis in goats. Immunogenetics 28, 303-309.

Schwaiger, F.W., Buitkamp, J., Weyers, E. & Epplen, J.T., 1993. Typing of MHC-DRB genes with the help of intronic simple repeated DNA sequences. Mol. Ecol. 2, 55-59.

Sherman, D.M., 1992. Goat handbook

Tyler, J.W. & Cullors, J.S., 1989. Titers, tests and truisms: Rational interpretation of diagnostic serologic testing. J. Am. Vet. Med. Assoc. 194, 1550-1558.

Vander Schale, J., 1994. Evaluation of a kinetic enzyme linked immunosorbent assay for detection of caprine arthritis encephalitis virus antibodies. J. Vet. Diagn. Invest. 6, 30-33.

Van de Poel, J.J., Groenen, M.A.M., Dijkhof, R.J.M., De Ruyter, D. & Giphart, M.J., 1990. The nucleotide sequence of the bovine MHC class II alpha genes: DRA, DQA and DYA. Immunogenetics 31, 29-36.

Peer-reviewed paper: 8th International Conference on Goats

Genetic characterisation of the Blanca Andaluza goat based on microsatellite markers

A.M. Martínez[1#], M.P. Carrera[2], J.M. Acosta[3], P.P. Rodríguez-Gallardo[4], A. Cabello[5], E. Camacho[6] and J.V. Delgado[1]

[1]Department of Genetics. University of Córdoba. Edificio Gregor Mendel. Córdoba. Spain
[2]Agronomical Sciences Center, Federal University of Paraiba. Areia, Paraíba, Brazil
[3]Dept. Biothechnology INIPRO. Fundación Inst. de Investigación y Ciencia de Pto. del Rosario. Fuerteventura, Spain
[4]Laboratorio de Genetica Molecular. Servicio de Cría Caballar. Córdoba. Spain
[5]Delegación de Turismo y Desarrollo Rural.Diputación de Córdoba, Spain
[6]CIFA de Hinojosa del Duque. Córdoba. Spain.

Abstract

This is a genetic characterisation of the Blanca Serrana Andaluza goat breed based on microsatellite markers. Fifty animal from five herds were typed with a set of 27 microsatellites proposed by the FAO and ISAG for biodiversity studies. Our results showed that this as an extremely endangered breed, though still posses a high level of genetic variability, as demonstrated by the values for the expected and observed mean heterocigocity (0.71 and 0.66, respectively). All microsatellites were polymorphic, showing a mean number of alleles of 8.22. The present situation of the breed indicates that most of the micropsatellites (18) shows a H-W equilibrium, and the Fis shows a low value (0.07), suggesting a good strategy in the conservation plan of the breed.

Keywords: Molecular markers; characterisation, conservation, goat biodiversity
[#]Corresponding author. E-mail: id1debej@uco.es

Introduction

The Blanca Serrana Andaluza goat breed used to be widely distributed in the Andalusian region until the eighties of the 20th century. Its importance was that it was a zoogenetic resource, exploited under the extensive farming condition on the Mediterranean, contributing together with other farm species to maintain the ecological equilibrium. In the another hand this breed contributed to the human fixation to the land based on the profitable use of the rusticity of the breed. After the eighties the milking goat farms displaced this breed of their traditional environment using two aggressions. The first was its substitution by milk specialised breeds such as Malagueña or Murciano-Granadina. The second was its crossbreeding with these breeds to produce its genetic substitution. Both actions produced genetic erosion locating the breed near the extinction in present times. The first action to conserve the breed was its genetic characterisation in order to define the breeds with respect to other genetics group. This is the objective of the present paper.

Material and Methods

We have obtained DNA from blood samples of 50 animals belonging to the five most representative farms of the breed. The farms were located in four Andalusian provinces (Córdoba, Huelva, Jaén and Sevilla). DNA was extracted using the kit, BLOODCLEAN (BIOTOOLS - Biotechnological & Medical Laboratories, S.A. Madrid, Spain).

The following 27 microsatellites have been studied: BM8125, BM1818, CSSM66, ILSTS011, INRA63, INRA23, SPS115, BM6506, ETH225, ETH10, INRA6, BM6526, HAUT27, CSRD247, MAF65, MAF209, OarFCB11, MM12, OarFCB304, BM1329, INRA5, TGLA122, HSC, MCM527, SRCRSP8, OarFCB48 and CSRM60. These microsatellites have been proposed by FAO and ISAG for biodiversity studies, because its no linked location in the genome and their high level of variation.

These markers were amplified by mean of the Polimerase Chain Reaction (PCR) technique according to the Martínez *et al.* (2000) method. To get the size separation of the obtained fragments we have developed electrophoresis in polyacrylamide gel in an automatic sequencer ABI 377XL (Applied Biosystems, Foster City, CA, USA). The analyses of the fragments and the allelic typing were developed in the software Genescan Analysis® 3.1.2 and Genotyper® 2.5.2 respectively.

Peer-reviewed paper: 8th International Conference on Goats

We have calculated the allelic frequencies, the heterocigocity levels and the values of Fis by mean of the software Genetix v. 4.02 (Belkhir, 2001). Also we have calculated the content of polymorphic information (PIC) according to the algorithm proposed by Botstein *et al*. (1980). We have also tested the Hardy-Weimberg (HW) equilibrium by mean of the software Genepop v. 3.1c (Raymond & Rousset, 1995) which apply the chain method of Monte Carlo Markov (Guo & Thompson, 1992).

Results and Discussion

All 27 microsatellites were polymorphic, finding a minimum of 3 alleles for INRA5, ETH10 and MAF209, and a maximum of 17 for BM6526, resulting a mean number of 8.22 (table 1). This value is higher than the 6.90 presented by Li *et al.* (2002) studding 12 Chinese breeds of goats. This is also superior to the values reported for other Asian (Barker *et al.* 2001) and French (Ouafi *et al.* 2002) breeds.

Table 1 Microsatellites analysed, Alleles obtained number, expected Heterozigosity (He), observed Heterozigosity (Ho), PIC (Polimorphic Information Content), Fis and probability value obtained for Hardy-Weinberg equilibrium (P-value).

LOCUS	NºAlleles	He	Ho	PIC	Fis	P-Value
MM12	13	0.8926	0.8333	0.88	0.078	0.3476
CSSM66	16	0.8622	0.5476	0.85	0.375	0.0000
OarFCB48	9	0.8417	0.8478	0.82	0.004	0.4870
HSC	13	0.8274	0.7647	0.81	0.091	0.0386
MAF65	9	0.8282	0.9149	0.81	-0.094	0.0742
BM1329	9	0.8228	0.8864	0.80	-0.066	0.2052
OarFCB11	13	0.8163	0.7556	0.80	0.086	0.4180
CRSM60	7	0.8096	0.8936	0.78	-0.093	0.5407
TGLA122	7	0.7977	0.6087	0.77	0.247	0.0000
INRA23	7	0.7958	0.8824	0.77	-0.079	0.9018
BM1818	8	0.7789	0.6944	0.75	0.122	0.0684
BM6526	17	0.7769	0.7391	0.75	0.060	0.5875
CSRD247	9	0.7549	0.6591	0.72	0.138	0.7300
HAUT27	6	0.7597	0.6757	0.72	0.124	0.1582
BM6506	7	0.7453	0.7500	0.71	0.006	0.6435
OarFCB304	11	0.7476	0.6304	0.71	0.167	0.0252
INRA6	8	0.7378	0.6563	0.70	0.126	0.1908
SRCRSP8	9	0.7144	0.6818	0.68	0.057	0.1834
McM527	6	0.7102	0.5789	0.66	0.198	0.0078
ILSTS011	7	0.6933	0.5854	0.65	0.168	0.3474
BM8125	8	0.6652	0.6444	0.64	0.042	0.3142
ETH10	3	0.5797	0.6596	0.51	-0.127	0.5450
INRA63	5	0.5536	0.4118	0.48	0.270	0.1224
SPS115	5	0.4798	0.3415	0.43	0.300	0.0004
INRA5	3	0.5095	0.6897	0.40	-0.338	0.0896
ETH225	4	0.2942	0.3333	0.28	-0.114	1
MAF209	3	0.2407	0.2292	0.22	0.058	0.6084
Media	*8.22*	*0.7050*	*0.6628*		*0.073*	

The expected mean heterocigocity was 0.71 and the observed 0.66, resulting these values higher than those presented by Saitbekova *et al*, (1999) in nine Swiss breeds and those reported by Barker *et al.* (2001). But they are lower to those found by Yang *et al*. (1999) in five Chinese breeds and similar to the reported by Ouafi *et al*. (2002) and Li *et al.* (2002) in the papers mentioned before. These values are indicating an important level of genetic variability for the breed even though its endangered state.

In table 1 the PIC values are presented, showing the level of informative capacity of the markers. Only ETH225 and MAF209 were low informative, the rest shown acceptable levels.

Table 1 also shows the Fis values and the probability values for the H-W equilibrium. In both cases 18 microsatellites shown H-W equilibrium, then a high stability could be expected for the breed. It indicates

Peer-reviewed paper: 8th International Conference on Goats

that the population could be responding to the conservation activities developed. The mean value of the Fis for all loci was 0.07, it indicates a low level of inbreeding taking into account the present situation of the breed. The value is lower to those reported by Barker *et al.* (2001) for 11 Asiatic local breeds.

Conclusions

This breed count with important levels of genetic varibility and low inbreeding, even its extremely endangered situation. This set of microsatellites was a very good tool for the genetic characterization of the breed and the study of its genetic structure. The H-W equilibrium encountered in most of the microsatellites is showing a correct genetic management in the conservation plan of the population.

References

Barker, J.S.F., Tan, S.G., Moore, S.S., Muekherjee, T.K., Matheson, J.L. & Selvaraj, O.S., 2001. Genetic variation within and relationships among populations of Asian goats (Capra hircus). J. Anim. Breed. Genet. 118, 213-233.

Belkhir, K., 2001. Genetix: Logiciel sous Windows™ pour la génétique des populations. Laboratoire Génome, Populations, Interactions. CNRS UPR 9060.

Botstein, D., White, R.L., Skolmick, H. & Davis, R.W., 1980. Construction of a genetic linkage map in man using restriction fragment lenght polymorphisn. Am. J. Human Genet. 32, 314-331.

Guo, S.W. & Thompson, E.A., 1992. Performing the exact test of Hardy-Weinberg proportions for multiple alleles. Biometrics 48, 361-372.

Li, M., Zhao, S., Bian, C., Wang, H., Wei, H., Liu, B., Yu, M., Fana, B., Chen, L., Zhu, M., Li, S., Xiong, T. & Li, K., 2002. Genetic relationships among twelve Chinese indigenous goat populations based on microsatellite análysis. Genet. Sel. Evol. 34, 729-744.

Martínez, A.M., Delgado, J.V., Rodero, A. & Vega-Pla, J. L., 2000. Genetic structure of the Iberian pig breed using microsatellites. Anim. Genet. 31, 295-301.

Ouafi, A.T., Babilliot, J.M., Leroux, C. & Martin, P., 2002. Genetic diversity of the two main Moroccan goat breeds: phylogenetic relationships with four breeds reared in France. Small Rumin. Res. 45, 225-233.

Raymond, M. & Rousset, F., 1995. Genepop: populations genetics software for exact tests and ecumenicism. J. Hered. 86, 248-249.

Saitbekoba, N., Gaillard, C., Obexer-Ruff, G. & Dolf, G., 1999. Genetic diversity in Swiss goat breeds based on microsatellite analysis. Anim. Genet. 30, 36-41.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Polymorphism of the αs1-casein, κ-casein and ß-lactoglobulin genes in the Hungarian milking goat

Gy. Veress[1], Sz. Kusza[2#], Zs. Bősze[3], S. Kukovics[4] and A. Jávor[2]

1: Szent Istvan University, 2100 Gödöllő, Páter Károly u. 1. Hungary,

[2]: University of Debrecen, Centre of Agricultural Sciences, Dept. of Animal Breeding and Nutrition 4032, Debrecen, Böszörményi st. 138. Hungary;

[3]: Agricultural Biotechnology Center, Department for Animal Biology 2100 Gödöllő, P.O. Box 411, Hungary;

[4]: Research Institute for Animal Breeding and Nutrition 2053 Herceghalom, Gesztenyés st. 1. Hungary

Abstract

The type and frequency of goat milk protein alleles have not been studied in Hungary yet. Here we report the initial, partial characterization of allelic polymorphisms of αs1-, κ-casein and β-lactoglobulin genes in a herd of Hungarian Milking Goat based on published RFLP-PCR and AS-PCR methods. Experiments are in progress to confirm and extend the caprine milk protein genotype data and to evaluate its influence on milk quality.

Keywords: Polymorphism, αs1-casein, κ-casein and ß-lactoglobulin genes
[#]Corresponding author. E-mail: kusza@helios.date.hu

Introduction

In the last one and half decades the number of goats has increased significantly in Hungary. The economical impact of the goat sector is not yet significant, but the potential of this small ruminant has been recognized by the Ministry of Agriculture and Rural Development. The Hungarian Central Statistical Office registered 100000 goats in 2002, of which 50000-55000 were ewes. Three imported (Alpine, Saanen, Boer) and four local goat breeds are found on goat farms. The four local breeds are the Hungarian Improved goat, Hungarian Milking White goat, Hungarian Milking Brown goat and the Hungarian Milking Multicolour goat. The last three Hungarian breeds constitute 75% of the total population (Kukovics, 2001).

Traditionally, goat milk is more important than goat meat in Europe. Goat cheese is an emerging product, which is becoming more and more popular with the Hungarian customer. The long term aim is to combine traditional selection methods with marker associated selection (MAS). Genetic variants of goat milk caseins and whey components were published and some of them have a significant impact on milk quality (Grosclaude *et al*., 1987; 1994). The most prominent is caprine αs1- casein. The CSN1S1 locus is characterized by seven alleles associated with at least four quantitative levels of the corresponding protein: strong (A,B,C); intermediate (E); weak (D,F) and null (0) (Grosclaude *et al*., 1987). From this follows that the frequency of the αs1-casein alleles has already been examined in several goat breeds in several countries (Grosclaude *et al*., 1987; Ramunno *et al*., 1991; Jordana *et al*., 1991; Grosclaude *et al*., 1994). It was confirmed that more cheese could be produced from milk (associated with the casein α s1: A, B, C alleles) with a high casein content, but the structure of the cheese made from this high casein type of milk has changed and its aroma was found to be atypical. In France, milk protein polymorphism assays have been adopted since 1996 in selection programmes for dairy goats (Pierre–Quere, 1995).

κ-casein is essential for micelle formation and stabilization, and influences the manufacturing properties of milk. Cheese making is based on the cleavage of the κ-casein Phe-Met peptide bond by enzymes or heat. Recent studies on goat κ-casein showed that the κ-casein gene is highly polymorphic (Caroli *et al*., 2001; Yahyaoui *et al*., 2001; Angiolillo *et al*., 2002; Jann *et al*., 2003). The β-lactoglobulin is the major whey protein in ruminants and is also present in the milk of other mammals but not in the milk of humans and rodents (D'Andrea *et al*., 2001).

The type and frequency of the caprine milk protein alleles have not been studied in Hungary. These initial experiments were performed with the assistance of A. Sanchez and co-workers at Universitat

Peer-reviewed paper: 8th International Conference on Goats

Autonoma de Barcelona, Faculty of Veterinary Medicine, Department of Animal and Food Science, Bellaterra, Spain.

Materials and Methods

Individual blood samples were collected from two herds (Ceglédbercel, Káva). Fifty Hungarian Milking Multicolour goats from Káva, 27 Hungarian Milking Brown goats, 13 Hungarian Milking Multicolour goats and 19 Hungarian Milking White goats from Ceglédbercel were used in the evaluation. The milk protein genotypes of 109 unrelated animals were determined. No differentiation was made between the above mentioned local goat types.

The DNA was isolated by standard methods (Bősze *et al*., 2000). Partial characterization of αs1-, κ-casein and β-lactoglobulin alleles was performed as published by Ramunno *et al*. (1991), Amills *et al*. (1996), Yahyaoui *et al*. (2000) and Yahyaoui *et al*. (2001).

Concurrent with the milk protein genotyping, milk protein, lactose, milk fat concentrations and somatic cell counts were determined on the individual milk samples.

Results and Discussion

For αs1-casein, genotyping was restricted to the E and F alleles, which were found to be the most frequent ones in other breeds. Those alleles have average (E) to low effects (F) on the milk αs1-casein content and have thus a considerable economical impact. The frequencies of αs1-casein E and F alleles were found to be much lower in Hungarian Milking goats compared with the French, Italian, Spanish goats (Table1).

Table 1 Allele frequencies of αs1-casein alleles in Hungarian Milking Goats and in references goats

Breeds (numbers)	A+B+C+D+0 alleles	E allele	F allele	References
Alpine (213)	0.14	0.34	0.41	Grosclaude *et al*.
Alpine (80)	---	0.35	0.59	Ramunno *et al.* (1991)
Saanen (159)	0.07	0.41	0.43	Grosclaude *et al.*
Saanen (70)	0.03	0.46	0.46	Ramunno *et al.* (1991)
Canaria (74)	0.28	0.20	-	Jordana *et a*l. (1991)
Hungarian Milking	0.61	0.08	0.31	

The low frequency of the E allele with an intermediate content of αs1-casein and of the F-allele with a reduced level of αs1-casein in the Hungarian Milking goat are in contrast to the predominance of those two αs1-casein alleles in the milk of Saanen and Alpine breeds. Experiments are in progress to determine the frequencies of the remaining five αs1-casein alleles (A, B, C, D and 0).

Table 2 Comparison of allele frequencies of A+B and C alleles of the κ-casein gene in Hungarian Milking goats and in Spanish and French goats

Breeds (numbers)	A+B alleles	C allele	References
Malaguena (17)	1	0	Yahyaoui *et al*. (2001)
Payoya (11)	1	0	Yahyaoui *et al*. (2001)
Canaria (48)	0.99	0.01	Yahyaoui *et al*. (2001)
Murciano-Granadina (38)	0.99	0.01	Yahyaoui *et al*. (2001)
Saanen (33)	0.89	0.11	Yahyaoui *et al*. (2001)
Hungarian Milking (109)	0.85	0.15	

The method published by Yahyaoui *et al*. (2001) did not enable us to differentiate between the A and B alleles of κ-casein. The frequency of the C allele of κ-casein was almost the same as that in the Hungarian Milking goat, but not to that in the Saanen breed (Table 2.). The impact of the κ-casein allelic variants on milk quality remains to be established.

Table 3 Allele frequencies of -60C and -60T alleles of β-lactoglobulin gene in Hungarian Milking goats and in Spanish goats

Breeds (numbers)	-60C allele	-60T allele	References
Murciano Granadina (69)	0.86	0.14	Yahyaoui *et al*. (2000)
Canaria (42)	1	-	Yahyaoui *et al.* (2000)
Payoya (11)	0.73	0.27	Yahyaoui *et al.* (2000)
Malaguena (18)	0.75	0.25	Yahyaoui *et al*. (2000)
Saanen (20)	0.73	0.27	Yahyaoui *et al*. (2000)
Hungarian Milking (109)	0.88	0.12	

Up to date 109 Hungarian Milking goats have been genotyped for β-lactoglobulin promoter polymorphism, based on the method published by Yahyaoui *et al*. (2000). The frequency of the -60T allele of β-lactoglobulin gene was found to be lower in the Hungarian Milking goat than in the Saanen breed (Table 3). The influence of the promoter polymorhism on β-lactoglobulin gene expression levels has to be evaluated.

Conclusions

The limited number of animals and restricted methods applied so far did not enable us to draw firm conclusions. We are planning to evaluate the CSN1S2 and CSN2 alleles and extend the characterization for all known CSN1 and CSN3 alleles in order to determine the casein haplotypes in the predominant Hungarian Milking goat breed. The direct relationship between the allelic variants of CSN1S1, CSN1S2 and CSN2 genes and casein content, which further influence the physico-chemical properties of milk, could be utilized in breeding schemes aiming at the improvement of milk processing quality and cheese yields of the Hungarian Milking goat breeds.

Acknowledgements

The authors would like to thank the farmers for their collaboration. This work was supported by the Spanish –Hungarian Grant E21/2001.

References

Angiolillo, A., Yahyaoui, M.H., Sanchez, A., Pilla, F. & Folch, J.M., 2002. Short communication: Characterization of a new genetic variant in the Caprine kappa-casein gene. J. Dairy Sci. 85, 2679-2680.

Angulo, C., Diaz-Carillo, E., Munoz, A., Alonso, A., Jimenez, I. & Serradilla, J.M., 1994. Effect of electrophoretic goat's κ-casein polymorphism on milk yield and main components yield. V World Congress on Genetic Applied to Livestock Production, Guelph 19. 333-336.

Amills, M., Francino, O. & Sanchez, A., 1996. Vet. Immunol. and Immunopath. 55, 255-260.

Bősze, Z., Hiripi, L., Virág, G., Toth, S., Makovic, S., Fontaine, M.L. & Devinoy, E., 2000. Polymorphism of the rabbit kappa casein gene and its influence on performance traits. Pflügers Arch. 439 (3 Suppl): R2-3.

Caroli, A., Jann, O., Budelli, E., Bolla, P., Jager, S. & Erhardt, G., 2001. Anim. Genet. 32, 226-230.

D'Andrea, M., Graziano, M., Angiolillo, A., Lagonigro, R. & Pilla, F., 2001. A new genetic polymorphism in the goat β-lactoglobulin promoter region. Proc. XLV Italian Society of Agricultural Genetics-SIGA Annual Congress Salsomaggiore terme, Italy- 26/29 September, 2001.

Folch, J.M., Coll, A. & Sanchez, A., 1994. Complete sequence of the caprine β-lactoglobulin gene. J. Dairy Sci. 77, 3493-3497.

Grosclaude, F., Mahé, M.F., Brignon, G., di Stasio, L. & Juenet, R., 1987. A Mendelian polymorphism underlying quantitative variation of goat αs1- casein. Genet. Sel. Evol. 19, 399-412.

Grosclaude, F., Ricordeau, G., Martin, P., Remeuf, F., Vassal, L. & Bouliion, J., 1994. From gene to cheese: the polymorphism of the caprine αs1- casein, its effects and evolution. INRA Prod. Anim. 7, 3-19.

Grosclaude, F. & Marin, P., 1997. Casein polymorphisms in the goat. pp. 241–253.

Jann, O., Prizenberg, E.M., Luikart, G., Caroli, A. & Erhardt, G., 2003 (Submitted).

Jordana, J., Sanchez, A., Jansa, M., Mahé, M. & Grosclaude, F., 1991. Inf. Tec. Econ. Agrar. 11. 598.

Kukovics, S., 2001. A kecske és a CAE vírus; Magyar mezőgazdaság melléklete, Magyar Juhászat 2001/9; 10 évf 4-5.

Pierre, A. & Quere, J.L., 1995. Cheese from goats milk with or without αs1- casein. Proc. Intern. Dairy Fed. Seminar on production and utilisation of ewes and goats milk, Limin- hersonissos, Crete, Greece, 19-21. October, 20.

Ramunno, L., Rando, A., DiGregorio, P., Massari, M., Blassi, M. & Masina, P., 1991. Structura genetica di alcune populazioni caprine allevate in Italian a locus della caseina αs1. Proc. IX. Congress NazASPA, Milan, 28-29. September, 579 p.

Yahyaoui, M.H., Coll, A., Sanchez, A. & Folch, J.M., 2001. Genetic polymophism of the caprine kappa casein gene. J. Dairy Res. 68, 209-216.

Yahyaoui, M.H., Pena, R.N., Sanchez, A. & Folch, J.M., 2000. Polymorphism in the goat β-lactoglobulin proximal promoter region. J. Anim. Sci. 78, 1100-1101.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Genetic variation of three commercial and three indigenous goat populations in South Africa

C. Visser[1], C.A. Hefer[1], E. van Marle-Köster[1#] and A. Kotze[2]
[1]Department of Animal & Wildlife Sciences, University of Pretoria, Pretoria 0002, South Africa
[2]ARC-AII, Private Bag X2, Irene 0062, South Africa

Abstract

Three commercial and three indigenous goat populations from South Africa were studied for genetic variation using ten microsatellite markers. Heterozygosity values of between 0.62 and 0.69 were obtained for the populations, except for the SA Boer Goat, which had the lowest variation (0.49). Genetic differentiation using FST values indicated a clear genetic differentiation between the SA Boer Goat and the Kalahari Red population (0.283), while only moderate genetic differentiation was observed among the other populations. This data forms part of an extensive study on the genetic characterization of South African goat populations and additional makers are being tested on more samples to determine phylogenetic relationships.

Keywords: Indigenous and commercial goats, microsatellite markers, genetic diversity
#Corresponding author. E-mail: evm.koster@up.ac.za

Introduction

Primarily three commercial breeds, the South African Boer Goat, Kalahari Red and Savanna goat, dominate the meat-producing goat industry in South Africa. These breeds are believed to originate from indigenous goat types found in South Africa (Ramsey *et al.,* 2000). Although these breeds as well as the local goat populations have been classified as separate breeds on phenotypic traits, allelic diversity and genetic relationships are unknown. Over the last thirty years, genetic improvement of agricultural species has accelerated at a staggering rate. As the profitability of these improved breeds become apparent, the traditional ways of farming are abandoned as too risky (Wollny, 2003). The replacement and uncontrolled crossbreeding of indigenous animals with "improved" breeds may lead to the replacement of indigenous populations and the subsequent loss of their unique genetic traits. South Africa has several indigenous goat populations associated with different geographical areas and genetic data on these populations are non-existent. A project was established in collaboration with the ARC AII (Irene) to study the genetic biodiversity of goat populations in South Africa. This is the first attempt to study genetic variation of both commercial and indigenous goats of South Africa, using DNA marker technology.

Materials and Methods

For this paper data of three commercial breeds (SA Boer Goat, Kalahari Red and Savanna) as well as three indigenous populations representing three different climatic regions (Eastern Cape, Mpumalanga and Northern Province) in South Africa were included. The SA Boer Goat, which is the main meat producing goat, originates from indigenous goats kept by farmers during the 1920's in the Eastern Cape. These goats were selected for adaptability, carcass quality, excellent conformation and distinctive red head and white body (http://www.dnafrica.co.za/boergoat.htm). The Savanna goat developed from the indigenous white goat stud of Messrs Cilliers and Sons, which was started in 1957 from a mixture of coloured indigenous ewes and a white ram (http://www.dnafrica.co.za/savanna). South African and Namibian farmers have collected red goats for the past 25 to 30 years and have specifically selected for the red colour, which resulted in a new breed known as the Kalahari Red. The breed was developed from mainly African types of red and speckled goats (http://www.dnafrica.co.za/k-red). The goats are evenly pigmented, and have a natural resistance against heat and the sun. The indigenous goat populations in South Africa exhibit quite distinct phenotypic variation in their size, and other conformation traits such as horns and ears. Breeds are not defined and are usually associated with specific areas, i.e. Venda and Lebowa goats. The indigenous populations included in this paper are firstly a population kept at Fort Hare University in the Eastern Cape, consisting of local, unimproved Boer Goat types. A second population kept at Delftzyl farm (a former experimental unit in the Northern Province) consists of local types, while a third population from Groblersdal (Mpumalanga) represents goats from local communities.

Peer-reviewed paper: 8th International Conference on Goats

Blood samples were collected from between 30 and 100 non-related animals per population. For the purpose of this study, 30 individuals per population were analyzed. After collection, the blood samples were frozen in Eppendorf tubes and kept at –70 °C until extraction was done using a Qiagen DNAeasy Tissue Kit. The DNA was quantitated by spectrophotometry and diluted to a final concentration of 50 ng/µL.

A total of 10 microsatellite markers was selected, based on the degree of polymorphism and genome coverage. Markers were selected from the ISAG and FAO recommended lists in order to compare results with global goat diversity studies. Microsatellite markers were optimised for PCR, multiplexed and PCR products analyzed on an ABI 377 sequencer and Genescan version 2.0 and Genotyper for MacIntosch were used to determine the fragment sizes. Statistical analyses were performed using Genepop (Raymond & Rousset, 1995), Arlequin (http://lgb.unige.ch/arlequin/) and Genetix (Belkhir *et al.,* 1996).

Results and Discussion

All ten microsatellite markers were found to be highly polymorphic, with the number of different alleles per marker varying from seven to 14 over all the populations studied. The heterozygosity (Hz) values per population are indicated in Table 1. Except for the Boer goats (0.49), which showed the lowest Hz, the other populations were fairly similar, ranging from 0.63 to 0.69. Similar Hz values using microsatellite markers in diversity studies in goats have been reported (Barker *et al.,* 2001; Li *et al.*, 2002; Kott *et al.,* 2003).

Table 1 Heterozygosity (Hz) values (Unbiased and observed (Obs)), with standard deviations (SD) for the six goat populations typed with 10 loci

Population	Loci typed	Unbiased Hz	Unbiased Hz SD	Obs Hz	Obs Hz SD
A (Groblersdal	10	0.6400	0.0466	0.6731	0.0272
BB (Boergoat)	10	0.4924	0.0602	0.4661	0.0295
D (Delftzyl)	9	0.6993	0.0451	0.6311	0.0304
J (Fort hare)	10	0.6981	0.0341	0.6448	0.0281
S (Savanna)	10	0.6238	0.0376	0.5838	0.0301
G (Kalahari Red)	10	0.6394	0.0452	0.6247	0.0245

Genetic differentiation was described using FST values (table not shown), which indicated a clear genetic differentiation between the SA Boer Goat and the Kalahari Red population (0.283). Moderate genetic differentiation occurred between populations A and J (0.11), D and J (0.098), A and S (0.095), D and S (0.12), J and S (0.14), with the least differentiation between populations A and D (0.085). The Kalahari Red (G) showed genetic differentiation with all other populations. Figure 1 is a graphical representation of the factorial correspondence analysis using GENETIX (Belkhir *et al.*, 1996), which also illustrates the genetic differentiation between the populations in the study, as well as a clear genetic differentiation of the G population from the other populations.

The results indicate a relatively high genetic variation in the different populations sampled, except for the SA Boer Goat. This is expected as the SA Boer Goat is the oldest of all the breeds and has been subjected to artificial selection for various traits since the late fifties. Genetic differentiation among these populations described by both FST values (Hartl, 1998) and factorial correspondence analyses (Belkhir *et al.*, 1996) indicate that the Boer Goat, Savanna and the Fort Hare population, which mainly consists of Boer Goats populations, have genetic similarities, while the Kalahari Red goats are the most different in genetic composition compared to the other populations. Although the Savanna goat is defined as a breed with specific characteristics, it seems that they are genetically closer to the Boer goat than previously thought. The Delftzyl was an experimental population with indigenous types and shows some differentiation. The Kalahari Reds were developed from Namibian and South African indigenous types and seem to be quite different from the others with the markers tested.

Conclusion

Microsatellite markers were found useful and informative for studying genetic diversity in goats. There is sufficient genetic variation within the populations, with a distinct genetic differentiation between the

Kalahari Red and other populations tested. Additional markers are being tested in order to complete the genetic characterization and determine phylogenetic relationships.

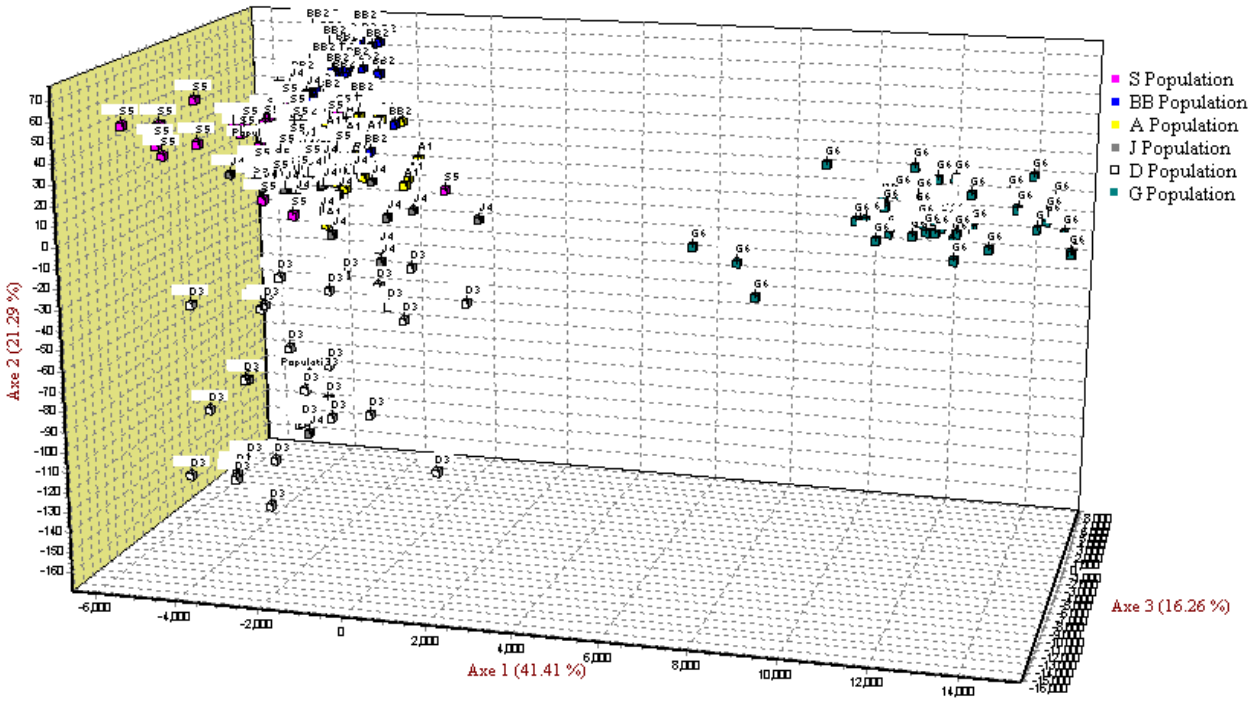


Figure 1 Factorial correspondence analysis of all the individuals in the study

References

Barker, J.S.F, Tan, S.G., Moore, S.S, Mukherjee, T.K., Matherson, J.L. & Selvaraj, O.S., 2001. Genetic variation within and relationships among populations of Asian goats (*Capra hircus*). J. Anim. Breed. Genet. 118, 213-233.

Belkhir, K., Borsa, P., Chikhi, L., Raufaste, N. & Bonhomme F., 1996. GENETIX 4.04, Logiciel sous Windows TM pour la génétique des populations. Laboratoire Génome, Populations, Interactions, CNRS UMR 5000, Université de Montpellier II, Montpellier (France). http://www.univ-montp2.fr/~genetix/genetix/constr.htm#download

Hartl, D.L., 1988. A primer for population genetics, second edition. Sinauer Associates, Inc., Sunderland, Mass. 01375,USA. ISBN 1-87893-301-8.

Kott, O.M.J.T., Kottová, B. & Czerneková, V., 2003. Seven microsatellite markers useful for determining genetic variability in White and Brown Short-haired goat breeds. Article in press: online Small Rum. Res. 4 Sept. 2003.

Li, M., Zhao, S., Bian, C., Wang, H.S., Liu, B., Yu, M., Fan, B., Chen, S., Zhu, M., Li, S., Xiong, T. & Li, K., 2002. Genetic relationships among twelve Chinese indigenous goat populations based on microsatellite analysis. Genet. Sel. Evol. 34, 729 -744.

Ramsey, K., Harris, L. & Kotze, A., 2000. Landrace Breeds: South Africa's indigenous and locally developed farm animals. Eds. Ramsey, K., Harris, L. & Kotzé, A., Farm Animal Conservation Trust, Pretoria.

Raymond, M. & Rousset, F., 1995. GENEPOP (version 1.2): Population genetics software for exact tests and ecumenicism. J. Hered. 86, 248-249. http://www.cefe.cnrs-mop.fr/wwwsite/default-English.htm

Wollny, C.B.A., 2003. The need to conserve animal genetic resources in Africa. Ecological economics 45, 341-351.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Ethno-veterinary practices and its scientific relevance in treatment of goats in Rajasthan

N. K. Barhat#, C. K. Murdia, Sheela Choudhary and Ajay Goswami
College of Veterinary and Animal Science, Bikaner, India-334001

Abstract

The ethno-veterinary practices used by a random sample of 210 goat farmers of three villages of Bikaner district of Rajasthan were assessed. Four clinical experts scientifically evaluated a total of 85 ethno-veterinary practices used to treat 18 diseases. Evaluation scores were on a continuous scale between -1 to 2 : contradiction as -1, irrelevant as 0, partially relevant as 1 and relevant as 2. The recovery claims of the farmers and scientific relevance were estimated for each practice. The classification revealed that 11.76% practices were contradictory, 12.95% were irrelevant, 27.06% were partially relevant and 24.70% were relevant. It was concluded that relevant practices should be evaluated pharmacologically and the clinical trials should be conducted before recommending it for the large-scale use.

Key words: Goat disease, ethno-veterinary practices and scientific relevance
#Corresponding author; E-mail: nkbarhat@yahoo.com

Introduction

Domestication of livestock was done with objectives such as food security, transportation and cultural or religious practices. Livestock were kept healthy and productive by treating with home remedies, surgical and manipulative techniques along with the application of magic, rituals and religion. The combined applications of these are known as ethno-veterinary practices (McCorkle, 1995). The meaning of the prefix "ethno" means traditional or indigenous. These practices depend on culture, custom and heritage of the society and vary not only among the nations but also within the state or region. Such practices pass on from one generation to the next on a verbal or hearsay basis and sometimes they are quite effective in the treatment of diseases and improvement of livestock production. The cost-efficacy, as well as the availability of modern veterinary drugs and treatment facilities is the principal reasons for the continued use of the ethno-veterinary practices in the rural areas of Rajasthan. They are cheap, easily available and usually safe for the livestock. There is a great danger these practices could be lost because of poor documentation and rational evaluation on scientific grounds. Hence efforts have been made to document the ethno-veterinary practices used in the treatment of goats in three villages in the Bikaner district of Rajasthan and assess their relevance through evaluation by veterinary clinical experts. A scientific relevance score (Dinesh Kumar, 2000) was used to evaluate ethno-veterinary practices used for the treatment of 18 goat diseases. It was found that approximately one quarter of treatments were irrelevant, approximately half could have had some beneficial result and only one quarter of treatments used would have been effective. It was suggested that pharmacological investigation and clinical trials should be done on those remedies with a score of 1.5 and above.

Materials and Methods

The study was conducted in three villages of Bikaner district. The survey was conducted on the use of ethno-veterinary practices and their effects in terms of results obtained by the farmers. In all 210 farmers were contacted and four Faculty members with clinical veterinary expertise evaluated the information gathered. The magical and religious aspects were not considered in this study. To assess scientific relevance the veterinary clinicians were asked to rank the ethno-veterinary practice on a continuous scale between –1 to +2. The scores were: contradictory as –1, irrelevant as 0, partially relevant as 1 and relevant as 2. The scoring method is an improvement of Dinesh Kumar (2002) where the negative score was not used. The average of the scores of the four was taken as a final score.

Peer-reviewed paper: 8th International Conference on Goats

Results and Discussion

Ethno-veterinary practices for the treatment of 18 diseases in goats were studied. The results obtained are presented in Table 1. It was observed that 85 ethno-veterinary practices were used by the goat breeders of the rural areas for the treatment of the 18 diseases. The percentage recovery claimed by the farmers ranged from 5 to 90 percent. Calculation of the relevant score revealed that ten practices (11.76%) were totally contradicted for treatment of the particular disease in which they were given and could have affected the goats adversely. The relevance score was 0 in 11 practices (12.95%). Hence it is evident that about one quarter of the practices were either contradictory or had no relevance which is of great concern.

In 23 of the practices (27.06%) the score was 0-0.5 and in 21 practices (24.70%) the score was 0.5 to 1.0. It can be inferred that half of the practices used by the goat breeders were slightly beneficial but not harmful. However; Dinesh Kumar (2002) observed 15% ethno-veterinary practices to be of relevance in sheep.

In 18 of the practices (21.18%) the score was 1-1.5 indicating that these practices were considered to be beneficial. The remaining two practices (2.35%) of giving asafetida and sesame oil in tympany bishop's weed and sodium bi carbonate in colic were highly beneficial. The pharmacological identification, testing and improvement of these effective ethno-veterinary practices should be given high priority.

Table 1 Scientific relevance score of best three ethno-veterinary practices of goat breeders

N	DISEASE AND ETHNO-VETERINARY PRACTICE	R.C.(%)	R.S.
1.	**Diarrhoea:** Tie up the tail	20	0
	Left over rice starch after cooking 250gms for 2 days	70-90	1.5
	Bajra flour 50 gms cooked paste with 100 ml whey, 3 days	70	0.75
	Opium 5 gms.1-2 days	50-60	1.375
2.	**Indigestion:** 25gms. Bishop's weed (Carum Ccopticum)+ 100 gms Jaggary 3-5 days	70	1.0
	100gms Kachari (Cucumis callosus) +50-100gmsJaggary,2d.	80	0.625
	20g.Black salt +100g. Bishop's weed (Carum Ccopticum) 3d.	50-90	1.375
3.	**Tympany or bloat:** Inhalation of Kerosene TID	70-80	1.375
	Mustard oil,50-100 ml TID	80-85	1.125
	100g.Kachari (Cucumis callosus) +250 ml. Whey +20g salt 2 days	70	1.375
	10g. Asafetida +250ml Til oil BID	80-90	1.875
4.	**Colic:** Bishop's weed (Carum Ccopticum) + Methi, 100g each 3d	50-60	1.25
	50g.Bishop's weed (Carum Ccopticum) + 50g.Sodium bi carbonate 2d	70-80	1.625
	50g Bishop's weed (Carum Ccopticum) + 20g black salt, 3d	80-90	1.125
5.	**Fever:** Ginger + Black pepper + Asafetida, 30-50 gms. each for 3 days	60	0.25
	Ginger +Black pepper +Turmeric(Curcuma longa)30-50 gms. 3 days	60	0.25
	30g Ginger + 100gJaggery +30g Turmeric (Curcuma longa),2-3d.	60-70	0.25
6.	**Pneumonia:** Bishop's weed + Jaggery 50g.each, 3 days	70	0
	50gBishop's weed + 50g.Jaggery +100 ml Wine, 2 days	70	0.25
	50g Ginger +30g. Black pepper in hot water for 3 days	70	0.875
7.	**Abortion:** 100g Jaggery + 200ml Til oil 3 days	60	0.75
	100g Turmeric (Curcuma longa) + 100ml Til oil, 3 days	70	0.5
	50g Turmeric +100ml Til oil +50g Bishop's weed, 5 days	80-85	0.5
8.	**Mange:** Massage by banana oil for 3-5 days	70-80	0.25
	Massage by coconut oil 3-4 days	80-85	1
	Coconut oil + camphor, 7 days	90	1.375
9.	**Retention of placenta:** Boiled Jaggery 100-150 ml, TID	70-80	0.375
	50g Bishop's weed + 100g Jaggery, TID	50	1.25
	Boiled bamboo + 100g Jaggery,BD	50	0.375
10	**Inflammation of uterus:** Drinking cold water	30	0
	Fomentation by cold water / uterine douche	40	0.5

Peer-reviewed paper: 8th International Conference on Goats

11	**Wound:** Bandage by Turmeric (Curcuma longa) + Til oil	80-85	1.5
	Ointment of turmeric and salt	80-85	1.25
	Butter oil + Turmeric	70-80	1.25
12	**Lameness:** Drinking 10 gms Turmeric with water.	60-70	1.0
13	**Facture of bone:** Bandage by turmeric and Til oil	60-70	1.125
	Drinking of turmeric and egg for 7 days	60-65	1.0
	Drinking of turmeric + egg +Oil + Milk	70-80	1.375
14	**Ecthyma:** Apply paste of Whey +salt + Oil	50-60	0.875
	Apply paste of turmeric, salt and curd	50-60	0.75
	Butter oil + Turmeric	60-70	1.25
15	**Mastitis:** Hot fomentation for 3-4 days	20	0.25
	Spray goat's milk on fire and expose its warmth on teats	20	-0.125
	Firing	10	0.125
16	**Conjunctivitis:** Spitting in the eye for 3 days	20	-0.125
	Ash of Millet	10	-0.25
	Alum + Salt	15	-0.75
17	**Foot rot:** Alum	70	1.375
	Warm oil	60-70	1.25
18	**Pox:** Firing	20	-1.0

R.C.=Recovery claimed by the farmer, R. S. = Relevance score given by the clinical scientist

Conclusions

The scientific basis for ethno-veterinary practices used by goat farmers in rural areas of Rajasthan is not yet well understood. It is thus recommended that for the practices where the score was 1.5 and above, the remedies should be pharmacologically evaluated and clinical trials should be undertaken before recommending them for large-scale use.

References

McCorkle, C.M., 1995. Back to the future, Lessons from ethno-veterinary R. D. & E. for studding and applying local knowledge. Agriculture and human values 12, 52-80

Dinesh Kumar, 2000. An approach for short-listing various ethno-veterinary practices. Compendium of abstracts; 1st Annual Conference of Indian Society of Veterinary Pharmacology and Toxicology, PAU Ludhiana, Punjab pp18.

Dinesh Kumar, 2002. The use and relevance of Ethno-veterinary practices in sheep. Ind. J. small Rum. 18(2), 124-128

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Seasonal variation of goat milk composition and somatic cell count in the Southeastern region of Brazil

C.H.P.Borges[1#], P.R.C.Cordeiro[2] and S.Bresslau[2]
[1]UCB - Rio de Janeiro - RJ - Brazil and FESO - Teresópolis - RJ - Brazil
[2]CCA Laticínios - Av. Antônio Mário de Azevedo, 2.143 - Nova Friburgo - RJ 28630-590 – Brazil

Abstract

Consistent information on goat milk composition and its year-round variation is limited in Brazil. In order to study these variations and provide dairy companies with useful information, bulk tank goat milk samples were collected on a weekly basis between August 2000 and December 2003 from 16 goat farms that supplied 2.96 millions liters of goat milk to a dairy company in southeastern Brazil. A total of 2.020 milk samples were analyzed for percentages of fat, protein, lactose, total solids and somatic cell count (SCC). It was found that composition and SCC varied widely according to season of the year and stage of lactation. Fat concentration increased to peak values of 3.79% in August and decreased to 3.07% in March, with mean level of 3.41%. Protein increased to 3.12% in May and decreased to 2.81% in December, with mean level of 2.98%. Lactose increased to 4.61% in August and decreased to 4.22% in February, with mean level of 4.42%. Total solids increased to 12.32% in August and decreased to 11.08% in January, with mean level of 11.67%. SCC increased to 1.24 X 10^6 ml^{-1} in April and decreased to 0.75 X 10^6 ml^{-1} in September, with median level of 0.94 X 10^6 ml^{-1}.

Keywords: goat milk, seasonal variation, composition, somatic cell count.
[#]Corresponding author; E-mail: chpizarro@terra.com.br.

Introduction

The Brazilian goat milk business has been growing rapidly for the past few years, especially in the southeastern region. Nowadays the goat milk industry and producers are concerned in marketing a uniform product both in composition and functional properties. Payment policies based on goat milk quality standards have also been a major subject. Determining accurate milk pricing formulas depends on the knowledge of goat milk composition and its year-round variation (Jenot *et al.*, 2000). However, consistent information based on goat farms with different management conditions and locations are limited in Brazil. Some research has been done on gross milk composition from small herds on individual farms (Barros & Leitão, 1992; Guimarães, 1993; Bonassi *et al.*, 1997; Ribeiro *et al.*, 1997) but little has been done to investigate the seasonal variation of commercial bulk tank goat milk used in industrial milk and cheese plants (Borges *et al.*, 1997; Souza *et al.*, 2002).

The objectives of the current study were to investigate monthly variations in the composition and SCC of bulk tank goat milk in southeastern Brazil and provide consistent information to the goat milk industry to design strategies to reduce variability in dairy products composition and develop accurate milk pricing formulas.

Materials and Methods

Bulk tank goat milk samples were collected on a weekly basis between August 2000 and December 2003 from 16 goat farms located in the southeastern region of Brazil (Rio de Janeiro and Minas Gerais States), that supplied 2.96 millions liters to CCA Laticínios, a local dairy goat company. During tanker truck loading, samples of 70 mL of commingled goat milk from six to ten consecutive milkings were collected from the bulk tank of each farm after five minutes of homogenization and were preserved with bronopol until processing. Samples were analyzed at EMBRAPA Milk Quality Laboratory, Juiz de Fora, MG, Brazil, for percentages of fat, protein, lactose, total solids using Bentley 2000 equipment and somatic cell count (SCC) using Bentley Somacount 300 equipment. The SCC, fat and protein values were corrected according to Zeng (1996) since equipments were calibrated with cow milk standards. The goats raised in the 16 farms were purebreds or

Peer-reviewed paper: 8th International Conference on Goats

crossbreds Saanen, French Alpine or Toggenburg dairy goats. Data were analyzed using the general linear model procedure of Statistical Analysis System (SAS) to evaluate changes over time.

Results and Discussion

A total of 2.020 bulk tank goat milk samples were analyzed between August 2000 and December 2003. The results, sorted by month of the year, are shown in Table 1 and Figures 1, 2, 3 and 4.

Table 1 Percentages of components and somatic cell count (SCC) of 2.020 bulk tank goat milk samples analyzed between August 2000 and December 2003 in southeastern Brazil acording to months of the year.

Months	Samples	Milk supplied (L)	Fat[1] (%)	Protein[1] (%)	Lactose[1] (%)	Total Solids[1] (%)	SCC[2] (X 10^6 ml^{-1})
January	210	251.024	$3.13^{ab} \pm 0.37$	$2.86^{b} \pm 0.23$	$4.27^{b} \pm 0.15$	$11.08^{a} \pm 0.55$	0.95
February	129	191.493	$3.27^{cd} \pm 0.41$	$2.89^{b} \pm 0.21$	$4.22^{a} \pm 0.14$	$11.22^{b} \pm 0.55$	0.98
March	115	178.861	$3.07^{a} \pm 0.38$	$3.02^{de} \pm 0.26$	$4.32^{c} \pm 0.11$	$11.24^{b} \pm 0.62$	1.08
April	150	196.866	$3.36^{de} \pm 0.40$	$3.05^{e} \pm 0.22$	$4.38^{d} \pm 0.13$	$11.64^{cd} \pm 0.62$	1.24
May	128	156.670	$3.61^{f} \pm 0.46$	$3.12^{g} \pm 0.23$	$4.52^{h} \pm 0.13$	$12.12^{e} \pm 0.63$	1.06
June	111	146.404	$3.61^{f} \pm 0.48$	$3.11^{fg} \pm 0.29$	$4.44^{efg} \pm 0.22$	$11.99^{e} \pm 0.75$	0.94
July	130	150.550	$3.63^{f} \pm 0.48$	$3.05^{ef} \pm 0.25$	$4.55^{h} \pm 0.14$	$12.05^{e} \pm 0.73$	0.94
August	165	275.175	$3.79^{g} \pm 0.32$	$3.01^{de} \pm 0.24$	$4.61^{i} \pm 0.13$	$12.32^{f} \pm 0.61$	0.86
September	236	316.170	$3.63^{f} \pm 0.46$	$2.99^{d} \pm 0.21$	$4.48^{g} \pm 0.13$	$12.02^{e} \pm 0.60$	0.75
October	238	360.359	$3.37^{e} \pm 0.45$	$2.94^{c} \pm 0.21$	$4.40^{de} \pm 0.16$	$11.65^{d} \pm 0.65$	0.80
November	213	378.277	$3.29^{de} \pm 0.45$	$2.89^{b} \pm 0.22$	$4.45^{fg} \pm 0.27$	$11.50^{c} \pm 0.86$	0.77
December	195	357.490	$3.19^{bc} \pm 0.35$	$2.81^{a} \pm 0.19$	$4.42^{ef} \pm 0.16$	$11.28^{b} \pm 0.49$	0.92
Total	2020	2959.339	3.41 ± 0.42	2.98 ± 0.23	4.42 ± 0.16	11.67 ± 0.64	0.94

[1] Mean (± standard deviation); [2] Median; ^{a,b,c,d,e,f,g,h,i} Column means with common superscripts do not differ (P > 0.05).

The composition and SCC of bulk tank goat milk varied widely according to two main factors: firstly, the seasonal reproduction pattern of dairy goat breeds usually raised in southeastern Brazil, with the majority of the does breeding in March-April, freshening in August-September, reaching peak production in October-November and drying off in May-June; and secondly, environmental factors such as heat stress during late spring and summer months (November-March). These factors are also mentioned by Barros & Leitão (1992), Guimarães (1993), Bonassi *et al.* (1997), Borges *et al.* (1997) and Ribeiro *et al.* (1997) in Brazil; Brendehaug & Abrahamsen (1986) in Norway; Espie & Mullan (1990) in Ireland; Zeng & Escobar (1995) and Guo *et al.* (2001) in the United States and Jenot *et al.* (2000) in France.

Although off-season breeding practices were adopted on some of the farms, assuring milk shipments throughout the year, the milk supply was seasonal with a peak to trough ratio of 2.6:1 (November:June) (Table 1 and Figure 1). Borges *et al.* (1997) also measured a ratio of 2:1 (December:June) for bulk-collected goat milk delivered to a commercial cheese company in Nova Friburgo, RJ, Brazil.

Fat, protein, lactose and total solids showed the same pattern of seasonal variation. Higher values were observed in late autumn and winter months (May-September) with the majority of the does in late or early lactation and lowest values were observed in late spring and summer months (November-March) when the the majority of the does are in mid-lactation. Fat concentration increased to peak values of 3.79% in August and decreased to 3.07% in March, remaining under the mean level of 3.41% between October and April (Table 1 and Figure 2). Protein concentration increased to peak values of 3.12% in May and decreased to 2.81% in December, remaining under the mean level of 2.98% between October and February (Table 1 and Figure 2). Lactose concentration increased to peak values of 4.61% in August and decreased to 4.22% in February, remaining under the mean level of 4.42% between October and April (Table 1 and Figure 2). Total solids concentration increased to peak values of 12.32% in August and decreased to 11.08% in January, remaining under the mean level of 11.67% between October and April (Table 1 and Figure 3).

SCC increased to peak values of 1.24 X 10^6 ml^{-1} in April during the breeding season of the majority of the does and decreased to 0.75 X 10^6 ml^{-1} in September, remaining under the median level of 0.94 X 10^6 ml^{-1} between August and December (Table 1 and Figure 4). These results support the findings of McDougall & Voermans (2002) indicating that estrus resulted in an increase in SCC.

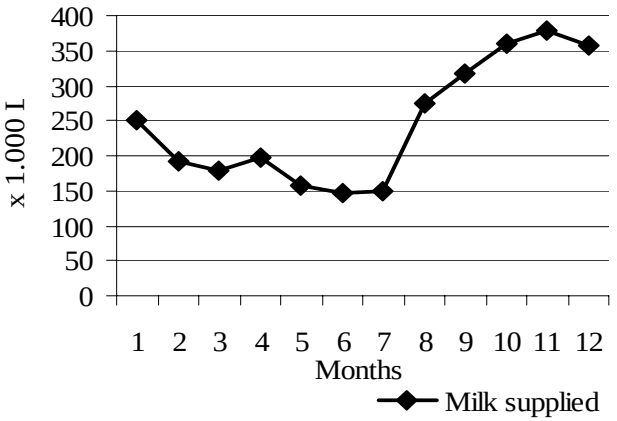


Figure 1 Monthly variation of the total milk supplied.

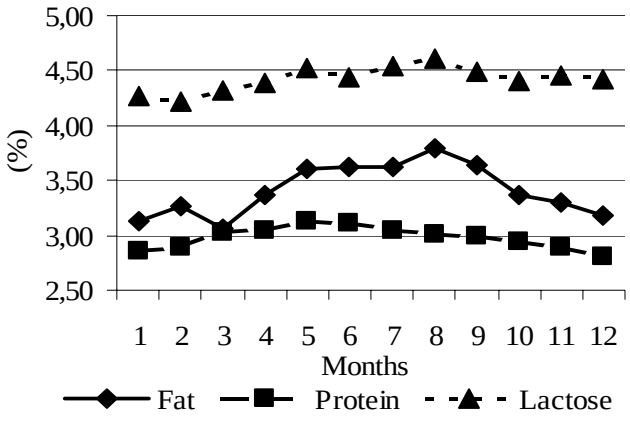


Figure 2 Mean monthly variation in the percentage of fat, protein and lactose.

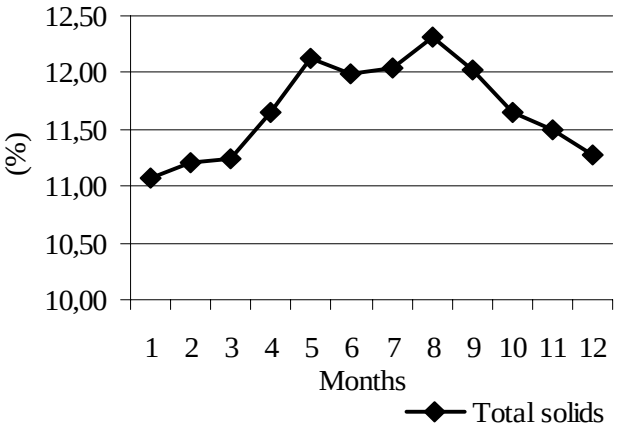


Figure 3 Mean monthly variation in the percentage of total solids.

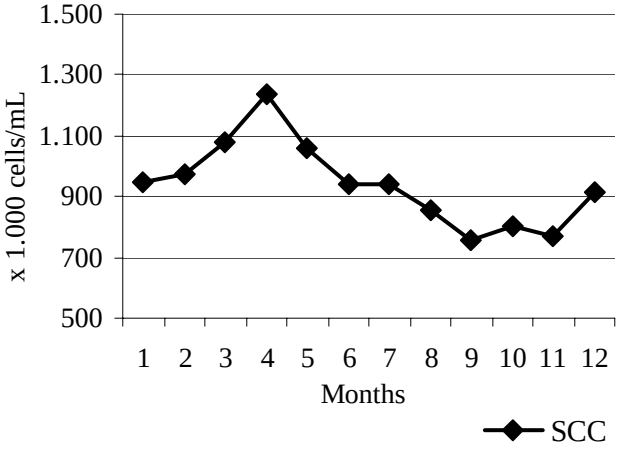


Figure 4 Median monthly variation in the somatic cell count (SCC).

Conclusions

The results indicated that the composition and SCC varied widely during the year according to season and stage of lactation. Due to the consistency of the samples analyzed, the goat milk industry of southeastern Brazil can rely on these results to design strategies to reduce variability in dairy products composition and develop accurate milk pricing formulas.

Peer-reviewed paper: 8th International Conference on Goats

References

Barros, G.C. & Leitão, C.H.S., 1992. Influence of mastitis on the physic-chemical features of goat's milk. Pesq. Vet. Bras. 12, 45-48.

Bonassi, I.A., Martins, D. & Roça, R.O., 1997. Chemical composition and physic-chemical properties of goat's milk in Brazil. Ciênc. Tecnol. Aliment. 17, 57-63.

Borges, C.H.P., Bresslau, S. & Cordeiro, P.R.C., 1997. Características físico-químicas do leite de cabra recebido na Queijaria Escola de Nova Friburgo, RJ. Proc. 25th Brazilian Congress on Veterinary Medicine, Gramado, RS, Brazil, pp. 271.

Brendehaug, J. & Abrahamsen, R. K., 1986. Chemical composition from a herd of Norwegian goats. J. Dairy Res. 53, 211-221.

Espie, W.E. & Mullan, W.M.A., 1990. Compositional aspects of goat's milk in Northern Ireland. Milchwissenschaft 45, 361-362.

Jenot, F. *et al*., 2000. Les taux du lait de chèvres et leur variation. L'Eleveur de chèvres 7, 12-15.

Guimarães, M.P.S.L.M., 1993. Avaliação da estabilidade físico-química do leite caprino congelado durante a estocagem comercial. MSc (Vet) thesis, Federal University of Minas Gerais, Brazil.

Guo, M.R., Dixon, P.H., Park, Y.W., Gilmore, J.A. & Kindstedt, P.S., 2001. Seasonal changes in the chemical composition of commingled goat milk. J. Dairy Sci. 84(E.Suppl.), E79-E83.

McDougall, S. & Voermans, M., 2002. Influence of estrus on somatic cell count in dairy goats. J. Dairy Sci. 85, 378-383.

Ribeiro, A.C. *et al*., 1997. Variation in goat milk composition along of the year in a herd of Brazilian southest. Proc. 34th Brazilian Animal Science Society Meeting, Juiz de Fora, MG, Brazil, pp. 331-333.

Souza, G.N., Cordeiro, P.R.C., Borges, C.H.P., Bresslau, S., Bastos, R.R, Brito, M.A.V.P. & Brito, J.R.F., 2002. Evaluation of milk quality of dairy goat herds in southeast Brazil. Proc 2nd Panamerican Congress on Milk Quality and Mastitis Control, Ribeirão Preto, SP, Brazil, pp.82.

Zeng, S. S., 1996. Comparison of goat milk standards with cow milk standards for analyses of somatic cell count, fat and protein in goat milk. Small Rumin. Res. 21, 221-225.

Zeng, S.S. & Escobar, E.N., 1995. Effect of parity and milk production on somatic cell count, standard plate count and composition of goat milk. Small Rumin. Res. 17, 269-274.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Goats in South Africa: a significant role player?

E van Marle-Köster#, C Visser and N H Casey
Department of Animal & Wildlife Sciences, University of Pretoria, Pretoria, South Africa

Abstract

Goats play an important role in both commercial livestock production and small-holder agriculture in South Africa. Poor records make it difficult to quantify the economic contribution. The informal goat sector is characterized by poor productivity, prejudices and the approach of goats being "kept" and not farmed, which limits commercialization of these goats. The aim of this paper is to review the significance of goats in commercial and small-holder agriculture in South Africa.

Keywords: goats, commercial, cultural, small-holder farming, limitations
#Corresponding author; E-mail: evm.koster@up.ac.za

Introduction

Goats were among the first animals to be domesticated by man for the production of meat, milk, skins and fibre. Deductions mainly based on the shapes and surface textures of horns suggest that *Capra aegagrus* (the Bezoar or Persian wild goat) is the common ancestor of domesticated goats (Porter, 1996). Archaeological evidence suggest that domestication took place as early as 7000BC in the Near East, from where goats spread to almost all the continents and climatic zones (Maree & Plug, 1993). Sheep, goat and cattle remains occur on archeological Iron Age sites in South Africa from 300AD onwards. The goats were introduced to South Africa during the latter part of the Stone Age, when Khoisan shepherds travelled southwards from Northern Botswana down to the Orange River. They later followed two additional routes to reach the Southern and Western Cape.

Goats are managed under a variety of production systems varying from intensive to the most extensive forms of nomadic grazing. Although goats contribute significantly to commercial production in South Africa, the majority of goats serve the poorest part of the rural population through their meat, milk, hair and skins. The aim of this paper is to review the significance of goats in commercial and small-holder agriculture in South Africa.

Statistics

Reliable statistics regarding goat numbers and distribution in South Africa are absent to a large extent. Various factors contributed to poor accumulation of statistics over the years. Historically goat production in South Africa consisted of mainly a commercial sector with the Angora goat contributing fibre and the SA Boer goat producing meat. The informal sector consists of mainly indigenous goats kept by small farmers, community farmers and households. Their role has been disregarded for many years. Goat meat consumption was limited to certain population groups and often slaughtering was done informally and therefore not recorded through formal channels such as auctions and abattoirs. Coetzee (1998) reported that only 0.55% of the total goat population is slaughtered at abattoirs. According to Coetzee (1998) there were approximately 6.6 million goats in South Africa in 1997. 64% of these goats were kept in the rural areas of the country (Table 1). The S A Boer Goat Association confirmed these figures, with 2 369 353 goats in commercial areas and 4 087 436 goats in rural areas in 2003. The majority of the goats in these areas are of indigenous types, except for the Angora goats, which are primarily found in the Eastern Cape. The Boer goats seemed to be more concentrated in the Northern Cape province and Northwest province with a total of 190 registered stud breeders (S.A. Boer Goat Society, 2003).

Regardless of the poor records available for the goat industry, goats have a crucial social and economic role in South Africa. Through the production of fiber, meat, milk, skin and hides they contribute both to the gross economic product of the country and the sustainability of subsistence farmers. The mohair industry alone made a contribution of R236 628 million to the agricultural sector during 2002 (Mohair SA, 2002).

Peer-reviewed paper: 8th International Conference on Goats

Table 1 Total goat numbers 1997: Commercial and rural (Coetzee, 1998)

PROVINCE	Commercial	Rural	Total	% in Rural Area
Western Cape	263 238	0	263 238	0
Northern Cape	446 114	0	446 114	0
Free State	65 949	9 600	75 549	13
Eastern Cape	1 290 214	857 451	3 147 665	59
KwaZulu-Natal	117 929	740 186	858 115	86
Mpumalanga	34 550	49 118	83 668	59
Northern Province	49 837	876 059	925 896	95
Gauteng	13 286	0	13 286	0
North West	112 984	717 412	830 396	86
Total	**2 394 101**	**4 249 826**	**6 643 927**	**64**

Breeds and production

The Boer Goat, Savanna and Kalahari Red are currently recognized as commercial goat breeds for production of meat and skin. Commercial goat's milk production is limited to the Saanen and Toggenburg, while, mohair is produced by the Angora. Various indigenous types are found in the different provinces and contribute primarily to family needs for meat and skin and to a lesser extent milk, depending on the prejudices of the community (Masika & Mafu, 2003). In Table 2 production norms for commercial breeds are shown. Production figures are limited for indigenous goats, as records are not usually kept in community systems. In general their production is lower compared to the commercial breeds, but they are usually subjected to less food, vaccinations and general care.

Table 2 Production norms for commercial goat breeds

Production trait	SA Boer Goat (SA Boer Goat Society, 2003)	Angora goat (Snyman & Griessel, 2002)
Kidding percentage	90%	78%
Fecundity	210%	127%
Weaning percentage	165%	
Weaning weight 120 days	29kg	15kg
Mature weight		36kg

Potential limitations to goat production

Goat production is subjected to a number of potential limitations including prejudice, disturbing the ecological balance, marketing and consumer preferences. Prejudice against goats can be traced to the Old Testament of the Holy Bible where the Israelites had to load their sins on a goat and drive it into the desert. Until today the reference to a "scape goat" has survived as having a negative connotation. In Europe it was common to keep a goat in the cattle and horse barns to attract disease and evil and keep it away from the other stock (Gall, 1981).

In South Africa, goats are slaughtered in a specific way for bridal ceremonies and eating of the meat is restricted to certain persons according to the customs of the families (Krige, 1962). Goats are also important in burial rituals, where the corpse is sprinkled with goats' bile to remove evil spirits (Drum, 1991). Goats are used in rituals by Sangomas where they have to suck the blood and wear the gall bladder as a headdress (Drum,

Peer-reviewed paper: 8th International Conference on Goats

1999). They also use the bile of goats' bladders in medicines. Goat's milk may only be consumed by children in certain tribes/communities (Junod 1966). All these practices may influence the way goats are "farmed" in rural areas. According to observations by Mahanjana, (1997), the most important factor limiting commercialisation of indigenous goats is that goats are "kept " by farmers and not farmed. Small farming of goats is to a large extent for subsistence, with low productivity and poor management (Masika & Mafu, 2003).

Goats are described as the most versatile of all ruminants in terms of their feeding behaviour and they are well adapted to relatively harsh environments. Historical evidence indicates that goats may have played a role in the Neolithic period in clearing land after primary forests have been burnt down. It is indicated that through the centuries goats contributed to the expansion of desert areas in the Sahara and Middle East (Clutton-Brock, 1987). They are opportunistic grazers and tend to select the most palatable and nutritious forage available and their diet selection are determined by the variety of plant species available. They could therefore contribute to overgrazing of veld if not properly managed.

Despite certain favourable carcass characteristics such as lower fat percentage (22%) compared to beef (32%) and favourable meat to bone ratio, per capita consumption is low compared to other red meats (Casey *et al*., 2003; Tshabalala *et al.*, 2003). Goat meat seemed to be preferred by a few specific communities in South Africa, but generally has a hard time competing for a market share. It has received little attention in terms of marketing and unfortunately has a negative connotation of an undesirable odour (Simela *et al*., 2003).

Challenges

South Africa is the world's major producer of mohair and the SA Boer goat is a well-known and established meat breed. Both mohair and goat meat are well-defined commercial sectors making a substantial contribution to the economy, which have distinct advantages for the South African goat industry. In terms of the rural goat populations there are certain challenges and some of these were identified at the workshop on the commercialization of local goats during 1998. The areas for investigation included:

- Genetic identification of local populations
- Evaluation of nutritional status
- Improvement of small-farming systems for goats

Some of these aspects are already being addressed in research programs and a number of different institutions are involved. It will be important to coordinate these programs and to define the role of the goat in the agricultural system and the society in South Africa. Research initiatives may differ for commercial goat production versus smallholder agriculture and programs should make provision for both. Researchers should take the cultural role of the goat into consideration when designing programs.

In a South African context goat production will always have to compete with the beef, dairy and poultry industry. In terms of numbers, contribution to the economy and livelyhood of South African communities, it can be concluded that goats have a significant role to play. It will however be important to identify a specific niche for the goat and direct research programmes towards the aspects desired by the different markets, "users" and consumers.

References

Casey, N.H., Van Niekerk, W.A. & Webb, E.C., 2003. Goat: Meat, Encyclopaedia of Food Sciences and Nutrition (2nd ed.) edited by B Caballero, L Trugo and P Finglas, Academic press, London. ISBN 0-12-227005-X. 2937-2944

Clutton-Brock, J., 1987. A Natural History of Domesticated Mammals. BAS printers Ltd Stockbridge, Hampshire.

Coetzee, R.J., 1998. Socio – economic aspects of sustainable goat production. In: Proceedings of the workshop on Research and Training Strategies for goat production systems in South Africa, King's Lodge Hotel, Hogsback, Eastern Cape, South Africa, Ed by Webb, E.C., Cronje, P.B. & Donkin, NF, pp. 14-16.

Drum Publications, 1991. Strange rituals and township burials: township funeral undertakers talk. Oct.1991,152, 48-49.

Drum Publications, 1999. Sangoma in the House: she's a member of parliament, but she wears goat gall bladders on her head. Aug. 362,12-13

Gall, C., 1981. Goat production. Academic Press, NY., 10-11

Junod, H.A., 1966. The Life of a South African Tribe II: Mental Life. Univ. Books inc. NY. 46-50

Krige, E. J., 1962. The social system of the Zulus'. Shuter and Shooter, Pietermaritzburg. pp. 138-139

Mahanjana, A., 1997. Critical sectors affecting goat production within the communal livestock systems. Proc. of a workshop held at Irene Animal Nutrition and Products Institute of the ARC 24 June 1997. Edited by M Smuts. Published by Advisory Bureau for Development, Pretoria, South Africa.

Maree ,C & Plug, I., 1993. Origin of Southern African Livestock and their potential role in the industry. In: Livestock Production Systems edited by Maree & Casey. Agri Development Foundation.

Masika, P.J. & Mafu, J.V., 2003. Aspects of goat farming in the communual farming systems of the central Eastern Cape, South Africa. Small Rum. Res. Article in press. Available online:www.sciencedirect.com

Mohair SA, 2002. Oorsig/Review. Mohair SA limited reg. No.1997/02/1800/09

Porter, V., 1996. Goats of the world. Farming Press, Ipswich. pp. 1-4, 96.

SA Boerbok Society, www.studbook.co.za/Society/B.Goat/comp

Simela, L.,Webb, E.C. & Bosman, M.J.C., 2003. Retailer and consumer perceptions of chevon and its quality in Zimbabwe and South Africa. Proc. Of 11th International Meat Symposium 2003. ARC Irene Pretoria, South Africa

Snyman M.A. & Griessel, J., 2002. Evaluation of a Genetically Fine Mohair Angora goat flock. http://gadi.agric.za/articles/Snyman

Tshabalala, P.A., Strydom, P.E., Webb, E.C. & De Kock, H.L., 2003. Meat quality of designated South African indigenous goat and sheep breeds. Meat Sci. 65, 563-570.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Goat milk products in Fortaleza: pilot study of supply and marketing

D. de Lima Vidal[1#], M. Siegmund-Schultze[2], and A. Valle Zárate[2]

[1]Semi-Arid Systems Study Laboratory (LESISA), Veterinary Faculty, State University of Ceará - UECE, Av. Paranjana, 1700, 60740-000 Fortaleza-CE, Brazil

[2]Institute of Animal Production in the Tropics and Subtropics (480a), University of Hohenheim, 70593 Stuttgart, Germany

Abstract

There is a gap between the high potential of the north-eastern region of Brazil in terms of goats kept and its small contribution to national goat dairying. The study aimed at systemising information on the segment of the related productive chain by gaining insights into offer and marketing, sanitary aspects and labour characteristics in bakeries that sell goat milk and goat milk processed into cheese in the city of Fortaleza, the capital of Ceará state. Semi-structured interviews have been conducted in thirty bakeries of Fortaleza. Roughly 13% of the bakeries were actually selling goat milk products. The range of those dairy products was very restricted and derived from one major regional supplier. In was concluded that vertical integration is almost lacking, thus, raw milk is hardly being sold to the industry, offering opportunities for informal marketing channels. A promising outcome of the present study was the regular sanitary monitoring of bakeries, a fact almost absent within rural home commercialisation. The companies are apparently conscious of hygienic problems, which may cause a potential bottleneck for commercialisation.

Key words: goat marketing channels, north-eastern Brazil, goat dairy products, commercialisation
[#]Corresponding author; E-mail: medea.p@lycos.com.

Introduction

Goat milk of up to 4.5 million litres is marketed per year in Brazil, generating about $ 12 million annually [about 7 million Euro in 2000]. The potential offer of goat milk has been estimated to be 6.1 million litres per year, whereas the estimated demand is 12 million litres per year, thus a deficit of 5.9 million litres annually (SEBRAE-APEX, 2000). Around 93 percent of the national goat flock is kept in the north-eastern region of Brazil, producing 26 % of the national goat milk volume. This represents 17 % of the total milk volume sold domestically (Silva, 1998). Despite the disproportion between size of the flock and production level in north-eastern Brazil, goat milk and cheeses are the most important goat products found on local and regional markets (Carvalho, 2000).

About 35% of pasteurised goat milk from north-eastern Brazil is sold through the rural producers themselves, 30% by specialised luxury shops ("delicatessen"), 25% by supermarkets and bakeries, and the remainder by pharmacies (especially goat milk powder). These marketing channels can play an important role for sustaining and promoting goat production within livestock systems of the semi-arid region of Brazil. Mainstream criticism of the sector concerns the irregularity of the offer, high prices and unsatisfactory quality. Little has been done to really understand the status of this market segment. The present study aims at providing the first systematic hints of the production chain of goat milk products in Fortaleza, the capital of Ceará state.

Materials and Methods

Bakeries of 15 districts, two per district, were selected randomly within a radius of 11km from the city centre, representing almost a quarter of all city districts. Wholesalers as well as retailers were included, as well as all socio-economic classes of consumers, such as workers with just the minimum wage, middle class, upper class and tourism consumption. Data collection was done during June 2003, which is the summer season. Three sets of variables have been assessed using semi-structured interviews, covering variables of offer and marketing condition, hygienic aspects and labour characteristics (Table 1). Most variables have been assessed qualitatively.

Peer-reviewed paper: 8th International Conference on Goats

Table 1 Topics covered by the interviews

Offer and marketing	Hygiene	Labour
Size of the enterprise	Temperature of the product for sale	Number of attendants
Marketing conditions	Temperature of the product in stock	Age of attendants
Origin of goat milk products	Temperature during transport	Tasks of attendants
Number of suppliers	Who packs/wraps and when	Presence of training
Diversity of the offer	Occurrence of rotten products	Duration of training
Differences in volume sold	Presence of sanitary control	
Security measures	Frequency and items of control	
Forecasting	Sampling and advice during control	

Results

From the total of 30 bakeries interviewed just four were actually selling goat milk or goat cheese. Three of the seller shops were small-sized with one to four tills, like all the other shops which were not selling goat milk product, whereas just one seller shop was bigger.

All four goat milk product selling bakeries relied on one single provider, which was the same for three of the four cases, namely the "Empresa Cambi". Half of the bakeries sold merely one type of cheese, the "queijo de tipo coalhado", a sort of fresh cheese. Only half of the bakeries had visible information on the type of goat product, price and validity date on their products, whereas the validity date was somehow to be found on the vacuum packages of three shops.

The majority did forecasting of their offer by stocking between one and 20 kg of the respective product under refrigerated conditions. Quantities sold were comparable over time. Occasionally adulterated goat milk products were sent back to the provider.

Cooling of the products in the salesroom was provided equally by all four seller shops. Twenty-nine of the 30 bakeries were monitored for sanitation. Principal aspects were: general hygiene, validity of the products and the products themselves (Table 2). The goat milk product sellers had been visited every two weeks (two cases), every three weeks or twice a year. Besides hygiene, temperature of stocks (three cases), validity (two cases) and the products as such, had been focused on. Product samples had seldom been taken and no case was reported for goat milk product sellers. However, sanitary advice had been given to all goat milk and cheese sellers.

Table 2 Items of sanitary monitoring in twenty-nine bakeries

	Hygiene	Validity	Product types	Temperature of stock	Quality	Condition of restrooms	General selling conditions	General stock conditions	Size of installations
%	100	41	24	17	14	7	3	3	3

The average labour force of the 30 bakeries was six employees (ranging from one to 33). There is a tendency of more female than male employees working in the bakeries. Median age was 30-years old. Training of personnel was almost always given, whereas just three interviewees could give a statement on the length (more than one day) of the training. Female staff was primarily working as sale assistants and males as bakers and others.

Discussion and Conclusions

The study revealed weak points of goat dairy product distribution within the bakeries visited: A few bakeries where offering a restricted range of goat dairy products, which were obtained from few suppliers. This situation can be partly explained by the almost not developed, or at least not linked, regional marketing and processing of such products (Vidal *et al.*, 2000), the related transaction costs,

Peer-reviewed paper: 8th International Conference on Goats

limited rational behaviour and insecurity (Takitane & Souza, 1995). Vertical integration is almost lacking, thus, the raw material milk is hardly being sold to the industry, opening ways to informal marketing channels. This again could allow dairy product industries from the southeast and south of Brazil to be well represented in the big supermarkets (Vidal, 2004). However, Souza *et al.* (2003), concluded from a consumer and retailer study in the state of São Paulo, that people preferred to buy regional products.

The local "coalhado" cheese follows mainly the technical indications established by Pimenta Filho & Simplício (1994). They recommend preparing also less refined types of cheese and a series of liquid products in order to better meet the local socio-economic conditions and to offer products at lower prices which could also help to expand the marketed volume. However, the raw milk from goats, which is normally used for home as well as industrial preparation of cheese, is generally being stocked and sold under deficient hygienic conditions affecting public health (Ribeiro, 1992). A promising outcome of the present study is the regular sanitary monitoring of bakeries, a fact almost absent within rural home commercialisation. The companies are apparently conscious of hygienic problems causing a potential bottleneck for commercialisation.

Active promotion of goat dairy products was not considered a generally important feature for the bakeries as just half of them provided adequate marketing conditions, expressed as number and type of information visible on the products. This may be due to ignorance of the nutritional advantages of goat milk and other goat milk products (Pimenta Filho & Simplício, 1994), such as their low content of cholesterol, high digestibility and being hypoallergic (Fisberg *et al*., 1999).

There is consensus for the prediction of future trends, namely the leading role of southern countries in terms of growth of animal production and increasing demand of animal products, due to changes in dietary habits within urban centres and increasing integration of livestock husbandry with rural cropping systems (Delgado *et al.*, 1999; Boutonnet *et al.*, 2000; FAO, 2000). Trends of the present pilot study comprise nonetheless the limited offer of products, the low variability in product types, the existence of primarily one supplier and the restricted marketing strategies of the shops. Future research will be done on a representative number of bakeries, applying factorial analysis to determine typologies of goat dairy marketing channels. The types will be used to understand and explain diversity and adaptation strategies in the linked rural-urban semi-arid areas of Brazil. Subsequently, recommendations can be formulated in order to optimise the functioning of the productive chain.

References

Boutonnet, J.P., Griffon, M. & Viallet, D., 2000. Compétitivité des productions animales en Afrique sub-saharienne. CIRAD-EMVT, Montpellier, France. 94 pp.

Carvalho, R.B. de., 1999. Potencialidades dos mercados para os produtos derivados de caprinos e ovinos. Capritec, São Paulo – Textos técnicos, 15 pp.

Delgado, C., Rosegrant, M., Steinfeld, H. & Elui, S., 1999. Livestock to 2020. The next food revolution. IFPRI, Washington, USA, 17 pp.

FAO, 2000. Annuaire statistiques. Ed. Karthala, Paris, 194 pp.

Fisberg, M., Nogueira, M., Ferreira, A.M.A. & Fisberg, R.M., 1999. Aceitação e tolerância de leite de cabra em pré-escolares. In: Pediatria Moderna, XXXV(7), 10 pp.

Pimenta Filho, E.L. & Simplício, A.A., 1994. Caprinocultura leiteira no Brasil: estádio de arte e perspectiva. In: Semana da Caprinocultura Tropical Brasileira, Sobral: EMBRAPA – CNPC, pp. 47-76.

Ribeiro, S.D.A., 1992. Produção e comercialização do leite de cabra e seus derivados. In: Simpósio Nordestino sobre Caprinos e Ovinos Deslanados, Taperoá, PB. Campina Grande, APACCO, pp. 33-36.

Peer-reviewed paper: 8th International Conference on Goats

SEBRAE-APEX, 2000. Projeto de apoio às exportações de produtos derivados da ovinocaprinocultura do NE, Fortaleza. 45 pp.

Silva, R.R., 1998. Agribusiness da caprinocultura de leite no Brasil. Salvador: Bureau, 1998, 74 pp.

Souza, E.M.; Murakani, A.K.; Guimarães, B.M.; Costa, M.C.R. & Villela, J.L., 2003. O leite de cabra: principais vantagens e consumo em S. J. Campos. In: V Encontro de Iniciação Científica. UNITAU, Taubaté, SP.

Takitane, I.C. & Souza, M.C.M. de. 1995. Coordenação de cadeias agroindustriais: o caso Illycafé. Informações Econômicas, SP, 25(7), 29-42.

Vidal, D.de L., 2004. Agronegócio sustentável do leite de cabra. Relatório de pesquisa em andamento. (LESISA) - Universidade Estadual do Ceará. 20 pp.

Vidal, D.de L.; Oliveira, J.A.M.; Magalhães, K.A. & Lima, L.A. de A., 2000. Achieving economical and social sustainability in goat husbandry in the semi-arid of Brazil: a question of marketing channels. In: Proc. of the 10th International Rural Sociology Congress, Rio de Janeiro, RJ, Brazil.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Comparison of different models to estimate purine bases absorbed in goats

H. Andrade-Montemayor[#1], F. Hernández[2] , J. Madrid[2] and M.D. Megías.[2]

[#1] Natural Sciences Faculty- Veterinary. University Autonomus of Querétaro. Edif. Octavio S Mondragon. 76010. Querétaro. México.

[2] Departament of Animal Production. University of Murcia. Campus Espinardo. Espinardo. Murcia. CP 30071. Spain.

Abstract

The purine bases absorbed (PBa) and microbial nitrogen flow (MNF) in the duodenum were estimated with five models proposed for sheep (1, 4), goats (2), cattle (5) and a goat-sheep mixed model (3). Data of purine derivatives excreted (PDe) in urine of eight digestibility trials were used. In these trials, eight adult male castrated Murciano-granadino goats (30.5 ± 4.95 kg of live weight) were used. Feed was offered as a total mixed ration and was based on alfalfa hay or barley straw and concentrates (50:50). The range in variation for daily DM intake, OM digestibility and nitrogen balance of the different rations were: 38 to 42 g/kg$LW^{0.75}$, 68 to 71% and 0.35 to -0.11 g/d respectively. The estimation to PBa, MNF and microbial yield, were different between equations. The estimation of PBa in equation 4 was underestimated by to high recovery of endogenous fraction of PDe in urine considered in this equation. The ratio between N content in the microbial population of the rumen (MNR) and PBa was lower in the equation 2 (0.55 mmol/day) than equations 1, 3, 4 and 5, (0.727 mmol/day). The variability of the factors used in the equations to estimate PDa and MNF within and among species limits its use.

Keywords: Endogeneus purine derivative, digestible organic matter intake (DOMI), microbial nitrogen synthesis, purine metabolism

Correponding author; E-mail: andrade55@yahoo.com

Introduction.

The knowledge of the microbial nitrogen synthesis in the rumen is an important factor in the new protein evaluation systems. The purine derivatives excreted (PDe) through the urine, could be used to estimate the microbial protein produced in the rumen and digested in the lower tract (Chen & Gomes, 1992). The use of this method requires knowledge of purine metabolism and the relation of PDe: purine bases absorbed (PBa). PDe is function of the plasma concentration of purine derivatives (PD), rate of glomerular filtration and the metabolic activity of xanthine-oxidase. These factors are different among species (Chen & Gomes, 1992).

Chen & Gomes (1992) proposed a model for sheep that have been used in goats, since these two species have similar xanthine-oxidase activity (Lindberg, 1989; Stangassinger *et al*., 1995; Belenguer *et al*., 2002). Variations to Chen & Gomes (1992) model for sheep have been proposed by Balcells *et al*. (1991) and for goats by Belenguer *et al*. (2002).

The objective of this work was to compare the use of five different models to calculate the PBa and the microbial nitrogen flow (MNF), by means of the excretion of PD in urine in Murciano-Granandino goats.

Materials and Methods.

Data of PDe in urine of eight digestibility trials were used. In this trials, eight castrated adult males of Murciano-granadino goats (30.5 ± 4.95 kg of live weight) were used. Feeds were offered as a total mixed ration based on alfalfa hay or barley straw and concentrate (50:50). Rations were offered in a restricted form (40 g of dry matter (DM)/kg $BW^{0.75}$ per day; Van Es & Van Der Meer 1980). Range of variation for daily intake, digestibility and nitrogen balance of the different rations is shown in Table 1.

Urine excretion was collected daily for 5 days and it was preserved with 100 ml of 10% H_2SO_4. The urine was weighed and 50 ml/animal/day was sampled and frozen at -20^{o}C. The PDe in urine were analysed by the HPLC (Kontron Data System 450-MT) with a column Kromasil C_{18} column.

The references for the equations used for the estimation of PBa , MNF and microbial yield (microbial N g/kg of Digestible organic matter fermented in the rumen (DOMR)) are shown in Table 2.

Peer-reviewed paper: 8th International Conference on Goats

Table 1 Characteriscs of the rations

	Means	Minimun	Maximun	SEM
Daily Intake g/kg $BW^{0.75}$				
Dry matter	40.46	38.55	42.36	0.95
Digestible organic matter	27.01	25.57	28.45	0.72
Digestible protein	3.62	3.34	3.90	0.14
Digestibility (%)				
Organic matter	70.17	68.53	71.82	0.83
Nitrogen Balance (gN/day)	0.58	-0.11	0.35	1.27

Table 2 Equations used to calculate PBa and MNF

Equation number	PBa (Species)	MNF (Species)
1	Chen & Gomes (1992) (Sheep)	Chen & Gomes (1992) (Sheep)
2	Belenguer *et al* (2002) (Goats)	Belenguer *et al* (2002) (Goats)
3	Belenguer *et al* (2002) (Goats)	Chen & Gomes (1992) (Sheep)
4	Balcells *et al* (1991) (Sheep)	Chen & Gomes (1992) (Sheep)
5	Chen & Gomes (1992) (Cattle)	Chen & Gomes (1992) (Cattle)

Results and Discussion

The results of PD excretion and PBa, MNF and microbial nitrogen yield/kg of digestible organic matter fermented in the rumen (MNF g/kg DOMR) estimation are shown in Table 3. The PD excretion was similar to the observed by Belenguer *et al*. (2002) for goats fed with alfalfa hay at a maintenance level. The PBa and MNF are different (P<0.01) among equations. PBa values ranged from 12.6 (equation 4) to 16.3 (equations 2 and 3) mmol/d. The models proposed for sheep (4) or cattle (5) underestimated the PBa values predicted for goat (2,3). The estimation of PBa is affected by the recovery of PDe and endogenous fraction of PD in urine. However, the recovery of urinary PD is variable within and among species. In sheep, it ranged from 84 to 93% (Chen & Gomez, 1992; Balcells *et al*., 1991), and in goats from 74 to 95% (Lindberg, 1991; Belenguer, 2002). On the other hand, goats and cattle have similar endogenous ratio PD excreted in urine (30% and 24-39% respectivelly) by they are different to sheep (9%-17%)(Mota *et al*., 2003). The ratio between N content in the microbial population of the rumen and PBa was lower in the equation 2 (0.55 MNF g/ PBa mmol) than equations 1, 3, 4 and 5, (0.727 MNF g/ PBa mmol). Therefore the Chen & Gomes (1992) models could have overestimated the MNF in goats. The estimation of MNF depends on the digestibility of duodenal PBa and the ratio between N content in microbial population of the rumen and PBa, this relation is not absolute and it can vary according to the experimental diet, nevertheless the range of change is not important (Chen & Gomes, 1992; Stangassinger *et al*., 1995; Sandoval-Castro & Herrera Gomez, 1999).On the other hand, the microbial yield was higher in equation 3, due to a greater ratio between PBa and PDe and to the ratio between MNR and PBa used in equations. Nevertheless, the estimates of microbial yield was similar to that reported by other authors, ranging from 25-45 g of MNF/kg DOMR (ARC, 198; Ranilla *et al*., 2003). The ratio MNF g / g N intake was higher than 1 in equations 1 and 3. The data suggest that these models could not be used for goats.

Table 3 Result of PDe and PBa and MNF estimated by differents equations

Equation	1	2	3	4	5	SEM	Sig[2]
PDe mmol/d	12.39	12.39	12.39	12.39	12.39	0.68	NS
PBa mmol/d	14.64a	16.3a	16.3a	12.68b	13.99b	0.84	**
MNF g/d	10.64a	8.99b	11.85a	9.22b	10.17ab	0.58	***
MNF g/kg DOMR[1]	48.35ab	40.84a	53.82b	40.82a	46.2ab	2.89	**
MNF g/N intake g	1.03ab	0.87a	1.15b	0.89a	0.98a	0.05	***

[1]DOMR: Digestible organic matter fermented in the rumen= DOM*0.65 (ARC, 1980)
[2]Significance level: NS:P> 0.05, ** P<0.01, *** P<0.001.
a-b Means among columns with different subscript are significantly different.

Peer-reviewed paper: 8th International Conference on Goats

Conclusion

The results suggest that the enzymatic activity is similar between sheep and goats, but that the variability between the factors used in the equations to estimate PDa and MNF within and among species limits its use.

References

ARC, 1980. The nutrient requirements of ruminant livestock. Surrey: The Gresham Press.

Balcells, J., J. A Guada, C. Castrillo & J. Gasa., 1991. Urinary excretion of allantoin and allantoin precursors by sheep alter different rates of purine infusion into the duodenum. J. Agric. Sci. Camb. 116, 309-317.

Belenguer,A., D. Yañez., J. Balcells., N. H. Ozdemir Baber & M. Gonzalez Ronquillo., 2002.Urinary excretion of purine derivatives and prediction of rumen microbial outflow in goats. Lives. Prod. Sci. 77,127-135.

Chen, X.B. & Gomes, M.J., 1992. Estimation of microbial protein suply to sheep and cattle based on urinary excretion of purine derivatives- and overview of the technical details. Int. Feed Resources Unit. Rowett Research Institute. Aberdeen. UK- p. 1-19.

Lindberg, J. E. 1989. Nitrogen metabolism and urinary excretion of purines in gotas kids. Br. J. Nutr. 61, 309-321.

Lindberg, J.E., 1991. Nitrogen and purine metabolism in preruminant and ruminant goat kids given increasing amounts of ribonucleic acids. Anim. Feed Sci.. Technol. 35, 213-226

Mota, M., J. Balcells., N. H. Ozdemir Baber., S. Bölüktepe & Belenguer, A., 2003. Endogenous contribution and effect of exogenous nucleic acid supply on urinary excretion of purine derivatives in dairy granadina goats. Proc. First Joint Seminar of the FAO-CIHEAM Sheep and Goat Nutrition and Mountain and Mediterranean Pasture Sub-Networks. "Sustainable grazing, nutritional utilization and quality of sheep and goat products. p. 93.

Ranilla, M.J., Carro, M.D., Valdés, C. & Gonzalez J.S., 2003. Digestion and digesta flow kinetics in goats fed two diets differing in forage to concentrate ratio. Proc. First Joint Seminar of the FAO-CIHEAM Sheep and Goat Nutrition and Mountain and Mediterranean Pasture Sub-Networks. "Sustainable grazing, nutritional utilization and quality of sheep and goat products". p. 97.

Sandoval-Castro, C. & F. Herrera-Gomez . 1999. Estimación de la síntesis de proteína microbial en rumiantes a través de la medición de los derivados de purinas en orina. Rev. Biomed. 10, 241-251.

Stangassinger, M., X. B. Chen., J.E. Linberg & D.Giesecke. 1995. Metabolism of purines in relation to microbial production. In. Ruminant. Physiology: Digestion, Metabolism, Growth and Reproduction: Proc. Eighth Int. Symp. on Ruminant Physiology. pp. 387-400.

Van Es, A. J.L. & Van Der Meer, J. M., 1980. Métodos de análisis para predecir el valor energético y proteíco de los alimentos. 31st Annual Meeting of European Association for Animal Production. Munich. Netherlands. pp. 40-41.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Effect of profiles of neutral detergent soluble carbohydrate on microbial protein synthesis in dairy goats

M. A. D. Bomfim*, M. T. Rodrigues[#], C. A. F. Rodrigues, R. H. Branco, M. M. C. da Silva; E. R. P. Bomfim and V. Viana

Departamento de Zootecnia da Universidade Federal de Viçosa, Viçosa - Minas Gerais - Brazil.

Abstract

This work had as objective to observe the effects of different profiles of Neutral Detergent Soluble Carbohydrate in low forage based diets on microbial protein synthesis and abomasum crude protein flow in goats. Five profiles of carbohydrates were differentiated by the ratio between the starch concentrations plus the soluble sugar (StSs) to the neutral detergent soluble fiber (StSs:NDSF) in diets, and goats were assigned to a 5 x 5 Latin square design. Bermudagrass hay was used as the only forage source. Microbial protein production was measured by using the purine basis technique in abomasal sample and ruminal bacteria. Statistical analysis demonstrated a linear and positive relationship between levels of starch and soluble sugar in diets and the microbial protein synthesis, crude protein and microbial protein flow to abomasum (P<0,01). High level of NDSF in diets, in pectin form, can limit the metabolizable protein supply of microbial source to abomasum leading to need of dietary supplementation of low ruminal degradable protein sources.

Keywords: Neutral detergent soluble carbohydrate, forage, goats
[#]Corresponding author; E-mail: mtrodrig@ufv.br

Introduction

The neutral detergent soluble carbohydrate fraction (NDSC), also named non-fibrous carbohydrate (NFC), represent the main energy source for high producing dairy goats. In this group are included the starches, soluble sugars, organic acids and the neutral detergent soluble fiber (NDSF), constituted of pectin, fructans and β-glucans. High dietary levels of NDSC, increase the fermentable energy intake and reduce ruminal ammonia concentration. resulting in greater efficiency of microbial protein synthesis and microbial protein flow to abomasum. Inmost cases, plasma amino acid concentration, milk protein concentration ,nitrogen retention and milk production increase. (Sutoh *et al*., 1996). Evaluation of the neutral detergent soluble carbohydrate profile in ruminant diets has indicated different effects of these components on protein metabolism. Solomon *et al*. (2000), Leiva *et al*. (2000), and Bomfim (2003), in studies with dairy cows and dairy goats respectively, have demonstrated that NDSF rich diets can reduce milk protein synthesis and nitrogen retention. These effects have been related to the effect of different carbohydrate sources on efficiency of microbial protein synthesis (Hall & Herejk, 2001). Therefore, the objective of this work was to evaluate the influence of different profiles of NDSC of low forage fiber diets on the efficiency of microbial synthesis and microbial protein flow to abomasum in dairy goats.

Material and methods

Treatments effects were evaluated using five non-pregnant and non-lactating goats, fistulated in the rumen and abomasum, with average live weight of 52,80 ± 5,72 kg, confined in individual cages. Animals were arranged in a 5 x 5 Latin square, to evaluate the effect of five profiles of neutral detergent soluble carbohydrate (NDSC) in low fiber diets by using Bermuda grass (*Cynodon spp.*) as the forage source. The independent variable used to characterize treatments was the ratio between the starch plus the soluble sugar (StSs) fraction and the neutral detergent soluble fiber (StSs:NDSF)fraction. This ratio was was based on the fermentation pathway and the lactic acidosis potential effect of the different carbohydrate fractions. The experimental diets are presented in Table 1. Animals were adapted to the diets for 12 days followed by a collection period of nine days. For quantification of microbial protein production, 150 ml of abomasal fluid was collected from each animal every 26 hours for a period of six days. During day nine of the collection period, for isolation of bacteria, 2,000 ml of ruminal liquid digesta was collected with 1,000 ml being collected before feeding and 1,000 ml collected six hours after feeding. The N-bacterial estimation was made according to purine basis technique (ratio N-total/N-RNA) in bacterial pellet and abomasal digesta. The production was corrected for abomasal flow (Zinn & Owens, 1986).Not in reference list Microbial efficiency

Peer-reviewed paper: 8th International Conference on Goats

synthesis was calculated as a function of carbohydrate (CHDR) and organic matter degraded in the rumen (OMDR), and obtained by the difference between consumption and the abomasal flow of these fractions. Analysis of variance, when significant, was tested by means of polynomial regression components. Significance of differences was declared at a 5% level of confidence. The section on how bacterial N flown and efficiency of synthesis was estimated is confusing and should be rewritten.

Table 1.Experimental diets composition and treatments effects on microbial protein synthesis and nitrogen compounds flow to abomasums.

Item	Unit	Treatment				
		T1	T2	T3	T4	T5
CP	g/kg	122,2	125,7	119,6	124,2	116,5
Net Energy	Mcal/kg	1,66	1,70	1,69	1,67	1,73
NDFf[1]	g/kg	270,3	270,4	270,4	270,4	270,4
NDSC	g/kg	378,9	378,90	382,6	366,7	382,1
Starch	g/kg	33,2	104,0	153,3	226,4	277,3
Soluble sugar	g/kg	153,4	116,9	82,80	55,20	26,00
NDSF	g/kg	226,3	169,6	144,5	95,8	56,60
StSs:NDSF[2]	--	0,82	1,30	1,63	2,94	5,35
Treatments effects						
Item	Equation				R^2	VC
CPFL ($g.d^{-1}$)[3]	$53, 86 + 6,39x^{*}$				0,82	31,22
MiCPFL ($g.d^{-1}$`)[4]	$47,98 + 5,40x^{**}$				0,43	46,53
	Synthesis efficiency					
g micN.KgCHDR^{-1}	$14,78 + 2,20x^{*}$				0,50	45,73
g micN.KgOMDR^{-1}	$13,17 + 2,48x^{*}$				0,50	49,22

[1] forage NDF; [2] Starch plus soluble sugar / Pectin ratio; * P<0,05; **P<0,01, [3] Crude protein flow, [4] Microbial Crude protein flow.

Results and discussion

Results from the effect of NDSC profile on microbial protein flow and efficiency of production are presented in Table 1. The NDSC profile increased efficiency of microbial protein in a linear fashion expressed as both g of N/Kg OMDR and g of N/Kg CHDR (P<0,05).Similarly, the StSs:NDSF ratio also increased the abomasal crude protein flow (P<0,05), probably as a consequence of the increased flow of microbial protein t to the abomasum (P<0,01). .

It has been observed that NDSF rich diets reduce the milk protein concentration and the nitrogen retention (Solomon *et al*, 2000; Leiva *et al*., 2000; Bomfim, 2003). This lower N consumed / N in milk conversion suggest a lower efficiency of metabolizable protein utilization in diets with high NDSF proportions, that can be related to a lower efficiency of microbial synthesis l in NDSF rich diets, as suggest by Hall & Herejk (2001). Furthermore, data of this study demonstrated that, as statistical differences were not observed between treatments for dry matter, protein, and carbohydrate intakes and in ruminal ammonia concentration (Bomfim, 2003), this increased efficiency of microbial protein synthesis is most probably due to differences in the efficiency of utilization of different profiles of NDSC. The metabolism of pectin, the major NDSF source in the experimental diets, was studied by Marounek & Dusková (1999), in *Butyrivibrio fibrisolvens* bacteria. A high activity for KDPGA aldolase enzyme was observed as pectin was fermented, but the activity was not detected, as glucose accounted for as substratum. This indicates that pectin monomers fermentation pathway is not made by the pentoses pathway associated to EMBDEN-MEYERHOF-PARNAS (EMP) pathway as believed, but for the ENTNER-DUODOROFF (ED) pathway. Rewrite the previous sentence

Although ED and EMP are different, both produce two molecules of pyruvate for each hexose fermented but, in the ED pathway 1 ATP is used for hexose phosphorylation and 2 ATPs are formed as hexose is converted into pyruvate, thus the ATP liquid yield for a molecule of hexose is one. In contrast, the net production in the EMP pathway is 2 ATP (Burrows, 1973). Therefore, one glucose fermented to acetic

Peer-reviewed paper: 8th International Conference on Goats

acid yield 4 ATPs as a net profit (Russel, 1988), while fermented pectin residues yield only 3, which represents 25% less energy from each hexose, not considering the energy cost for KDPGA enzyme synthesis. This can partially explain the reduction in milk protein synthesis observed by Solomon *et al*. (2000), Leiva *et al*. (2000) and Bomfim (2003) as well as, the positive response when feeding non degradable protein sources in pectin rich diets (Mertens *et al*., 1994).

Conclusions

Diets with a high content of pectin in the neutral detergent soluble fiber fraction f can limit the flow of microbial metabolizable protein to the abomasum and may require supplementation with low ruminal degradable protein sources containing balanced amino acid profiles.

References

Bomfim, M.A.D., 2003. Carboidratos solúveis em detergente neutro em dietas de cabras leiteiras. Viçosa: Universidade Federal de Viçosa, 2003. 135p. Tese (Doutorado em Zootecnia) – Universidade Federal de Viçosa.

Burrows, W., 1973. Textbook of microbiology. Philadelphia: W.B. Saunders Company, 1035p.

Hall, M.B.& Herejk, C., 2001. Differences in yield of microbial crude protein from in vitro fermentation of carbohydrate. J. Dairy Sci. 84, 2486-2493.

Leiva, E.; Hall, M.B.& Van Horn, H.H., 2000. Performance of dairy cattle fed citrus pulp or corn products as sources of neutral detergent-soluble carbohydrate. J. Dairy Sci. 83, 2866-2875.

Marounek, M.& Dusková, D., 1999. Metabolism of pectin bacteria *Butyrivibrio fibrisolvens* and *Prevotella ruminicola*. Letters in Applied Microbiology. 29, 429-433.

Mertens, D.R., Broderick, G.A.& Simons, R., 1994. Efficacy of carbohydrate sources for improving utilization of N in silage. J. Dairy Sci.77 (l), 240.

Russel, J.B., 1988. Energy yielding and consuming reactions. In: Hobson, P.N. (Ed.) The rumen microbial ecosystem. London: Elsevier Science Publishers, p.185-215.

Solomon, R.; Chase, L.E. & Ben-Ghedalia, D., 2000. The effect of nonstructural carbohydrate and addition of full fat extruded soybeans on the concentration of conjugated linoleic acid in the milk fat of dairy cows. J. Dairy Sci. 83,1322-1329.

Sutoh, M.; Obara, Y.& Miyamoto, S., 1996. The effect of sucrose supplementation on kinetics of nitrogen, ruminal propionate and plasma glucose in sheep. J. Agric. Sci.126, 99-105.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Effect of dietary forage fibre levels and type on response of dairy goats

R. H. Branco, M. T. Rodrigues[#], C. A. F. Rodrigues, M. M. C. da Silva, V. Viana, R. de A.Torres Filho, R. da S.Matos , M. de S. Duarte, F. O. Morbi
Departamento de Zootecnia da Universidade Federal de Viçosa, Viçosa - Minas Gerais - Brazil.

Abstract

This study evaluated the effect of forage NDF (FNDF) levels and forage maturity (low maturity and advanced maturity) on dry matter intake and milk yield of dairy goats fed iso-nitrogenous diets. Tifton hay was used as the only source of forage. Ten dairy goats averaging 60 days in milk at the beginning of the trial, were assigned to five forage NDF levels (20.0, 28.0, 36.0, 44.0, and 50.0% FNDF) in a two 5x5 Latin square design.Fiber concentration of diets affected dry matter intake of goats. Considering the use of forage of low maturity, it was found that dry matter intake did not vary among treatments with 20.0, 28.0, 36.0, and 44.0% FNDF. Reduction on feed intake was observed ($P<0.05$) as one compares intake of goats fed the ration with 20% to those with 50% FNDF. A different pattern of response on dry matter intake was observed as maturity of forage source changed. Intake of goats was higher for diets formulated to contain 28.0 and 36.0 % of FNDF. A reduction on feed intake was observed at a level of 44.0% of fiber from forage in the diet, showing that maturity may play a role in limiting rumen fill. Dietary FNDF level affected milk yield of dairy goats. Considering the use of forage of low maturity, milk yield did not differ among treatments with FNDF levels of 20.0, 28.0 and 36.0%. Adding fiber to the level of 44.0 and 50% FNDF, reduced milk yield ($P<0.05$) as compared to 20.0% FNDF. A similar tendency was observed as forage hay with advanced maturity was used. It should be considered the magnitude of milk yield observed for the two squares. Milk yield average was 2.40 kg/day as low maturity grass hay was used. Changing fiber quality by altering the nature of the lignified cell wall of forage, contributed to reduce milk yield average to 1.54 kg/day which may represent a constraint for goats to express their genetic potential.

Keywords: Dietary fibre, forage, goats
[#]Corresponding author; E-mail: mtrodrig@ufv.br.

Introduction

Energy is considered the most important component of diets that have an influence on animal feed intake. Forage is also being a major contributor of energy in ruminant animals. However, the nature of fiber in forage is variable and can affects both rumen fill and availability of energy which in turn may limit animal performance.

Recommendations of fiber levels in dairy goat diets have not been defined by the world literature. To assist the energy demand of dairy animals, producers have relied on great amounts of concentrate and forages of high quality, with relatively low amounts of fiber. However, ruminants demand adequate NDF(The first time write out all abbreviations.) intake to guarantee normal rumen function, and to maintain fat content in the milk.

Fiber is not considered to be a nutritionally, chemically, or physically uniform material (Van Soest, 1991). Therefore, to address the effect of fiber on animal response, one needs to consider both fiber concentration and fiber quality. To measure the individual effect of both concentration and maturity of fiber is difficult due to interactions of other factors such as rumen size, level of intake and production.

Ruminal function is associated with the maintenance of mastication and rumination to maintain adequate salivation and optimal pH for ruminal microorganisms (Santini *et al*., 1992). According to Mertens (1983), the amount of fiber ingested, the size of particles and fiber type, all influence fermentation rate, rumination, milk yield, and milk fat content.

The objective of this study was to address the importance of forage fiber levels and forage maturity on dry matter intake and milk yield of dairy goats.

Material and Methods

This study, totaling 105 days, was accomplished from February to June, 2003 by using ten dairy goats averaging 52 kg BW and 60 days of DIM??? at the beginning of the trial. Goats were assigned to two 5 x 5

Peer-reviewed paper: 8th International Conference on Goats

Latin square design to evaluate effects of forage NDF levels (FNDF) on milk yield. Each experimental period lasted 21 days, with 14 days for adaptation to diets and management, and 7 days of data collection. Dietary FNDF levels were set to 20.0, 28.0, 36.0, 44.0, and 50.0% by using grass hay with low maturity (11.52% CP, 82.41% NDF and 46.25% ADF) in one square and a forage hay of advanced maturity (6.48% CP, 87.87% NDF and 52.38% ADF) in the other square.

Animals were confined in individual stalls with a slotted floor during the experimental period. Dairy goats were fed twice a day, at 8 AM and 4 PM, using a total mixed ration. Feed offered and orts were daily weighed to record feed intake. Orts were maintained at a level of 10% of what was offered to guarantee voluntary feed intake by animals and to avoid diet selection. Goats were milked twice a day, at 6 AM and 4 PM. Animals were weighed at the beginning of experimental periods, at the beginning of collection period, and at 21 days of each experimental period. Data were submitted to analysis of variance and the means compared by Student Newman Keuls test, using the statistical package SAS (1990).

Forage to concentrate ratio changed accordingly to meet the established FNDF levels of diets. Physical effectiveness of fiber from concentrates was assumed to be null. Maize, soybean meal and a mineral premix were used as a concentrate mixture, and Tifton 85 hay (*Cynodon* spp.) used as the only forage source. Diets were iso-nitrogenous with 17.0% CP (%MS). Feed ingredients and chemical composition of diets are showed in Table 1.

Table 1 Physical and chemical composition of experimental diets

	Low maturity hay FNDF?? level (%)					Advanced maturity hay FNDF level (%)				
	20.0	28.0	36.0	44.0	50.0	20.0	28.0	36.0	44.0	50.0
Ingredient % (DM basis)										
Tifton hay	22.76	33.98	43.68	53.39	60.67	24.27	31.86	40.97	50.07	56.90
Ground corn	51.33	44.08	35.32	26.56	19.99	52.83	41.98	32.62	23.26	16.25
Soybean meal	24.37	20.42	19.46	18.51	17.80	21.37	24.62	24.88	25.13	25.32
Dicalcium phosphate	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
Calcium limestone	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51
Chemical composition(dry matter basis										
DM (%)	87.50	86.97	86.69	86.42	86.22	87.24	87.33	87.15	86.98	86.85
CP (%)	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00
NDF total (%)	28.29	35.28	42.27	49.26	54.5	28.56	35.66	42.76	49.86	55.18
NE (Mcal/kg)Change to MJ	1.65	1.58	1.51	1.44	1.38	1.66	1.6	1.54	1.47	1.42
Ca:P	1.24	1.29	1.34	1.39	1.43	1.21	1.25	1.28	1.32	1.34
For.:Conc. ratio	25:75	35:65	44:56	54:46	61:39	23:77	33:67	42:58	52:48	58:42

Results and Discussion

Fiber concentration of diets affected dry matter intake (Table 2). Considering the use of forage of low maturity, it was found that dry matter intake did not vary among treatments with 20.0, 28.0, 36.0, and 44.0% FNDF. Reduction on feed intake was observed ($P<0.05$) as the intake of goats fed a ration with 20% FNDF was compared to those with 50% FNDF.

A different pattern of response on dry matter intake was observed as maturity of the forage source changed. Intake of goats was higher for diets formulated to contain 28.0 and 36.0 % of FNDF. A reduction on feed intake was observed at a level of 44.0% of fiber from forage in the diet, showing that maturity may play a role in limiting rumen fill. Forage of low maturity allowed the supply of higher amounts of fiber in the diet without reducing intake of goats. This is in agreement with the feed intake control theory of the NDF-energy intake system, as proposed by Mertens (1985, 1987).

It is speculated that the lower value of feed intake observed for the diet containing 20%FNDF with forage of advanced maturity might be due to alteration on the fermentation pattern caused by a higher

Peer-reviewed paper: 8th International Conference on Goats

contribution of carbohydrates from concentrate, thus altering kinetics of degradation and transit. According to Nelson *et al*. (1992) the increase of forage maturity has been correlated positively with ruminal repletion and negatively with DMI. It should also be noted that the average dry matter intake of goats fed diets with the same level of fiber but with forage with low and advanced maturity, varied in magnitude being 1.86 kg/day and 1.62 kg/day, respectively.

Table 2 Dry matter intake (kg/day) according to forage type and forage neutral detergent fibre (FNDF) concentration

Forage type	FNDF level (%)				
	20.0	28.0	36.0	44.0	50.0
Low maturity	2.110[a]	2.153[a]	1.820[ab]	1.723[ab]	1.494[b]
Advanced maturity	1.547[b]	1.867[a]	1.737[ab]	1.499[b]	1.485[b]

Means, within a row, followed by different letters differ significantly (P<0.05) by Student Newman Keuls test.

Dietary FNDF level affected milk yield of dairy goats (Table 3). Considering the use of forage of low maturity, milk yield did not differ among treatments with FNDF levels of 20.0, 28.0 and 36.0%. Adding fiber to the level of 44.0 and 50% FNDF reduced milk yield (P<0.05) as compared to 20.0% FNDF.

Table 3 Milk yield (kg/day) according to forage type and FNDF(see Table 2) concentration

Forage type	FNDF level (%)				
	20.0	28.0	36.0	44.0	50.0
Low maturity	2.746[a]	2.583[ab]	2.604[ab]	2.207[b]	1.884[c]
Advanced maturity	1.722[ab]	1.867[a]	1.587[ab]	1.443[b]	1.094[c]

Means, within a row, followed by different letters differ (P<0.05) by Student Newman Keuls test.

A similar tendency was observed as forage hay with advanced maturity was used. It should be considered the magnitude of milk yield observed for the two squares. Milk yield average was 2.40 kg/day as low maturity grass hay was used. Changing fiber quality by altering the nature of the lignified cell wall of forage, contributed to reduce milk yield average to 1.54 kg/day which may represent a constraint for goats to express their genetic potential.

If feed efficiency is considered, the use of low maturity forage contributed to obtain 1.43 kg of milk/kg of DM consumed at 36% FNDF level. The highest value of efficiency obtained for diets using forage of advanced maturity was 1.11 kg of milk/kg of DM consumed at 20% FNDF.

Conclusions

Fiber levels of diets affect dry matter intake of dairy goats.Difference in magnitude of intake is observed as diets contain similar levels of fiber but vary on nature of fiber from forage source. Diets with a high concentration of fiber can be formulated without reducing dry matter intake as forage of low maturity is used. Milk yield is affected by concentration of fiber from forage present in diets. FNDF levels of 36% were considered satisfactory to maintain milk yield for goats averaging 2.4 kg/day. Maturity of fiber has an impact on milk yield reducing energy availability to the animal. Limiting capacity to strech rumen capacity, results in lower milk yield as animals fed diets with similar concentration of fiber compared to diets prepared with a less mature forage source.

References

Mertens, D. R., 1983. Using neutral detergent fiber to formulate dairy rations and estimate the net energy content of forages. Page 60 in Proceedings... Cornell Nutr, Conf. Feed Manuf., Syracuse, NY. Cornell Univ., Ithaca, NY.

Mertens, D.R., 1985. Factors influencing feed intake in lactanting cows: From theory to aplication using neutral detergent fiber. In: PROC. 46 TH GA. NUTR. CONF. Athens. University of Georgia,1985.

Mertens, D.R., 1987. Prediciting intake and digestibility using mathematical models of ruminal functions. J. Animal Sci., 64 (7), 1548-58.

Peer-reviewed paper: 8th International Conference on Goats

Nelson, W.F. & SATTER, L.D., 1992. Impact of stage of maturity and method of preservation of alfalfa on digestion in lactating dairy cows. J.Dairy Sci. 75, 1571

Santini, F.J., Lu, C.D. & Potchoiba, M.J., 1992. Dietary fiber and milk yield, mastication, digestion, and rate of passage in goats fed alfalfa hay. J. Dairy Sci. 75,209-219.

Van Soest, P. J., Robertson, J. B., & Lewis, B. A., 1991. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74,3583-3597.

SAS. Statistical user's guide. Cary. North Carolina. SAS Institute. 1990.V.1. 890p.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

A comparison of plant form and browsing height selection of four small stock breeds – Preliminary results

I. du Plessis[1#], C. van der Waal[1] and E.C. Webb[2]
[1] Mara Research Station, Private Bag X 2467 Makhado (Louis Trichardt) 0920, South Africa
[2] Department of Animal & Wildlife Sciences, University of Pretoria, Pretoria, 0002, South Africa

Abstract

A direct observation technique was used to establish the foraging behaviour of Boer goats, Nguni goats, Pedi sheep and Dorper sheep. According to the Chi-square dissimilarity measure, plant-form (grass, forb, woody) differences between the diets of goats and sheep were greater than differences between the goat breeds and sheep breeds. The results from this study confirm that goats and sheep exhibit different foraging strategies. Sheep tend to forage more frequently from the herbaceous layer compared to goats, which also browse substantially from woody plants. Both goats and sheep increase their relative intake of woody plant products in winter. Goats tend to increase their woody browsing height in winter, probably adapting their foraging behaviour to fit differences in the canopy structures of prominent summer and winter forage species. Further research should be conducted to determine whether subtle differences in the foraging habits of different goat and sheep breeds exist.

Keywords: Browse, foraging behaviour, optimal resource use, savanna, stocking rate
[#] Corresponding author. E-mail: iduplessis@lantic.net

Introduction

The inclusion of small stock breeds is often perceived to complement cattle production systems due to the alternative use of foraging types by different animals. These differences should be quantified to assure optimal and responsible resource use. Furthermore, goats have been promoted as a biological remedy for the bush encroachment problem in southern Africa (Du Toit, 1972; Cooper, 1982). There are, however, indications that limitations imposed by the absolute intake of browse (Orihuela & Solana, 1999) and the height range (Dziba *et al*., 2003) of woody plant impact might limit the practicality of using goats as bush control agents.

The aims of this study were to compare four small stock breeds in terms of the diet overlap in plant-form (grass, forb, woody) composition and browsing height selection patterns.

Materials and Methods

The study was conducted on the eastern section of the Mara Research Station (23° 05' S and 29° 25' E; 961 m.a.s.l.). The Una official rainfall station (situated in the study area) measured a mean of 423.4 mm per annum from 1945 to 2002. Rainfall in the study area is concentrated in the hot summer months. Winter temperatures are mild and frost an infrequent occurrence. Mara is situated in the Arid Sweet Bushveld (Acocks, 1988). The vegetation in the study area comprises a short, shrubby structure that varies from open to closed woodland. Prominent woody species include *Combretum apiculatum, Commiphora pyracanthoides, Acacia tortilis*, *Grewia* species and *Boscia albitrunca*. The herbaceous layer includes the gramenoid species; *Eragrostis rigidior, Panicum maximum, P. coloratum* and *Urochloa mosambicensis* and various forb species.

A direct observation technique was used to study the foraging behaviour of Boer goats, Nguni goats, Pedi sheep and Dorper sheep. Animals were kept overnight in a holding pen and released into grazing camps in the mornings. Animals were habituated to human presence to such an extent that observations from a distance nearer than 5 m were possible. Four randomly selected foraging animals per breed were observed per session. Record was kept of the number of bites taken per plant species per focal animal. The height at which feeding took place from woody plants was also recorded. A minimum of 100 bites was observed per focal animal per observation session and in total two observation sessions were conducted in summer (February and March) and four in winter (June to September).

The overlap in plant-form (grass, forb, woody) selection between breeds was analysed with a Chi-square dissimilarity distances test (SPSS, 2002). Differences in foraging height between sheep and goats

Peer-reviewed paper: 8th International Conference on Goats

were analysed with the Kruskall-Wallis and Man-Whitney tests (SPSS, 2002) with animal type, season, plant form and browsing height as the main factors.

Results and Discussion

The dissimilarity distances between species (sheep *vs*. goats) were far greater (>17%) than between breeds of the same species (<9%) during both summer (Table 1) and winter (Table 2). This indicates that the goat breeds selected for a similar plant-form composition as did the two sheep breeds. The difference between the composition of sheep and goat diets is consistent with the results obtained in the Arid Karoo (Du Toit *et al*. 1995a) and in the Noorsveld (Du Toit *et al*., 1995b). In the present study the magnitude in plant-form dissimilarity between sheep and goats, which was the greatest between Nguni goats and Pedi sheep in winter (27.96%, Table 2), suggests considerable overlap in plant-form diet composition in both seasons studied. The narrowing of the dissimilarity distance between the goat breeds and the Dorper sheep during the winter (Table 2) suggests an increase in plant-form diet overlap relative to the diet overlap between goats and Pedi sheep. It follows that competition between different sheep and goat breeds is likely during times of forage shortages, e.g. dry seasons and droughts. The large overlap in the diet also indicates the futility of using both species to complement cattle in multi species production systems aimed at optimal resource utilisation. Grazer stocking rates should also be adapted to accommodate the inclusion of small stock in a farming enterprise.

Table 1 Dissimilarity matrix for the plant-form (grass, forb, woody) forage selection patterns of Boer goats, Nguni goats, Pedi sheep and Dorper sheep in summer

	Chi-square between sets of frequencies		
	Boer goats	Nguni goats	Pedi sheep
Nguni goats	4.033		
Pedi sheep	25.460	25.101	
Dorper sheep	23.385	22.714	7.731

Table 2 Dissimilarity matrix for the plant-form (grass, forb, woody) forage selection patterns of Boer goats, Nguni goats, Pedi sheep and Dorper sheep in winter

	Chi-square between sets of frequencies		
	Boer goats	Nguni goats	Pedi sheep
Nguni goats	5.558		
Pedi sheep	27.092	27.963	
Dorper sheep	17.350	19.212	8.812

Predictably a larger ($P < 0.05$) proportion of bites from woody plants was observed for goats compared to sheep. Sheep tend to restrict their foraging to the herbaceous layer (forbs and grass) (Figure 1). Both species, however, tend to increase woody plant use in winter (Figure 1).

Sheep and goats preferred to forage below a height of 1.0 m above ground in both seasons, with only a small proportion of bites taken from above 1 m height (Figure 1). The marked preference of sheep for feeding in the herbaceous layer precludes further analysis of height selection patterns in woody plant use by this species. Goats, in contrast, foraged extensively from woody plants and differences ($P < 0.05$) in the height stratification of bites from woody plants were evident between seasons (Figure 1). In the summer observations, goats preferred foraging in the 0-0.5 m stratum and shifted their feeding behaviour to forage from higher strata during winter when a greater ($P < 0.05$) proportion of bites was taken from above 0.5 m. It was only during winter that goats were observed foraging higher than 1 m above ground (Figure 1). The presumption that all browse up to a height of approximately 1.6 m is available to goats, as suggested by (Aucamp & Du Toit, 1980) for goats in the Eastern Cape, might not hold for other vegetation types and/or light stocking rates. The shift in browsing height, which tends to be at higher levels in winter, might be linked to a general decline in woody foliage availability due to the shedding of foliage of deciduous species and a decline in the nutritive value of the grass component. Under these conditions the remaining acceptable forage resources might be temporally under pressure. The depletion of foliage resources at preferred height

levels might subsequently force animals to increase the height of feeding. A contributing factor in our study, which could probably help explain the foraging-height behaviour of goats, might be linked to canopy shape differences between staple woody species in the study area. In the study area *Commiphora pyracanthoides* is a low-growing, early deciduous, spiny shrub that tends to have a skirt of branches resting on the ground with a tapering crown. *Boscia albitrunca* constitutes an evergreen tree species, which usually has a single trunk (which might branch into several stems) and a well-developed canopy. *C. pyracanthoides* (*ca*. 40% of goat bites) and *B. albitrunca* (*ca*. 35% of goat bites) were the woody species selected most frequently during the summer and winter respectively. It appears that goats adapted their feeding height in correspondence to the vertical arrangement of foliage resources on the respective woody species (Figure 2). A higher ($P < 0.05$) frequency of bites was taken below 0.5 m from *C. pyracanthoides* than from *B. albitrunca* while a higher ($P < 0.05$) frequency of bites was taken between 0.5 and 1.0 m from *B. albitrunca* than from *C. pyracanthoides*. These results are consistent with that of Du Toit (1972) that goats adapt easily to changes in the availability of forage. However, Dziba *et al*. (2003) did not find breed or season effects on browsing height preferences of goats.

Both Donaldson (1979) and Erasmus (2000) concluded that goats complement grazers in savanna areas by utilizing the woody component, but doubted their efficiency as bush control agents in extensive production systems and in the absence of fire. An overlooked factor might be the role that goats can play in controlling woody seedlings, which might over time shape woody plant communities and in the long-term reverse bush thickening. The apparent preference of goats to forage at levels close to the ground (<0.5 m) in this study (summer) and in a feeding height experiment (Haschick & Kerley, 1996) might predispose woody seedlings to goat herbivory at a vulnerable time in a woody plant's life cycle.

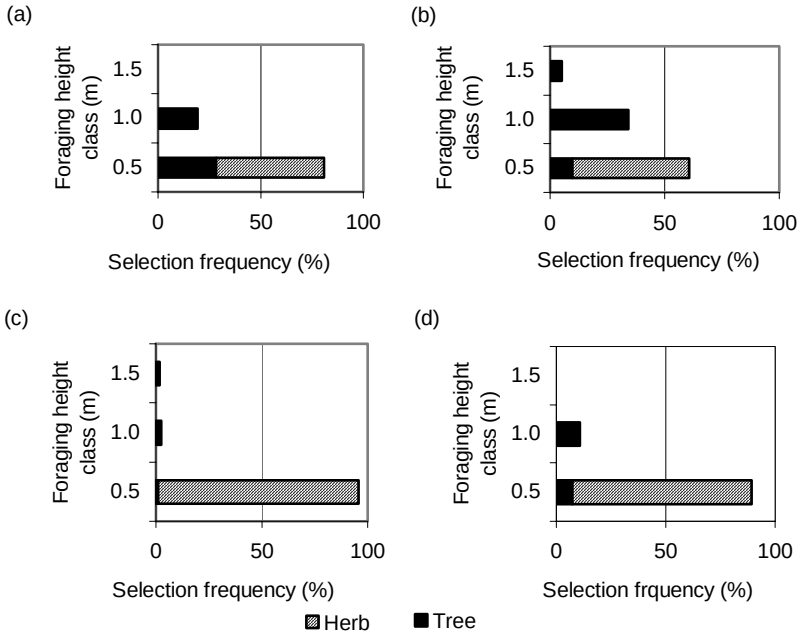
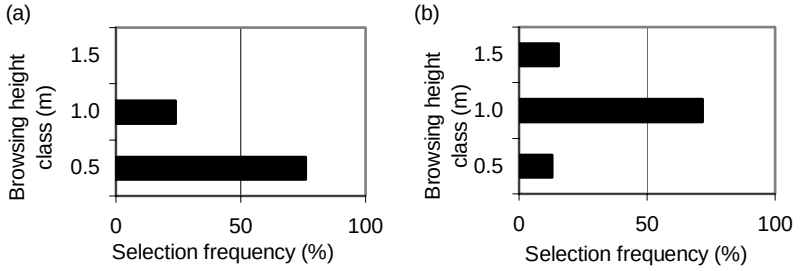


Figure 1 Preferred foraging height for goats (panels a and b) and sheep (panels c and d) during the summer (panels a and c) winter (panels b and d) based on all the forage plant types



Peer-reviewed paper: 8th International Conference on Goats

Figure 2 Preferred foraging height for the goats browsing *C. pyracanthoides* (panel a) and *B. albitrunca* (panel b)

Conclusion

Although goats and sheep have diet dissimilarities, they also have a large overlap in diet selection, resulting in inter-species competition for available forage under heavy stocking rates. Although goats can readily change their foraging behaviour according to changes in vegetation and plant growth form, both goats and sheep prefer to forage at levels below 0.5 m. It is thus recommended that where goats are used in conjunction with other grazing animals, correct stocking rates should be adhered to. The design of this study did not allow for subtle differences in foraging behaviour of the respective sheep and goat breeds to be established. Further research should therefore be conducted in an effort to quantify such possible differences.

References

Acocks, J.P.H., 1988. Veld types of South Africa. Memoirs of the Botanical Survey of South Africa 57.

Aucamp, A.J. & du Toit, P.F., 1980. The Boer goat in a grass-bush community. Boer Goat News. 1, 17-25.

Cooper, S.M., 1982. The comparative feeding behaviour of goats and impalas. Proc. Grassld. Soc. S. Afr. 17, 117-121.

Donaldson, C.H., 1979. Goats and/or cattle on Mopani veld. Proc. Grassld. Soc. S. Afr. 14, 199-123.

Du Toit, P.F., 1972. The goat in a bush-grass community. Proc. Grassld. Soc. S. Afr. 7, 44-50.

Du Toit, P.C.V., Blom, C.D. & Immelman, W.F., 1995a. Diet selection of sheep and goats in the Arid Karoo. Afr. J. Range For. Sci. 12, 16-26.

Du Toit, P.C.V., Blom, C.D. & Immelman, W.F., 1995b. Diet selection of sheep and goats in the Noorsveld. Afr. J. Range For. Sci. 12, 27-37.

Dziba, L.E., Scoggings, P.F., Goedon, I.J. & Raats, J.G., 2003. The feeding height preference of two goat breeds fed *Grewia occidentalis L.* (*Tiliaceae*) in the Eastern Cape, South Africa. Small Rumin. Res. 47, 31-38.

Erasmus, J.A., 2000. Adaptation to various environments and resistance to disease of the Improved Boer goat. Small Rumin. Res. 36, 179-187.

Haschick, S.L. & Kerley, G.I.H., 1996. Experimentally determined foraging heights of Bushbuck *Tragelaphus scriptus* and Boer goats *Capra hircus*. S. Afr. J. Wildl. Res. 26, 64-65.

Orihuela, A. & Solano, J.J., 1999. Grazing and browsing times of goats with 3 levels of herbage allowance. Appl. Anim. Behav. Sci. 61, 335-339.

SPSS, 2002. SPSS Version 11.5 for Windows. SPSS Inc., USA (www.spss.com).

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

The effect of type and level of carbohydrate supplementation on intake and digestibility of *Atriplex nummularia* cv. De Kock

C.J.L. du Toit*, W.A. van Niekerk#, N.F.G. Rethman[1] and R.J. Coertze
Department of Animal and Wildlife Sciences, University of Pretoria, Pretoria 0002, South Africa
[1]Department of Plant Production and Soil Science, University of Pretoria, Pretoria, 0002, South Africa

Abstract

The effects of type of carbohydrate supplementation on intake and digestibility of *Atriplex nummularia* cv. De Kock were investigated. Ten rumen cannulated sheep were fed different increments of maize and barley supplements (0%, 15%, 30%, 45%) to a basal diet of *A. nummularia* cv. De Kock. Supplementation of *A. nummularia* cv. De Kock with an energy source tended to increase NDF digestibility, decrease rumen pH and with maize as a supplement, increase intake.

Keywords: *Atriplex*, carbohydrates, fermentability
#Corresponding author. E-mail: willem.vanniekerk@up.ac.za
*Present address: Department of Agriculture: Animal Production, Tshwane University of Technology, Private Bag X680, Pretoria, 0001, South Africa

Introduction

Atriplex nummularia has proved to be a very useful drought tolerant crop for bridging the periods when natural pasture does not satisfy the nutritional requirements of small stock (Jacobs & Smit, 1977). Research has shown that the nutritive value of *A. nummularia* (cv. De Kock) is sufficient for maintenance of small stock (Verschoor, 1992). The most limiting nutrient is energy (6.1 MJ ME /kg DM), with crude protein (21%) being sufficient to maintain a certain level of production (Weston *et. al.*, 1970). The aim of this experiment was to quantify the influence of type and level of carbohydrate supplementation (high and medium fermentability) on the digestibility of *A. nummularia* cv. De Kock.

Materials and Methods

Ten rumen cannulated sheep were used in a split plot design. The experimental diets consisted of *A. nummularia* supplemented with maize (medium fermentability) and barley (high fermentability) at three different levels (15%, 30% and 45%) on a dry matter basis. Neutral detergent fibre (NDF) concentrations of the diets were determined by the method described by Van Soest & Wine (1967). An electronic pH meter was used to determine the pH of rumen fluid after each sample was taken (Robinson *et. al.,* 1986).

An analysis of variance with the Proc GLM model (SAS, 1994) was used to determine the significance between treatments and different levels of supplementation. Least square means and standard errors (SE) were determined. Significance of difference (5%) between least square means was determined by using Bonferroni's test (Samuels, 1989).

Results and Discussion

The results in Table 1 indicate that supplementation of both energy sources tended towards an increase (not significant) in dry matter intake when compared to the control. Significant differences occurred at the 45% of maize and 30% of barley inclusion levels compared to the lower supplementation levels. The higher intake could have been as a result of the higher palatability and digestibility of the two energy sources. The NDF digestibility tended towards a significant increase from 0% to 15% and from 0% to 30% and 45%. These increases may be due to positive associative effects occurred in the rumen. Significant positive associative effects of grain supplementation were noted for feedlot animals by Huck *et al*. (1998). Fermentation of starch in the rumen increased propionic acid concentrations in the rumen and improved starch utilization. It also appeared to increase estimated uptake of amino acids from the small intestine (Theurer *et al.,* 1999). This may partly explained the higher intake with energy supplementation. With the 30% and 45% supplementation rates of both energy sources, there was a drop in the NDF digestibility (not significant), most probably due to negative associative effects in the rumen. There was a significant drop in rumen pH from the control group to 30% and from the control group to 45% supplementation rates in both

Peer-reviewed paper: 8th International Conference on Goats

the energy sources. The drop in pH supported the possibility of negative associative effects in the rumen. These negative associative effects were most probably responsible for the decrease in NDF digestibility (non significant) when the supplementation was raised from 15% to 30% and from 30% to 45% in both treatments. The lower intake of barley at the 45% supplementation level (high fermentation rate), together with a drop in rumen pH, correlated with the lower NDF digestibility. It is well known that a lower ruminal pH will have a negative effect on cell wall digestibility and thus on intake (Minson, 1990).

The differences between the two carbohydrate sources were overall small and not significant, except for intake at the 45% supplementation level. McCarthy *et al*. (1989) reported positive intake results in favour of the slower fermentable carbohydrate source, which was the case with maize supplementation in this study.

Table 1 Dry matter intake, % NDF digestibility and rumen pH, of sheep fed *Atriplex nummularia* cv. De Kock at different levels of supplementation by two energy sources

		Treatments	
	Supplementation level (%)	Maize	Barley
Intake /kg W (g /day)	0	23.46_1^{a} (±3.7)*	32.2_1^{ab} (±3.3)
	15	23.58_1^{a} (±3.3)	21.2_1^{a} (±3.7)
	30	33.51_1^{ab} (±3.3)	37.9_1^{b} (±3.3)
	45	38.63_1^{b} (±3.3)	25.7_2^{a} (±3.7)
% NDF digestibility	0	30.24_1^{a} (6.5)	28.21_1^{a} (5.8)
	15	51.58_1^{a} (5,8)	61.57_1^{b} (6.5)
	30	40.22_1^{a} (5.8)	51.54_1^{b} (5.8)
	45	42.72_1^{a} (5.8)	41.56_1^{ab} (6.56)
pH (H_2O)	0	6.98_1^{a} (±0.11)	7.05_1^{a} (±0.10)
	15	6.77_1^{ab} (±0.10)	6.75_1^{ab} (±0.11)
	30	6.50_1^{bc} (±0.11)	6.53_1^{b} (±0.10)
	45	6.10_1^{c} (±0.10)	5.94_1^{c} (±0.10)

Column (a,b,c) and row (1,2) means with common scripts do not differ ($p>0.05$)
*Values in brackets designate standard errors

Conclusion

Supplementation of *A. nummularia* cv. De Kock with an energy source tended to increase intake. The tendency of energy sources to increase NDF digestibility diminished when the supplemental level was raised from 15% to 30% and from 30% to 45%. These results suggested that barley and maize supplemented at a level of 15% gave the highest incremental increase in DM and NDF digestibility in *A. nummularia* cv. De Kock. Negative associative effects occurred in the rumen at supplemental levels of 30% and above.

Acknowledgement

This research was supported in part under Grant No. TA-MOU-99-C16-091 funded by the U.S.-Israel Cooperative Development Research Program, Bureau for Economic Growth, Agriculture and Trade, U.S. Agency for International Development.

Peer-reviewed paper: 8th International Conference on Goats

References

Huck, G.L., Kreikemeier, K.K., Kuhl, G.L., Eck, T.P. & Bolson, K.K., 1998. Effects of feeding combinations of steam flaked grain sorghum and steam flaked high moisture or dry rolled corn on growth performance and carcass characteristics in feedlot cattle. J. Anim. Sci. 76, 2984-2988.

Jacobs, G.A. & Smit, C.J., 1977. Benutting van vier *Atriplex* spesies deur skape. Agroanimalia 9, 37-41.

McCarthy, R.D., Klusmeyer, T.H., Vicini, L.J. & Clark, J.H., 1989. Effect of source of protein and carbohydrate on ruminal fermentation and passage of nutrients to the small intestine of lactating cows. J. Dairy Sci. 72, 2002-2016.

Minson, D.J., 1990. Forage in ruminant nutrition. Academic Press, Toronto. Pp. 1-8.

Robinson, P.H., Tamminga, S. & Van Vuuren, A.M., 1986. Influence of declining level of feed intake and varying portion of starch in the concentrate on rumen fermentation in dairy cows. Livest. Prod. Sci. 15, 173-189.

Samuels, M.L., 1989. Statistics for the life sciences. Collier MacMillan Publishers, London.

SAS, 1994. Statistical Analysis Systems User's Guide. Statistics Version 6. SAS Inst., Inc. Cary, NC., USA.

Theurer, C.B., Wanderley, R. & Huber, J.T., 1999. Steam flaking grains may improve nutritional value. Feedstuffs 71(20), 16.

Van Soest, P.J. & Wine, R.H., 1967. Use of detergents in the analysis of fibrous feeds IV. Determination of plant cell constituents. J. Assoc. Off. Anal. Chem. 50,50.

Verschoor, A., 1992. Die rol van oumansoutbos (*Atriplex nummularia* lindl) as weigewas in hoë reënval gebiede. M.Sc. (Agric) dissertation, University of Pretoria, Pretoria, South Africa.

Weston, R.H., Hogan, J.P. & Hemsley, J.A., 1970. Some aspects of the digestion of *Atriplex nummularia* by sheep. Proc. Aust. Soc. Anim. Prod. 8, 507-512.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Level of feed intake on performance of two goat genotypes

J.M. Dzakuma[1#], E. Risch[1], C.O. Smith[1]* and H.D. Blackburn[2]

[1]International Goat Research Centre, Box 4079, Prairie View A&M University, Prairie View, TX 77446, USA
[2]National Animal Germplasm Program, National Centre for Genetic Resources Preservation, ARS, USDA, Fort Collins, CO 80521, USA

Abstract

There is a paucity of literature characterizing response to varying levels of feed intake in goats. A controlled experiment was designed at Prairie View A&M University (PVAMU) with purebred goats, to measure feed intake, and its subsequent effects on growth of different goat genotypes when raised intensively. Two goat populations, the Spanish (SP) and the Tennessee Stiff-legged (TS) were fed three levels: 100% or *ad lib.*, 85% and 70% of *ad lib.*, of the same ration containing 18% CP and 65% ME. Daily feed intake, bi-weekly growth weights, orts and faeces were collected until yearling age. Feed intake, in intermediate sized SP (67.7 kg), was equal to that of small sized TS (66.7 kg), at 13 months. Feed efficiency calculated for SP and TS breeds, respectively, from weaning to six months was 0.122 *vs* 0.167 kg and from 9 to 13 months was 0.088 *vs* 0.104 kg), and differed significantly from each other. This implies that the TS breed was more efficient in converting feed into weight gain compared to the SP breed. Knowledge of the interaction between feed intake, genotype and subsequently, body composition changes will help characterize growth curves in goats.

Keywords: Spanish, Tennessee Stiff-legged, goats, feed intake, efficiency
[#]Corresponding author. E-mail: jackson_dzakuma@pvamu.edu
[*]Present address: Cargill Foods, Inc./Excel Corporation, 33 Dart Rd., Newnan, GA 30265. USA

Introduction

Feed intake in ruminants is difficult to measure, particularly when animals are free grazing. It is, however, one of the most, if not the most important factor in allowing meat animals to express their genetic potential. Studies have been conducted with cattle (Woldehawariat *et al.*,1990*;* Patterson *et al.,* 2003). Intake studies conducted with goats are limited and are usually of shorter duration. Sahlu *et al.* (1999) concluded that the level of feed intake can have a more prolonged effect on mohair growth than body weight change. The small-bodied Assamese goat (8 kg at 9-10 months) in India is very prolific. The goat was crossbred to the medium sized Beetal breed to increase growth and meat yield. Saikia *et al*. (1995) measured feed intake in the crossbred goat to determine energy required for optimum growth, and reported that a diet containing 120 g CP/kg, 70% ME and 3 MJ DE/kg DM was most suitable. On the other hand, Smith (2000) and Dzakuma *et al.* (2002) have conducted intake studies over longer periods of time, from weaning to yearling ages. Such measures of intake are needed, for different goat genotypes, in order for growth to be fully expressed and studied. There is a dearth of literature characterizing response to varying levels of feed intake in goats. Thus, a controlled experiment with purebred goats raised intensively was conducted. The objective of this paper is to present results on feed intake and measures of feed efficiency and their interactions with genotype. Effects of feed intake on growth of these goats have been presented by Risch *et al.* (2001) and Blackburn *et al.* (2001).

Materials and Methods

In 1997/98, the International Goat Research Centre at Prairie View A&M University established a project to perform growth curve analyzes on different goat genotypes under varying nutritional regimes. Twenty four goats of each breed, comprised of equal sexes, were penned in individual crates and fed varying levels (100% or *ad libitum*, 85% and 70% of the previous week's *ad lib* averages for both males and females) of an 180 g CP/kg and 65% ME diet. Amount of feed given was weighed daily and orts, faeces and urine were collected and weighed. Bi-weekly weights were taken on all goats until they were slaughtered at approximately six and 13 months of ages. Two breeds of goats, the Spanish (SP) representing an intermediate breed and the Tennessee Stiff-legged (TS) representing a small mature size breed were used in characterizing growth curves. (Mature sizes, as measured on three- to four-year old PVAMU female goat population, were: SP = 47.5 and TS = 36.8 kg). Weaning weight was adjusted to a constant age by

Peer-reviewed paper: 8th International Conference on Goats

multiplying average daily gain (ADG) from birth to weaning by the standard length of time in days,

i.e., Adjusted weaning weight = Birth weight + 70 (Average daily gain from birth to weaning). Average daily gain, post weaning, was calculated as the difference in weight between the final and initial weights divided by the interval in days from the dates the initial and final weights were taken,

i.e., ADG = Weight gain / interval in days.

Feed efficiency (FE) was calculated as the difference in weight between the final and initial weights divided by the amount of feed consumed between the dates the initial and final weights were taken,

i.e., FE = Weight gain / Feed consumed.

These variables (ADG post weaning and FE) were calculated between weaning and six months and then between nine and 13 months of age in the 1997/98 population. These periods corresponded to where data were collected on these goats. Analyses of all variables used in this paper were performed using the GLM procedure in SAS (1999), with dietary level, breed, and sex as main effects. Interaction effects tested were, breed *x* dietary level, and sex *x* dietary level, and breed *x* sex *x* dietary level. Only results from the main effects and two way interactions will be presented in this paper.

Results and Discussion

For the main effects of dietary level, weights from weaning (wn, 70 days) to six months (176 days) and from nine months (219 days) to 13 months (395 days) correspond to where data were collected (Table 1). Consistent differences existed at all three dietary levels for the two breeds of goats as measured at biweekly intervals. Cumulative amount of feed eaten, from weaning to 176 d of age, differed ($P < 0.001$) between goats maintained at the 70%, 85% and 100% levels (41.7, 48.1 and 62.9 kg), respectively. Differences also existed in the cumulative intake from 219 to 395 days of age. Intake for goats maintained at the 70% levels differed ($P < 0.001$) from those at the 85% and 100% levels (61.0 *vs* 68.9 and 71.7 kg), respectively. These differences may have been caused as a result of restricting the amount of feed given, however, they provide meaningful interpretation of results.

Table 1 Feed intake least squares means (kg): Main effects of dietary level, breed and sex

Days	85	99	114	128	141	155	176	Cum 6 Mo intake	Avg[1] daily intake	Cum 13 Mo intake	Avg[2] daily intake
Dietary Level											
70%	2.10	4.24	5.15	6.43	7.64	6.61	9.56	41.73[a]	0.39[a]	60.99[a]	0.35[a]
85%	2.43	5.20	6.34	7.89	9.00	7.06	10.17	48.10[b]	0.44[b]	68.89[bc]	0.39[bc]
100%	3.41	6.64	7.81	9.67	11.54	9.03	14.76	62.86[c]	0.61[c]	71.69[c]	0.41[c]
Breed											
SP	2.54	5.48	6.67	8.14	9.28	7.64	11.51	51.52	0.49	67.72	0.38
TS	2.76	5.24	6.20	7.86	9.51	7.49	11.49	50.54	0.47	66.65	0.38
Sex											
F	2.60	5.47	6.43	8.21	9.27	7.48	11.62	51.08	0.49	63.69[a]	0.36[a]
M	2.69	5.25	6.43	7.78	9.52	7.65	11.38	50.71	0.48	70.69[b]	0.40[b]

[a,b,c]Column means with different superscripts differ significantly ($P < 0.05$)
[1]Average daily intake at 6 months. [2]Average daily intake at 13 months

No statistically significant differences were observed for main effects of breed in feed intake amounts between the SP and the TS breeds throughout the duration of the study (Table 1). Cumulative amount of feed intake for the SP and the TS breeds, respectively, from weaning to six months of age were (51.5 and 50.5 kg) and from 6-13 months of age were (67.7 and 66.7 kg). The smaller TS breed ate just about the same amount of feed as the intermediate SP breed. Differences ($P < 0.001$) in cumulative intake amounts were observed for female and male goats (63.7 and 70.7 kg), respectively, at 395 days, but not at 176 days.

For the interaction effects of dietary level x breed, comparisons were made between SP and TS at 70, 85 and 100% levels. The following results, in kg, were obtained for, respectively, comparing the SP at 70% to the TS at 70% level of the ration, at the following days: 85 (12.0 *vs* 8.7); 99 (13.3 *vs* 10.3); 114 (13.4 *vs* 9.5); 128 (14.7 *vs* 11.9); 141 (16.4 *vs* 13.3); 155 (17.0 *vs* 14.1) and 176 (18.5 *vs* 16.0). From day 85 through

Peer-reviewed paper: 8th International Conference on Goats

day 176 or six months of age, the SP breed maintained at the 70% dietary level was significantly heavier ($P < 0.05$) than the TS breed maintained at the same level. Thereafter there were no differences in weight gain of the two breeds compared at the same dietary level. This may be because the SP and TS breeds were virtually eating the same amount of feed as shown in Table 1. No differences ($P > 0.05$) were observed in cumulative feed intake from 219 days to 395 days for the SP and the TS breeds, respectively, at 70% level (61.1 *vs* 60.9 kg) nor at 85% level (69.2 *vs* 68.6 kg) and at 100% level (72.9 *vs* 70.5 kg). This implies the same amount of feed intake for SP and TS breeds within nutritional levels of the ration.

Least squares means for feed efficiency (FE) and average daily gain (ADG) are shown in Table 2. Feed efficiency as indicated by the main effects of breed for SP and TS breeds, respectively, $FE_{wn\text{-}6\ mo}$ (0.122 *vs* 0.167) and $FE_{9\text{-}13\ mo}$ (0.088 *vs* 0.104) were different ($P < 0.01$) from each other. Similarly, $ADG_{wn\text{-}6mo}$ (0.058 *vs* 0.083) differed ($P < 0.01$) but not $ADG_{9\text{-}13\ mo}$ (0.034 *vs* 0.038). This would imply that during $FE_{wn\text{-}6\ mo}$, the TS breed was more efficient in growth, gaining 0.167 kg weight/kg of feed consumed compared to a gain of 0.122 kg weight/kg feed consumed for the SP breed. Breed differences in the efficiency of body weight gain over a fixed age or weight intervals have been clearly shown in beef cattle (Smith *et al.*, 1976; Cundiff *et al.*, 1981).

Table 2 Main effects on least squares means for feed efficiency (FE_i) and average daily gain (ADG_i).

	$FE_{wn\text{-}6\ mo}$	$FE_{9\text{-}13\ mo}$	$ADG_{wn\text{-}6\ mo}$ kg	$ADG_{9\text{-}13\ mo}$ kg
Dietary Level				
70%	0.153	0.119[a]	0.060[a]	0.042
85%	0.132	0.071[b]	0.061[a]	0.028
100%	0.148	0.097[a]	0.092[b]	0.039
Breed				
SP	0.122[a]	0.088	0.058[a]	0.034
TS	0.167[b]	0.104	0.083[b]	0.038
Sex				
F	0.142	0.095	0.071	0.034
M	0.146	0.096	0.071	0.038

[a,b]Column means with different superscripts differ significantly ($P < 0.05$)

Statistically significant differences were observed in birth (3.2 *vs* 2.5 kg) and in weaning weights (12.8 *vs* 10.1 kg), respectively, for SP and TS goats. Prior experiences with these breeds formed the basis for classifying the SP as an intermediate sized breed and the TS as a small sized breed, *a priori*. Despite the size differences, when the "P" values obtained from analyses of growth weights of these two breeds were examined, they indicated that the differences in weights started to diminish from 85 days through to 141 days. On approaching 176 days, no statistically significant differences in growth weights were observed between the SP and TS breed (19.1 *vs* 18.6 kg), respectively. Neither were there statistically significant differences in growth weights, for the SP and the TS breeds, from 219 days through to 395 days when the project was terminated. Such a result implies TS is growing more efficiently than SP, confirmed by feed efficiency and average daily gain calculated on these goats in Table 2. Blackburn *et al.* (2001) from fitting the Brody (1945) growth function to these data also reported the same maturing rates (0.00268) for the SP and the TS breeds.

Conclusions

Feed efficiency showed how much weight was gained from consuming one kilogram of feed for Spanish (0.122 kg) and Tennessee Stiff-legged (0.167 kg) breeds. Statistically significant weight differences existed between the intermediate size SP and the small size TS breed to a point when dietary level x breed interactions were examined. However, the smaller TS breed was more efficient in converting feed into kilograms of weight gain and eventually grew at the same rate as the intermediate SP breed. The average daily gain indicated that the TS gained faster than the SP (0.083 *vs* .058 kg at six months). Intake at six months (50.5 *vs* 51.5 kg) and 13 months (66.7 *vs* 67.7 kg), respectively, for TS and SP was similar. Knowledge of the interaction between feed intake and genotype will help the characterization of growth curves.

Peer-reviewed paper: 8th International Conference on Goats

References

Blackburn, H.D., Dzakuma, J.M. & Goetsch, A.L., 2001. Goat growth in relation to feed intake. J. Anim. Sci. 79 (Suppl. 1), 179.

Brody, S., 1945. Bioenergetics and Growth. Hafner Publishing Co., New York.

Cundiff, L.V., Koch, R.M., Gregory K.E. & Smith, G.M., 1981. Characterization of biological types of cattle – Cycle II. IV Postweaning growth and feed efficiency of steers. J. Anim. Sci. 53, 332-346.

Dzakuma, J.M., Risch, E., Beckfod, N.C., Smith, C.O., Johnson, P.M., Nuti, L.C. & Kom, S.E., 2002. Goat production in relation to nutrition and environmental conditions. In: Proc. Scientific Conf. on Goats. Eds. Dzakuma, J.M., Risch, E. & Johnson, B.M., 2002. Prairie View A&M University. Prairie View, Texas, USA. pp. 52-69.

Patterson, H.H., Klopfenstein, T.J., Adams, D.C. & Musgrave, J.A., 2003. Supplementation to meet metabolizable protein requirements of primiparous beef heifers: I. Performance, forage intake, and nutrient balance. J. Anim. Sci. 81, 800-811.

Risch E., Dzakuma, J.M., Johnson, P.M., Smith, C.O. & Blackburn, H.D., 2001. Growth as a function of feed intake. In: Proc. 6th Intl. Livest. Environ. Symp. ASAE. Louisville, Kentucky, USA. pp. 103-118.

Sahlu, T., Hart, S.P. & Goetsch, A.L., 1999. Effect of level of feed intake on body weight, body components, and mohair in Angora goats during realimentation. Small Rumin. Res. 32, 251-259.

Saikia, G., Baruah, K.K., Buragohain, S.C., Saikia, B.N. & Pathak, N.N., 1995. Feed intake, utilization of nutrients and growth of Assamese x Beetal goats fed three levels of energy. Small Rumin. Res. 15, 279-282.

SAS, 1999. SAS/STAT User's Guide (Version 8). SAS Institute Inc., Cary, North Carolina, USA.

Smith, C.O., 2000. Feed intake, growth and body composition changes in Spanish and Tennessee Stiff-legged goats. MS thesis. Prairie View A&M University. Prairie View, Texas, USA.

Smith, G.M., Laster, D.B., Cundiff, L.V. & Gregory, K.E., 1976. Characterization of biological types of cattle. II. Postweaning growth and feed efficiency of steers. J. Anim. Sci. 43, 37-47.

Woldehawariat, G., Cartwright, T.C. & Long, C.R., 1990. Efficiency of weight gain of serial slaughtered bulls of a five-breed diallel. J. Anim. Sci. 68, 3096-3102.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Effect of level of rumen protected CLA supplementation on milk yield and composition in Saanen goats

L.J. Erasmus[1#], Z. Bester[1], T. Fourie[2], R.J. Coertze[1] and L. Hall[3]
[1]Department of Animal and Wildlife Sciences, University of Pretoria, Pretoria 0002, South Africa
[2]Limpopo Dairy, 19 Trichardt Street, Makado 0920, South Africa
[3]BASF Animal Nutrition S.A. (Pty) Ltd, 7 Foundry Road, Isando, South Africa

Abstract

The objective of this study was to investigate the effect of level of rumen protected conjugated linoleic acid (CLA) 35 on milk yield and composition in Saanen goats. Eight multiparous goats were used in an eight animals and four periods repeated Latin square experimental design. Supplementation levels were based on 10% of the recommended level for cows. Goats were fed either a control, 1.3 g/d, 2.6 g/d or 3.9 g/d. The rumen protected CLA 35 contained 17.5% of each of the *cis 9-trans 11* and *trans 10-cis 12* isomers respectively. Supplementation of up to 3.9 g rumen protected CLA 35, which is on a bodyweight basis, equivalent to 150% of the recommended level for cows, did not affect milk yield or composition. In a second trial 10 additional goats were used in a two treatment factorial design and fed either 30 or 60 g of rumen protected CLA 35. Milk lactose, protein and milk urea nitrogen concentrations were not affected. When the average milk fat percentage of the two days prior to the trial were compared with the fat percentage on day 8, 60 g rumen protected CLA 35 reduced milk fat by 0.57 percentage units compared to 0.07 units when 30 g rumen protected CLA 35 was fed. The results suggest that much higher levels of rumen protected CLA/unit of body weight would be needed in goats, as compared to cows, to suppress butterfat production to the same extent as in cows. Therefore, dairy goats cannot merely be used as a model for cows in butterfat depression studies and more long-term studies on CLA supplementation of goats are needed.

Keywords: Conjugated linoleic acid, Saanen goats, milk composition, milk yield
[#]Corresponding author. E-mail: lourens.erasmus@up.ac.za

Introduction

Conjugated linoleic acids (CLA) are a group of fatty acids that are microcomponents of ruminant fat. Research interest in CLA stemmed from the fact that CLA has been shown to have anticarcinogenic properties and possibly other effects that would be positive for human health (Pariza, 2001).

As a consequence of the positive health effects of CLA, there has been a large effort to increase CLA content in milk, thus increasing the value of milk. A surprising result from studies that attempted to increase milk CLA was that CLA also significantly reduced milk fat percentage and yield (Chouinard *et al*., 1999; Mackle *et al.,* 2002). Rumen protected CLA also decreased milk fat in cows fed either a total mixed ration (TMR) or pasture grazing (Giesy *et al.*, 1999; Medeiros *et al.*, 2000). The magnitude of milk fat depression depends on the amount fed and can be up to 50% (Baumgard *et al.*, 2002). The CLA supplements used in abovementioned studies contained various types of CLA. It is now well accepted that the *trans-10, cis-12* CLA isomer is responsible for milk fat depression and the *cis-9, trans-11* isomer is important due to its potential health benefits (Bauman *et al.*, 2001).

In most milk payment schemes a premium is paid for milk volume, milk fat, milk protein and hygienic quality. Nutritional strategies therefore aim to prevent depression of milk solids. There are, however, some scenarios in which reduced output of milk fat would be advantageous (Bauman *et al.*, 2001).

More than one third of fresh milk consumed in South Africa is purchased on the basis of volume and hygienic quality. Only some milk buyers require a minimum fat %. It would be pointless for milk producers supplying these milk buyers, to sell milk with a high fat content. They could benefit from CLA supplementation by producing higher volumes of low fat milk. Theoretically it would be possible to adjust the level of CLA supplementation to produce milk with a fat % preferred by the milk buyers.

Supplementation with CLA is also a strategy that could be employed during the immediate *post partum* phase to decrease the magnitude of the energy deficit by decreasing the amount of energy secreted as milk fat. Theoretically a milk fat depression would relieve some of the energy demands of the fresh cow,

allowing the cow to reach a higher peak production and increase overall performance (Baumgard *et al*., 2002).

Results available in dairy cows, goats and sheep showed that responses to fat supplementation differ considerably between the species. Milk yield increases in mid-lactation cows, but not in goats and ewes. Milk fat content and secretion sharply increases in dairy ewes and goats, but not always in dairy cows in which it could often either decrease or remain unchanged. Milk protein content decreases in dairy cows and ewes, but not in goats. The reasons for these differences in dairy performance in response to fat supplementation between ruminant species are not easy to identify since less information is available for goats and ewes than for cattle (Chilliard *et al.*, 2003).

The demand for goat milk has increased significantly in South Africa and goat milk producers are constantly looking for ways to increase fluid milk production. A controlled milk fat depression through CLA supplementation has shown to increase milk production in Holsteins (Giesy *et al.,* 1999), but it is questionable whether these results can be extrapolated to goats. The purpose of this study was to determine the effect of short term supplementation of various levels of CLA on milk composition and yield in Saanen goats and to determine whether lactating goats could be used as a model for cows when conducting milk fat depression studies.

Materials and Methods

Multiparous Saanen goats (58 ± 10 days in milk) were used in an 8 animal and 4 period repeated Latin square design (Gill, 1978). Conjugated linoleic acid supplementation levels were calculated on a body weight (BW) basis and based on 10% of the manufacturer's recommended level for cows (26 g/d). The treatments were control (C), 50% of the recommended level for cows (0.5 CLA, 1.3 g/d), 100% of the recommended level for cows (1.0 CLA, 2.6 g/d) and 150% of the recommended level (1.5 CLA, 3.9 g/d). The rumen protected CLA 35 (RP CLA 35) contained 17.5% of the *cis-9, trans-11* and 17.5% of the *trans-10, cis-12* isomers, respectively (BASF Aktiengesellschaft, 67056 Ludwigshafen, Germany). Each of the four periods lasted eight days.

The goats were fed a pelleted lucerne and maize based total mixed ration (170 g CP/kg, 10.9 MJ ME/kg DM) *ad lib*. The RP CLA 35 was administered orally each morning after milking. Milking times were 06:00 and 18:00 and goats were milked in a 10 point herringbone parlour. Milk production and dry matter intake were recorded daily and composite milk samples were taken two days before the onset of the trial and thereafter on days 1, 3, 5, 7 and 8 of each experimental period. Milk was analyzed for fat, protein, lactose and milk urea nitrogen (MUN) using a Milkoscan 6000 system (Hillerod, Denmark). An analysis of variance with the ANOVA model (SAS, 1994) was used to determine the significance between different levels of rumen protected CLA for the Latin square design. Means and standard error of the mean (SEM) were calculated. Significance of difference (5%) between means was determined by multiple comparisons, using Tukey t-test (Samuels, 1989).

Preliminary inspection of results suggested no response in milk fat and yield due to CLA supplementations and a second trial was conducted using 10 additional multiparous Saanen goats in a two treatment factorial design. The purpose of this trial was to determine if milk fat would be depressed when feeding 30 g or 60 g of RP CLA 35/goat/d. This represents approximately a 10 and 20 fold increase respectively of the "recommended" level. Each treatment was randomly allocated to five goats and was fed for eight days. The goats were in the same stage of lactation and similar in milk production and composition. Management and sampling were similar to experiment 1. An analysis of variance with the ANOVA model (SAS, 1994) was used to determine the significance between different levels for the balanced data. The response in milk components was determined as the difference between the average milk composition of the 2d prior to the trial and d 8 of the experimental period.

Results and Discussion

The effect of various levels of RPCLA 35 on intake, milk yield and composition is shown in Table 1 (Trial 1). None of the parameters measured was affected by supplementation of up to 0.63 g of the *trans-10, cis-12* CLA isomer. This is in contrast to studies where abomasal infusions of 2.5 g and 3.5 g respectively of the *trans 10, cis 12* isomer reduced butterfat from 3.12 to 2.60% and from 3.00 to 2.28% in cows (Baumgard *et al*., 2002). Chouinard *et al*. (1999) reported a production increase of 3.6 kg/d and fat reduction of 0.52% in cows after supplementation with rumen protected CLA. Results from trial 1 suggest

Peer-reviewed paper: 8th International Conference on Goats

that dairy cows and goats differ in their responses to fat supplementation, suggesting that the dairy goat is perhaps not suitable to be used as a model for milk fat depression studies in cows. It has been suggested by Hart (2000) that rate of passage of digesta in goats is higher than in cows. In goats this could decrease the effect of dietary fatty acids on the yield of some ruminal factors that reduced mammary lipogenesis in cows.

Table 1 Effect of level of rumen protected CLA on milk composition, yield and dry matter intake of Saanen goats (Trial 1)*

	Control	0.5 CLA	1.0 CLA	1.5 CLA	SEM
Milk (kg/d)	3.96	3.88	3.80	3.89	0.19
Fat (%)	3.53	3.61	3.65	3.50	0.21
Protein (%)	2.97	2.98	2.93	2.98	0.10
Lactose	4.58	4.63	4.61	4.61	0.10
MUN (mg %)	32.0	32.5	31.4	31.2	1.83
DMI (kg/d)	2.75	2.69	2.62	2.78	0.20

[ab]Values in the same row with different superscripts differ ($P < 0.05$)
*0.5 CLA = 1.3 g/d; 1.0 CLA = 2.6 g/d; 1.5 CLA = 3.9 g/d.

The effect of high levels of RPCLA 35 (Trial 2) on milk yield and composition of Saanen goats is shown in Table 2. Milk protein, lactose and MUN levels were not affected. Sixty grams of RPCLA 35, however, caused milk fat % to be reduced by 0.57 percentage units ($P < 0.05$) compared to 0.07 units with 30 g RPCLA 35 when comparing the average milk fat of the two days prior to the trial with that on day 8. Results suggest that much higher levels of RPCLA 35/unit of BW are needed in goats to suppress butterfat % to the same extent as in cows. Our results support the conclusion of Gulati *et al.* (2000) that further long term feeding and dose response trials need to be undertaken to study the effect of RPCLA 35 on milk yield and composition of dairy goats.

Table 2 Effect of supplementation of 30 or 60 g of rumen protected conjugated linoleic acid 35 on milk composition response in Saanen goats (Trial 2)

	30 g RPCLA[1]	60 g RPCLA	SEM
Change in[2]:			
Fat (%)	0.07[a]	0.57[b]	0.20
Protein (%)	0.05	0.01	0.54
Lactose (%)	0.00	0.06	0.23
MUN (mg%)	1.28	3.73	4.31

[ab]Values in the same row with different superscripts differ ($P < 0.05$)
[1]Product contained 17.5% each of the *cis 9, trans 11* and *trans 10, cis 12* isomers
[2]Percentage units change when the average milk composition of the 2d prior to the trial is compared to the average milk composition on d 8.

Conclusion

Rumen protected CLA, based on level of supplementation data extrapolated from cow data, did not affect short term milk yield and composition of lactating Saanen goats. Results suggest that much higher levels of rumen protected CLA might be needed to significantly depress butterfat and the dairy goat cannot merely be used as a model when conducting butterfat depression studies with cows. Further long term dose response and lactation studies are needed to quantify the effect of RPCLA on dairy goat performance.

Acknowledgements

BASF Aktiengesellenschaft, Ludwigshafen, Germany, is thanked for financial support and Joubert Fourie and Corne Willemse from Limpopo Dairy for providing facilities to conduct the study.

Peer-reviewed paper: 8th International Conference on Goats

References

Bauman, D.E., Corl, B.A., Baumgard, L.H. & Griinari, J.M., 2001. Conjugated linoleic acid in the dairy cow. In: Recent Advances in Animal Nutrition. Eds. Garnsworthy, P.L. & Wiseman, J., Nottingham University Press, Nottingham, UK. pp. 221-240.

Baumgard, L.H., Moore, C.E. & Bauman, D.E., 2002. Potential application of conjugated linoleic acids in nutrient partitioning. Proc. Southwest Nutr. Mgmt. Conf. Univ. Arizona, AZ, USA.

Chouinard, P.Y., Corneau, L., Barbano, D.M., Metzger, L.E. & Bauman, D.E., 1999. Conjugated linoleic acids alter milk fatty acid composition and inhibit milk fat secretion in dairy cows. J. Nutr. 129, 1579–1584.

Chilliard, Y., Ferlay, A., Rouel, J. & Lamberet, G., 2003. A review of nutritional and physiological factors affecting goat milk lipid synthesis and lipolysis. J. Dairy Sci. 86, 1751-1770.

Giesy, J.G., Viswanadha, S., Hanson, T.W., Falen, L.R., McGuire, M.A., Skarie, C.H. & Vinci, A., 1999. Effects of calcium salts of CLA and estimated energy balance in Holstein cows in early lactation. J. Dairy Sci. 82 (Suppl 1) 74 (Abstr.)

Gill, J.L., 1978. Design and analysis of experiments in the animal and medical sciences. Vol 2. Iowa State University Press, Ames, IO.

Gulati, S.K., Kitess, S.M., Ashes, J.R., Fleck, E., Byers, E.B., Byers, Y.G. & Scott, T.W., 2000. Protection of conjugated linoleic/acids from ruminal hydrogenation and their incorporation into milk fat. Anim. Feed Sci. Technol. 86, 139-148.

Hart, S.P., 2000. Nutrition for the high producing dairy doe. J. Anim. Sci. 78 (Suppl. 1), 8.

Mackle, T.R., Kay, J.K., Auldist, M.J., MacGibbon, A.K.H., Philpott, B., Baumgard, L.H. & Bauman, D.E., 2002. Effects of abomasal infusion of conjugated linoleic acid on milk fat concentration and yield from product fed dairy cows. J. Dairy Sci. (Submitted).

Medeiros, S.R., Oliveira, D.E., Aroeria, L.J.M., McGuire, M.A., Bauman, D.E., & Lanna, D.P.D., 2000. The effect of long term supplementation of CLA of dairy cow grazing tropical posture. J. Dairy Sci. 83 (Suppl. 1), 169.

Pariza, M.W., Park, Y. & Cook, M.E., 2001. The biologically active isomers of conjugated linoleic acid. Progress in Lipid Research 40, 283.

Samuels, M.L., 1989. Statistics for the life sciences. Collier MacMillan Publishers, London.

SAS, 1994. Statistical Analysis Systems users guide: Statistics Version 6. SAS Institute Inc., Cary, NC, USA.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Essential amino acid requirements of meat and milk goats

A.V. Ferreira
Department of Animal Sciences, Faculty of Agricultural and Forestry Sciences, University of Stellenbosch, Private Bag X1, Matieland 7602, South Africa

Abstract

The essential amino acid (EAA) profile of the Boer goat and Saanen kids was investigated. The EAA composition of the components differed from the whole empty body (WEB) concentration. No significant differences between the two species WEB EAA composition were found. Therefore, the average empty body EAA composition (g EAA/100 g crude protein) for goats was as follow: 5.65 arginine; 2.69 histidine; 2.94 isoleucine; 7.86 leucine; 6.83 lysine; 1.83 methionine; 3.04 phenylalanine; 5.55 threonine; 4.86 valine. This composition can serve as the ideal EAA requirements for growth in meat and milk goats.

Keywords: Boer goat, Saanen, essential amino acids, carcass, offal, whole empty body
#Corresponding author. E-mail: avf@sun.ac.za

Introduction

Ruminants utilize protein for growth most efficiently when provided with a supply of amino acids that matches tissue requirements (Hussein *et al*., 1991). It is also recognized that the balance of amino acids required for growth in mammals can be determined from the amino acid composition of body protein (Cole & Van Lunen, 1994). According to Boisen *et al*. (2000) the ideal protein can be defined as the perfect ratio among individual amino acids and nitrogen required for optimal performance. Once the amino acid profile of the ideal protein has been established, it can be used indirectly to identify the limiting amino acids in the diet supplied to the animal in order to achieve a particular productive performance (Chen & Ørskov, 1994). In an attempt to obtain more information on the EAA requirements of goats, the ideal protein concept can be used to determine the optimal amino acid profile required for growth. Ferreira *et al*. (1999) recommended that in ruminants the WEB should be used for this purpose.

The potential of the Boer goat as a meat-producing animal was recognised by early researchers such as Owen & Norman (1977). On the other hand most of the male Saanen kids on a dairy farm are being culled at a very early age mainly because of their low growth rates. This may be improved with better knowledge about their nutrient requirements. Since there is no information regarding the EAA requirements of goats, further research is required. The purpose of the present study was to determine: (a) the proportional protein contribution in the carcass, external and internal offal of Boer and Saanen goats relative to whole empty body (WEB) protein, (b) to compare the EAA composition of the carcass, internal and external offal of Boer and Saanen kids and (c) the EAA requirements (ideal protein) for WEB growth of meat and milk goats.

Material and Methods

A group of 20 castrated goats, 10 Boer goat and 10 Saanen kids, all aged seven months, was slaughtered after receiving a feedlot diet for 60 days. The average live weight of the Boer goats and Saanen kids were 35.03 ± 1.24 kg and 34.90 ± 1.95 kg, respectively. The carcasses were split medially through the vertebrae. The right side of the carcass, external offal (head, feet and skin) and internal offal (heart, heart fat, liver, lungs and trachea, kidneys, kidney fat, gastro-intestinal fat, spleen, diaphragm, stomachs and intestines) were stored at –20 °C. All the body components were milled twice through a carcass mill while still frozen. The EAA composition of the carcass, external offal and internal offal were determined separately. Representative samples of all the components were mixed, according to weight, to obtain a WEB sample. The freeze-dried samples were then milled through a 1 mm screen, thoroughly mixed and stored at –10 °C. The EAA composition of the WEB samples were determined with a BECKMAN SYSTEM 7300 high performance analyser after 22 h of acid hydrolysis (6N HCL) at 110 °C (AOCA, 1997). Analyses of variance were performed on the data using SAS (2000).

Peer-reviewed paper: 8th International Conference on Goats

Results and Discussion

The mean protein concentration of the WEB was similar between Boer goats (27.64 ± 0.8%, as is) and Saanen kids (28.34 ± 0.9%, as is). There were no significant differences in the proportional protein contribution (Table 1) in the carcass, external offal and internal offal relative to the WEB protein content between the two goat species. Comparing the proportional percentage of protein in the carcass of the goat species to that of sheep (MacRae *et al*., 1993; Ferreira *et al*., 1999) the goats have a higher proportional percentage of protein in the carcass than sheep (38.4 – 49.2%), but a lower proportional percentage of protein in the external offal (34.0 – 38.1%).

Table 1 Proportional protein contribution (%) (mean ± s.e.) in the carcass, external and internal offal of Boer goat and Saanen kids (n = 10) relative to whole empty body protein

Component	Protein distribution (%)	
	Boer goat	Saanen
Carcass	56.51 ± 2.3	56.26 ± 2.3
External offal	21.46 ± 3.1	18.69 ± 2.6
Internal offal	22.03 ± 2.8	25.04 ± 2.7
Whole empty body	100 ± 0.0	100 ± 0.0

The WEB EAA composition remained similar regardless of species and data were therefore pooled (Table 2). The comparison of the EAA composition of carcass, internal and external offal exhibited significant differences in and between species. This illustrates that different organs and tissues have different required amino acid ratios. The average amino acid concentrations of the carcass, internal and external offal also differed ($P < 0.05$) with that of the WEB. This confirms the importance to use WEB values for predicting EAA requirements for growth.

Table 2 The amino acid composition (mean ± s.d.) of carcass, internal-, external offal and whole empty body of Boer goats (BG) and Saanen kids (g EAA/100 g CP) (n=10)

EAA	Carcass		Internal offal		External offal		Whole
	BG	Saanen	BG	Saanen	BG	Saanen	empty body[1]
Arg	5.93^{c} ±0.51	6.23^{b} ±0.31	4.51^{d} ±0.35	3.94^{e} ±0.21	6.33^{b} ±0.62	6.79^{a} ±0.32	5.65^{c} ±0.22
His	2.67^{c} ±0.26	2.80^{c} ±0.18	3.74^{a} ±0.22	3.13^{b} ±0.31	1.33^{d} ±0.18	1.43^{d} ±0.17	2.69^{c} ±0.16
Iso	3.44^{a} ±0.43	3.64^{a} ±0.17	1.99^{d} ±0.30	1.99^{d} ±0.23	2.40^{c} ±0.24	2.57^{c} ±0.17	2.94^{b} ±0.19
Leu	7.32^{d} ±0.81	7.76^{c,d} ±0.32	10.49^{a} ±0.77	8.70^{b} ±0.59	5.97^{f} ±0.59	6.50^{e} ±0.40	7.86^{c} ±0.36
Lys	6.37^{b} ±0.99	6.78^{b} ±0.56	6.82^{b} ±0.59	5.19^{c} ±0.64	8.88^{a} ±0.98	9.24^{a} ±0.52	6.83^{b} ±0.42
Met	2.05^{a} ±0.31	2.21^{a} ±0.13	1.79^{b} ±0.18	1.55^{c} ±0.19	1.11^{d} ±0.12	1.07^{d} ±0.10	1.83^{b} ±0.15
Phe	2.79^{d} ±0.27	2.99^{c} ±0.13	4.27^{a} ±0.23	3.39^{b} ±0.35	2.27^{e} ±0.18	2.38^{e} ±0.15	3.04^{c} ±0.13
Thr	5.23^{c} ±0.64	5.60^{b} ±0.23	6.58^{a} ±0.40	5.96^{b} ±0.25	4.61^{d} ±0.49	5.19^{c} ±0.46	5.55^{b} ±0.29
Val	4.55^{c} ±0.51	4.83^{c} ±0.18	6.08^{a} ±0.41	5.36^{b} ±0.22	3.97^{d} ±0.38	4.19^{d} ±0.26	4.86^{c} ±0.23
Σ EAA	40.35^{b} ±1.85	42.84^{a,b} ±1.96	46.27^{a} ±2.71	39.21^{b} ±2.1	36.87^{b,c} ±2.61	39.96^{b} ±2.77	41.27^{a} ±2.07

^{a,b,c,d,e,f}Values in rows bearing different superscript letters are significantly different ($P < 0.05$)

[1]Average for Boer and Saanen empty body

Table 3 Average body essential amino acid (EAA) composition (g EAA/100 g protein), chemical score (mean ± SD) and EAA index for microbial protein of goats (n = 20)

EAA	Goats	Chemical score[1]	Bacteria[2]
Arg	5.65 ± 0.22	90.2 ± 4.31	5.1
His	2.69 ± 0.16	74.3 ± 8.13	2.0
Iso	2.94 ± 0.19	193.8 ± 3.39	5.7
Leu	7.86 ± 0.36	103.0 ± 4.39	8.1
Lys	6.83 ± 0.42	115.6 ± 5.25	7.9
Met	1.83 ± 0.15	142.1 ± 5.61	2.6
Phe	3.04 ± 0.13	167.6 ± 2.46	5.1
Thr	5.55 ± 0.29	104.5 ± 4.93	5.8
Val	4.86 ± 0.23	127.6 ± 3.67	6.2
EAA Index (%)[3]		96.1	

[1] Chemical score presents the proportion of a specific EAA relative to that of WEB protein; [2] NRC (1996)

[3] EAA index presents the proportion of all the EAA studied relative to that of WEB protein

In order to identify a first- and second-limiting amino acid for goats, the chemical score and resulting EAA index were calculated (Table 3). The chemical score in Table 3 suggests that the first- and second-limiting amino acids in bacterial protein are histidine and arginine. More than adequate ratios are presented for the other amino acids. Richardson & Hatfield (1978) reported that methionine, lysine and threonine were the first three limiting amino acids in growing steers when rumen microbial protein was the sole source of protein. It should, however, be mentioned that, according to Newbold (1988) the importance of arginine may be overestimated when comparing the amino acid composition of tissues with that of the duodenal digesta. Arginine tends to be only semi-essential for ruminants (Boisen *et al.*, 2000) and it is not known if arginine is synthesized or released at adequate rates to meet arginine requirements (Zinn & Owens, 1993). Furthermore, histidine requirements may also be overestimated by using tissue chemical scores, since histidine is found in large endogenous reservoirs as non-protein dipeptides, carnosine and serine (Zinn *et al*., 2000).Based on the EAA index (Table 3), the microbial protein contains 96.1% of the total EAA needed by the WEB for optimal growth in goats.

Conclusion

The proportion of protein in the carcass of the two goat species investigated was much higher, compared to sheep. The carcass also represents the major site of protein deposition (56%). The EAA required for carcass muscle growth would therefore be required at higher dietary concentrations than the EAA needed for non-carcass proteins. The significant differences in EAA concentration between body components emphasized the use of WEB values for predicting EAA requirements. There were no differences in the EAA composition of the WEB of the meat and milk goats investigated.

References

AOAC, 1997. Official methods of analysis (15th ed.) Association of Official Analytical Chemists, Arlington, VA, USA.

Boisen, S., Hvelplund, T. & Weisbjerg, M.R., 2000. Ideal amino acid profiles as a basis for feed protein evaluation. Livest. Prod. Sci. 64, 239-251.

Chen, X.B. & Ørskov, E.R., 1994. Amino acid nutrition in sheep. In: Amino Acids in Farm Animal Nutrition. Ed. D'Mello, J.F.P., Guildford, UK.

Cole, D.J.A. & Van Lunen, T.A., 1994. Ideal amino acid patterns. In: Amino Acids in Farm Animal Nutrition (Chapter 5). Ed. D'Mello, J.F.P., Guildford, UK.

Ferreira, A.V., Van der Merwe, H.J., Loëst. C.A. & Fair, M.D., 1999. Amino acid requirements of South African Mutton Merino lambs. 2. Essential amino acid composition of the whole empty body. S. Afr. J. Anim. Sci. 29, 27-39.

Hussein, H.S., Jordan, R.M. & Stern, M.D., 1991. Ruminal protein metabolism and intestinal amino acid utilization as affected by dietary protein and carbohydrate sources in sheep. J. Anim. Sci. 69, 2134-2146.

MacRae, J.C., Walker, A., Brown, D. & Lobely, G.E., 1993. Accretion of total protein and individual amino acids by organs and tissue of growing lambs and the ability of nitrogen balance techniques to quantitate protein retention. Anim. Prod. 57, 237-245.

Newbold, J.R., 1988. Nutrient requirements of intensively reared beef cattle. In: Recent Advances in Animal Nutrition (vol 2). Eds. Haresign, W. & Cole, D.J.A., Butterworths, London.

Owen, J.E. & Norman, G.A., 1977. Studies of the meat production characteristics of Botswana goats and sheep. 2. General body composition, carcass measurements and joint composition. Meat Sci. 1, 283-306.

Richardson, C.R. & Hatfield, E., 1978. The limiting amino acids in growing cattle. J. Anim. Sci. 46, 740-745.

SAS, 2000. Statistical Analysis Systems user's guide (Version 8.2), SAS Institute Inc., Cary NC, USA.

Zinn, R.A. & Owens, F.N., 1993. Ruminal escape protein for lightweight feedlot calves. J. Anim. Sci. 71, 1677-1687.

Zinn, R.A., Alvarez, E.G., Monto, M.F. & Ramirez, J.E., 2000. Interaction of protein nutrition and laidlomycin on feedlot growth performance and digestive function in Holstein steers. J. Anim. Sci. 78, 1768-1778.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Feed intake and growth of Saanen kids weaned at 42 and 70 days of age

A.V. Ferreira# and J.D. Thornton
Department of Animal Sciences, Faculty of Agricultural and Forestry Sciences, University of Stellenbosch, Private Bag X1, Matieland 7602, South Africa

Abstract

The effect of weaning age (42 *vs* 70 days) on the feed intake and growth performance from seven to 140 days of age was investigated, using 58 male Saanen kids. Final body weight, average daily gain and feed conversion efficiency did not differ significantly between weaning ages during the creep (days 7-80), growth diet (days 81-140) or the total (days 7-140) experimental periods. Only feed intake, cumulative feed intake, dry matter (DM) intake and cumulative DM intake differed significantly in the creep (days 7-80) period. The creep intake (days 7-80) of the 42 day weaning treatment was 48%, which was significantly higher than the 70 day treatment due to creep feed replacing milk intake. Corresponding with a feed intake of 240 g/day and a total metabolisable energy intake of 295 ± 1.4 MJ/kid over the 7 to 42 day period, the kids underwent no post-weaning shock in terms of their growth performance and had the same final weight (29.9 ± 2.0 kg) as the 70 day weaning treatment at 140 days of age.

Keywords*:* Saanen, kids, weaning age, intake
#Corresponding author. E-mail address*:* avf@sun.ac.za

Introduction

Goats are found all over the world, whether it is mountainous, flat, hot, cold, wet or dry. They not only survive but also manage to generate products in the form of meat, fibre and milk (Haenlein, 1996). Goat milk is an important source for cheese and ice-cream. Feeding milk to kids would be an expensive practice when there is a great demand for milk. Thus, the weaning of the kids as early as possible would be beneficial provided that the growth performance and feed intake of kids are not affected in a negative way. Knowledge on the effect of weaning age on the performance of dairy goat kids is scarce when compared with dairy calves. Mowlem (1992) suggested that kids weaned at an early age will not undergo a post-weaning growth shock, provided their DM intake is sufficient. This study was conducted to determine the effect of weaning age (42 *vs* 70 days) of age of Saanen kids on their feed intake and growth performance from 7 to 140 days.

Materials and Methods

A pelleted creep and growth diet (Table 1) was formulated according to the NRC (1985). At 7 days of age 58 male Saanen kids were randomly assigned to a 42 or 70 day weaning age treatment. Kids received 1200 mL of Saanen ewe milk per day (increased by 100 mL/day from 600 mL/day at 7 days) for either 42 or 70 days. The ewes' stage of lactation correlated with the age of the kids. Until 7 days of age the kids were grouped to prevent losses due to the cold. At 7 days of age the kids were individually penned, and feed and water were available *ad lib.* Kids received creep pellets *ad lib.* from day 7 to day 80 and growth pellets *ad lib.* from day 81 to day 140. Kids were fed twice daily and orts was collected daily, and the pooled weight determined weekly. Kids were also weighed weekly. Feed intake (creep and growth diet), DM intake (milk plus creep and/or growth diet), average daily gain and feed conversion efficiency (kg feed/kg weight gain) were calculated for each kid. The mathematical model for the analyses of feed intake, DM intake, daily gain and feed conversion included fixed effects due to weaning age (42 *vs* 70 days) and residual error (SAS, 1990).

Results

The effect of weaning age on the performance of Saanen kids receiving a creep and growth diet is presented in Table 2. Final body weight, average daily gain and feed conversion efficiency did not differ significantly between weaning age in the creep diet (7-80 days), growth diet (81-140 days) or the total (7-140 days) experimental period. Only the feed intake, cumulative feed intake, DM intake and cumulative DM intake differ significantly in the creep (7-80 days) period. The creep intake (7-80 days) of the 42 day

Peer-reviewed paper: 8th International Conference on Goats

weaning treatment was 48% higher ($P < 0.05$) than the 70 day treatment. In the 42 day weaning treatment the kids were consuming 240 g creep diet per day at weaning. The total ME intake of this group over the 7 to 42 day period was calculated as 295 ± 1.4 MJ/kid (26.1 ± 0.2 L milk/kid with 4% butter fat content and 3.2 ± 0.034 kg creep/kid on a DM basis).

Table 1 Physical (on an air dry basis) and chemical (on a dry matter basis) composition (g/kg) of the creep and growth diet

Item	Content	
	Creep	**Growth**
Physical composition		
Maize meal	205.6	323.4
Wheat bran		137.5
Groundnut oilcake (450 g/kg CP)	33.3	33.3
Sunflower oilcake (375 g/kg CP)	107.9	16.2
Soya oilcake (465 g/kg CP)	23.4	
Full fat soya	50.0	
Maize germ oil[1)]	100.0	100.0
Lucerne meal	300.0	220.0
Molasses meal	90.0	90.0
Supermax premix[2)]	68.1	54.6
Vit A,D,E premix	1.0	1.0
Eco oxytet 20 %	0.5	0.5
Salt	10.2	15.8
Sheep minerals[3)]	0.5	0.5
Ammonium chloride	5.0	7.5
Taurotec[4)]	0.3	0.3
Limestone	3.8	1.6
Chemical composition		
Dry matter (g/kg)	898.1	881.0
Organic matter (g/kg)	908.2	888.0
Crude protein (g/kg)	210.0	165.0
UDP[5)] (g/kg)	59.6	45.2
ME[5)] (MJ/kg)	11.6	11.6
Crude fibre (g/kg)	113.7	97.1
ADF (g/kg)	152.2	159.2
NDF (g/kg)	306.3	298.1
Fat (g/kg)	49.7	38.2
Ca[5)] (g/kg)	7.7	7.7
P[5)] (g/kg)	3.9	3.9
Na[5)] (g/kg)	2.3	3.4

1) Supplied by Cape Oil (Berkley road, Box 16, Maitland, South Africa)
2) Rumen inert fat, supplied by marine Oil (Division of Tiger Brands, Main road Didovalley, Simons Town, South Africa)
3) A standard macro- and micro mineral supplement formulated according to the NRC (1985) (Meadow Feed Mills, South Africa)
4) Growth promoter supplied by Roche (Wycroft road, Box 13167, Mowbray, South Africa)
5) Chemical composition as calculated by Meadow Feed mills Cape (Paarl, South Africa)

Morand-Fehr (1976) reported that there was no detrimental influence due to weaning when Alpine kids were consuming 30-50 g dry feed per day. As seen from Table 2, the Saanen kids had, due to their normal growth pattern, a faster growth rate between 81 and 140 days on the growth diet, than between 7 and 80 days on the creep diet. In addition, the results of the present study associated with live weight values are consistent with those reported in the literature (Morand-Fehr *et al.,* 1982).

Peer-reviewed paper: 8th International Conference on Goats

Table 2 The effect of weaning age on the performance (mean ± s.e.) of male Saanen kids from 7 to 140 days of age

Measurement	Weaning age (days)	
	42	70
No. of kids	30	28
7–80 days: Creep diet		
Initial body weight (kg)	6.4±0.17	6.4±0.18
Final body weight (kg)	15.9±0.57	15.4±0.60
Cumulative feed intake (kg)	24.9±1.32[a]	16.8±1.39[b]
Feed intake (g/day)	395±20.9[a]	266±22.0[b]
Cumulative dry matter intake[1)] (kg)	27.6±1.18[a]	22.7±1.24[b]
Dry matter intake[1)] (g/day)	437±18.7[a]	361±19.7[b]
Average daily gain (g/day)	150±8.1	142±8.6
Feed conversion efficiency[1)] (kg feed/kg weight gain)	3.0±0.13	2.8±0.14
81-140 days: Growth diet		
Initial body weight (kg)	15.9±0.57	15.4±0.60
Final body weight (kg)	29.9±1.95	29.9±2.05
Cumulative feed intake (kg)	50.6±3.21	51.9±3.38
Feed intake (g/day)	904±57.2	927±60.3
Cumulative dry matter intake (kg)	45.2±2.86	48.1±3.02
Dry matter intake (g/day)	807±51.0	858±53.8
Average daily gain (g/day)	250±23.9	259±25.2
Feed conversion efficiency (kg feed/kg weight gain)	3.3±0.25	3.4±0.25
7-140 days: Total period		
Initial body weight (kg)	6.4±0.17	6.4±0.18
Final body weight (kg)	29.9±1.95	29.9±2.05
Cumulative feed intake (kg)	75.5±5.30	68.7±5.59
Feed intake (g/day)	634±44.6	577±46.9
Cumulative dry matter intake[2)] (kg)	72.7±4.73	70.8±4.99
Dry matter intake[2)] (g/day)	610±39.8	594±41.9
Average daily gain (g/day)	197±15.6	198±16.5
Feed conversion efficiency[2)] (kg feed/kg weight gain)	3.2±0.14	3.0±0.14

[a,b] Values within a row not followed by the same superscript letters differ ($P < 0.05$)
[1)] Milk plus creep diet intake
[2)] Milk plus creep and growth diet intake

Conclusions

In this trial weaning at 42 days of age has proven to be effective. Kids underwent no post-weaning shock and had the same final weight as the 70 day weaning treatment at 140 days of age. There were no problems associated with health and mortality in reared kids.

References

Haenlein, G.F.W., 1996. Status and prospects of the Dairy Goat Industry in the United States. J. Anim. Sci. 74, 1173-1181.

Morand-Fehr, P., 1976. Growth. In: Goat Production. "Growth", Academic Press Inc., pp. 253-283.

Morand-Fehr, P., Hervieu, J., Bas, P.& Sauant, D., 1982. Feeding of young goats. Proc. Third Int. Conf. Goat Production and Disease. Tucson, Arizona, USA. pp. 90-104.

Mowlem, A., 1992. Goat farming (2nd ed.). Kid rearing. Farming Press. pp. 81-95.

NRC, 1985. Nutrient requirements of domestic animals. Nutrient requirements of sheep. (6th rev. ed.). National Academy of Sciences, Washington, D.C., USA. p. 47.

SAS, 1990. Statistical Analysis System user's guide (Version 6, 4th ed.). SAS Institute Inc. Cary, NC, USA. pp. 891.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

The effect of dietary protein degradability on production characteristics of lactating Saanen does

A.V. Ferreira# and J.D. Thornton
Department of Animal Sciences, Faculty of Agricultural and Forestry Sciences, University of Stellenbosch, Private Bag X1, Matieland 7602, South Africa

Abstract
Twenty-one lactating Saanen goats of similar milk yield and lactation number were fed one of three experimental protein diets: low UDP (160 g CP/kg DM), high UDP, low protein (128 g CP/kg DM), and high UDP high protein (160 g CP/kg DM). The aim of the study was to determine whether an increased UDP and decreased RDP content would increase production and also whether a decreased CP content and an increased UDP content would sustain the production of lactating Saanen does. The does on the low UDP diet had significantly higher feed intakes and were significantly heavier at the end of the trial period of 120 days. No differences in milk production or composition were observed. The CP intake/kg milk yield was 113 ± 0.01 g (4% butterfat). The low protein (20% less CP) high UDP diet was able to sustain a similar milk production with a significantly better conversion (29.3%) of N into milk protein than the other diets. In contrast the decrease in RDP and increase in UDP content, at the same CP level, did not improve the production potential of the does.

Keywords: Dairy goats, Saanen, protein degradability, milk production
#Corresponding author. E-mail: avf@sun.ac.za

Introduction
During the past 20 years the dairy goat population across the globe has increased by 52% (Haenlein, 2000). Knowledge on the protein requirements and particularly protein degradability requirements of dairy goats is scarce. In recent years there has, however, been an increased interest in the effect of protein supplementation to lactating animals (Mishra & Rai, 1996). Santos *et al*. (1998) reviewed 108 published studies from 1985 till 1995. It was strongly suggested that the use of rumen undegradable protein (UDP) in the diets of dairy cows often resulted in a decreased rumen degradable protein (RDP) intake, and a change in absorbed amino acid profiles. The review concluded that increased UDP levels in the diet do not consistently improve lactation production. The aim of the present study was to determine whether an increased UDP and decreased RDP content would increase production and also whether a decreased crude protein (CP) content and an increased UDP content would sustain the production of lactating Saanen does.

Material and Methods
Twenty-four lactating Saanen does (59.0 ± 2.6 kg live weight) were divided according to milk production and lactation number into three groups of eight each. Each group was allocated to one of the experimental protein diets: low UDP, low protein-high UDP and high UDP on an *ad lib* feeding regime. The RDP:UDP ratios in the pelleted diets were 72:28, 62:38 and 55:45, respectively. The low UDP and high UDP diets were iso-nitrogenous, at 160 g CP/kg DM, whereas the low protein-high UDP diet contained 20% less CP (128 g CP/kg DM). All the diets were iso-energetic. Local fish meal and cotton oilcake were used as natural sources of UDP.

The experiment was carried out over a 120 day lactation period, starting at 14 days *post partum*. The does were milked twice daily at 6:30 and 15:30. Milk production was recorded after each milking. The body weight, feed intake and milk samples for analyses were taken on a weekly basis. During the second last week of the production trial, six does/diet were used to compare the three diets in a nitrogen metabolism trial. Total collection of faeces and urine was conducted daily. Twenty millilitre of urine preservative (80 g potassium dichromate and 20 g mercuric chloride dissolved in 1 L of distilled water) were added each morning to the urine collection jugs to prevent volatilisation of ammonia from the urine. Faeces and urine were sub-sampled daily (10%) and composited over the whole period, prior to chemical analysis. Nitrogen (N) retention was corrected both for endogenous urinary N and metabolic faecal N according to McDonald *et al*. (1988). Methane gas production (MJ/day) was calculated as 8% of energy intake (McDonald *et al*., 1988).

Peer-reviewed paper: 8th International Conference on Goats

Milk samples were analysed with a Milk-O-Scan apparatus for butterfat, protein, lactose and urea. The N and gross energy content of the feed, faeces and urine were determined according to the AOAC (1995). During the third week of the trial three does of different treatments became ill with bluetongue and refused all feed for a couple of days. Therefore, the data from these does' omitted. Data were tested for normality using the Shapiro-Wilk statistic (Shapiro & Wilk, 1965). Data were analysed as a randomised block, using the GLM procedure of SAS (1994).

Results and Discussion

From Table 1 it is evident that both feed and dry matter intake were higher ($P < 0.05$) in the low UDP group than in the other treatments. Neither milk production, nor milk composition differed between treatments. Only the CP intake showed a significant difference between diets for all the milk production efficiency characteristics calculated.

Table 1 The effect of dietary RDP:UDP ratio and crude protein concentration on the milk production parameters and efficiency (mean ± s.e.) in lactating Saanen does over a 120-day trial period

	Low UDP	Low protein, high UDP	High UDP
Number of animals	8	6	7
Initial bodyweight (kg)	61 ± 2.4	55 ± 2.6	61 ± 2.8
Final bodyweight (kg)	65 [a] ± 2.1	56 [b] ± 2.3	58.6 [ab] ± 2.8
Feed intake (kg)	2.1 [a] ± 0.11	1.7 [b] ± 0.11	1.7 [b] ± 0.12
Dry matter intake (kg/day)	1.9 [a] ± 0.01	1.5 [b] ± 0.10	1.6 [b] ± 0.11
Milk production (kg/day)	1. 3.0 ± 0.25	1. 2.6 ± 0.29	12.8 ± 0.34
Fat corrected milk, 4% (kg/day)	2.8 ± 0.06	2.5 ± 0.26	2.4 ± 0.31
Milk protein (%)	2.7 ± 0.06	2.7 ± 0.07	2.7 ± 0.08
Milk lactose (%)	4.5 ± 0.06	4.6 ± 0.07	4.6 ± 0.08
Corrected fat (%)	2.3 ± 0.13	2.7 ± 0.15	2.3 ± 0.18
Total fat for 120 days (kg)	9.4 ± 0.74	8.2 ± 0.84	8.7 ± 0.10
Total protein for 120 days (kg)	13.1 ± 1.09	12.1 ± 1.24	11.2 ± 1.46
Urea (mg/dl)	34.5 ± 1.65	31.5 ± 1.87	34.8 ± 2.21
Milk yield per kg dry matter intake (kg)	1.6 ± 0.10	1.7 ± 0.11	1.8 ± 0.12
Fat corrected milk (4 %) per kg dry matter intake (kg)	1.5 ± 0.11	1.7 ± 0.12	1.6 ± 0.13
ME intake (MJ/day)	18.1 ± 0.96	15.7 ± 1.03	16.0 ± 1.11
ME intake per kg milk yield (MJ)	6.1 ± 0.43	6.5 ± 0.45	5.8 ± 0.49
CP intake (g/day)	350 [a] ± 0.02	260 [b] ± 0.02	300 [b] ± 0.02
CP intake per kg milk yield (g)	120 ± 0.01	110 ± 0.01	110 ± 0.01

[a, b] Values in rows bearing different superscript letters differ significantly ($P < 0.05$)

According to Van der Merwe & Smith (1991) a 50 kg doe requires 150 g of CP for the production of 1 kg of milk. This differs considerably from the value for goats stated in the NRC (1981), where the total protein requirement for the production of 1 L milk with a 3% butterfat is given as 64 g. In the present study the CP intake per kg milk yield was 113 ± 0.01 g (4% butterfat). This value was similar to that recorded by Mishra & Rai (1996) for lactating goats.

According to Table 2 the does on the low UDP diet had a significantly higher intake of N than the low protein high UDP diet, due to their higher feed intake and higher dietary CP level. Regarding N loss through the faeces and urine, the same differences ($P < 0.05$) as in N intake were observed. No significant differences in N loss through milk production were observed. The total loss of N was higher ($P < 0.05$) in the low UDP diet compared with the low protein high UDP diet. Nitrogen secretion in milk as a percentage of the total N intake was significantly higher in the low protein high UDP diet compared with the low UDP diet.

Peer-reviewed paper: 8th International Conference on Goats

Table 2 The effect of dietary RDP:UDP ratio and crude protein concentration on nitrogen balance (mean) in lactating Saanen does over a 120-day trial period (n = 6)

	Low UDP	Low protein, high UDP	High UDP	SEM
$Nitrogen_{in}$ (g/day)	57.2^{a}	44.2^{b}	51.1^{ab}	3.42
$Nitrogen_{faeces}$ (g/day)	15.1^{a}	10.7^{b}	11.5^{ab}	1.22
$Nitrogen_{urine}$ (g/day)	23.4^{a}	11.7^{b}	17.8^{ab}	2.88
$Nitrogen_{milk}$ (g/day)	12.8	13.1	13.1	1.41
$Nitrogen_{out\ total}$ (g/day)	51.4^{a}	35.4^{b}	42.4^{ab}	4.38
$Nitrogen_{retention}$ (% of total nitrogen)	16.4	19.7	20.9	3.57
$Nitrogen_{secretion\ in\ the\ milk}$ (% of total nitrogen)	22.4^{b}	29.3a	25.6^{ab}	1.94

[a, b] Values in rows bearing different superscript letters differ significantly ($P < 0.05$)

Conclusions

Different RDP:UDP ratios in the diets increased the DM intake in the low UDP diet. This did not influence the milk production or composition between diets. However, the low protein (20% less CP) high UDP diet was able to sustain similar milk production with a significantly better conversion (29.3%) of N into milk protein than the other diets.

References

AOAC, 1995. Official methods of analysis (16th ed.). Association of Official Analytical Chemists, Arlington, Virginia, USA, AOAC International.

Haenlein, G.F.W., 2000. Past, present and future perspectives of small ruminant dairy research. J. Dairy Sci. Suppl. 1, 83, 7.

McDonald, P., Edwards, R.A., Greenhalgh, J.F.D., 1988. Evaluation of foods. In: Animal Nutrition, 4th ed. pp. 260-283.

Mishra, S. & Rai, S.N., 1996. Effects of different RDP and UDP ratios on voluntary intake, milk production and feed conversion efficiency in lactating goats. Small Rumin. Res. 20, 31-38.

NRC, 1981. Nutrient requirements of domestic animals. Nutrient requirements of goats. National Academy of Sciences, Washington, D.C.

Santos, F.A.P., Santos, J.E.P., Theurer, C.B. & Huber, J.T., 1998. Effects of rumen-undegradable protein on dairy cow performance: A 12-year literature review. J. Dairy Sci. 81, 3162-3213.

SAS, 1994. Statistical Analysis System user's guide (Version 6, 4th ed.). SAS Institute Inc. Cary, NC, USA.

Shapiro, S.S. & Wilk, M.B., 1965. An analysis of variance test for normality. Biometrika 52, 591-611.

Van der Merwe, F.J. & Smith, W.A., 1991. Dierevoeding. Anim. Sci. (Pty) Ltd. p. 160.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Intake, digestibility and ruminal fermentation of ground and whole corn bran fed to American Alpine goats

Franz[2], C., F. Garza-Cazares[1], G. Hernández-Vidal[2], E. Olivares-Sáenz[1], H. Fimbres-Durazo[2], C.D. Lu[3] and J.R. Kawas[1]

[1]Centro de Investigaciones Agropecuarias, Facultad de Agronomía, Universidad Autónoma de Nuevo León. [2]Departamento de Nutrición y Metabolismo Animal, Facultad de Medicina Veterinaria y Zootecnia, Universidad Autónoma de Nuevo León, Lázaro Cárdenas 4600, Monterrey 64930, N.L, Mexico. [3]Office of Vice Chancellor for Academic Affairs, University of Hawaii at Hilo, 200 W. Kawili Street, Hilo, HI 96720-4091

Abstract

A study was conducted to determine the effect of quantity and physical form of corn bran (CB) in diets of goats, on intake, digestibility and rumen fermentation. Sixteen male American Alpine goats weighing approximately 24 kg, were randomly assigned to four groups in a completely random design with a 2 x 2 factorial arrangement of treatments (2 levels of CB, 15 and 30%; and 2 physical forms, whole and ground). Quantity and physical form of CB did not affect (P>0.05) DM intake or digestibility. DM intake was 96.6 and 87.2 g/kg$^{0.75}$ for goats on the 15 and 30% CB diets, respectively. For treatments with whole and ground CB, intake was 93.4 and 90.4 g/kg$^{0.75}$, respectively. DM digestibility was 72.4 and 71.9% for 15 and 30% CB in the ration. Grinding CB did not improve (P>0.05) digestibility (71.9% and 72.4%) for whole and ground CB, respectively. Time spent eating (min/day) was not affected (P>0.05) by quantity or physical form of CB. Time spent ruminating was greater (P<0.05) for goats fed the 15% CB rations (397 min/day) than for those fed rations with 30% CB (338 min/day). Grinding of CB did not significantly change the time goats spent ruminating (P>0.05). Whereas total time spent masticating was lower (P<0.05) for 30% CB rations, no effect (P>0.05) of grinding of CB was observed. As CB increased from 15 to 30%, total VFA production increased (P<0.05) from 85.5 to 112.1 mmoles. Increasing CB from 15 to 30% in the ration increased (P<0.05) concentrations (mmoles) of acetate (from 55.7 to 72.6), propionate (from 19.9 to 26.1) and butyrate (from 85.5 to 112.1). Grinding CB had no effect (P>0.05) on total volatile fatty acid production (101.7 vs. 95.9 for whole and ground, respectively). Molar percent propionate increased (P<0.05) from 19.9 to 26.1 when CB increased from 15 to 30%. Molar percent of other VFA (acetate, 65.1 vs. 64.8; butyrate, 11.7 vs. 11.8) did not change (P>0.05). Grinding CB had no effect (P>0.05) on VFA molar percent.

Keywords: Alpine goats, corn bran, intake, digestibility, ruminal fermentation
[#]Corresponding author: E-mail address: jkawas@ccr.dsi.uanl.mx.

Introduction

In the semi-arid regions of México, annual precipitation is generally lower than 250 mm and forage in rangelands is scarce (Kawas, 1990). Feeding goats in confinement is a common practice during the most critical months of the year. In the production of tortilla flour (nixtamal) for human consumption, corn bran (CB), a byproduct of the industry, is available for animal feed. CB is high in cell wall content (60% NDF), primarily hemi-cellulose (90% of NDF). Van Soest (1994) suggests a discount on the nutritive value of 18% for CB.

Feeds that contain a high cell wall content, but are poorly lignified such as CB or soybean bran, are generally considered to have higher discount values. Grinding these byproducts may increase the surface area for microbial activity in the rumen, which could increase digestibility. On the other hand, whole bran has a larger particle size that can be more easily ruminated by small ruminants (Van Soest, 1994).

The objective of this study was to determine the effect of quantity and physical form of corn bran on DM intake and digestibility, mastication activities (eating and rumination) and VFA concentrations in rumen fluid.

Materials and methods

Sixteen American Alpine growing male, with 6 weeks of age, were randomly assigned to 4 groups in a completely randomized design with a 2 x 2 arrangement of treatments (2 levels and 2 physical forms of CB). The study lasted 28 days, 21 days for adaptation of goats to metabolic crates and feed, and 7 days for

Peer-reviewed paper: 8th International Conference on Goats

collection of samples and data. Goats were confined to individual metabolic cages (1.5 m^2). Animals were de-wormed and injected vitamins A, D and E. Water was offered free choice. Animals were weight two consecutive days, at the beginning and at the end of the sampling phase. Rations are presented in Table 1. Chemical composition of the rations with 15 and 30% CB, respectively, were: CP, 15.1 and 15.4; NDF, 46.6 and 53.1%; ADF, 21.7 and 22.7%; and hemi-cellulose, 24.9 and 30.2%. Feed was offered ad libitum, 3 times during the day. Samples of offered and rejected feed and feces were dried in an oven at 60°C and ground through a 1 mm sieve in a Wiley mill, before analysis. Total feces were collected and daily weight recorded every morning, to determine DM excretion and digestibility. Samples were analyzed to determine residual DM at 105°C (AOAC, 1997). Ash content was obtained after combustion of samples in a muffle furnace at 550°C, during 3 hours. Neutral detergent fiber (FDN) and its constituents were analyzed according to procedures reported by Goering and Van Soest (1970). N content of samples was determined using the micro-kjeldahl method (AOAC, 1997), and crude protein was calculated as N x 6.25. During a 24 h period, eating and ruminating activities were recorded every 5 mm, to determine the total mastication time. Rumen fluid was obtained using a stomach tube 2 h postprandial. VFA concentrations were determined by means of gas chromatography (Goetsch and Galyean, 1983). Results were statistically analysed by means of analysis of variance for a completely randomized design with a 2 x 2 factorial arrangement of treatments. Sources of variation were level (LE) and physical form (PF) of CB in the ration, and the corresponding error term.

Table 1 Composition of rations for goats, with two levels of corn bran (QU) and two physical forms, whole and ground

	15% Corn bran		30% Corn bran	
	Ground	Whole	Ground	Whole
Ingredient, g/kg				
Grass hay	400	400	400	400
Sorghum, ground	227	227	64	64
Corn bran	150	150	300	300
Cottonseed meal	62	62	75	75
Soybean meal	80	80	80	80
Molasses	60	60	60	60
Dicalcium phoshate	10	10	10	10
Calcium carbonate	9	9	9	9
Premix[1]	2	2	2	2

[1]Premix: contained essential trace minerals and vitamins A, D_3 and E.

Results and Discussion

DM intake and digestibility of Alpine goats fed two levels of CB, whole and ground are presented in Table 2. DM intake was not affected (P>0.05) by quantity or physical form. DM intake was 1022 (96.6 $g/kg^{0.75}$) and 967 g/d (87.2 $g/kg^{0.75}$) for goats fed the 15 and 30% CB rations, respectively. Apparently, particle size of CB did not physically limit DM intake. DM intake was 1,015 g/d (93.4 $g/kg^{0.75}$) and 975 g/d (90.4 $g/kg^{0.75}$) for whole and ground CB rations, respectively. Although no difference in DM intake was observed, numerically, intake ($g/kg^{0.75}$) was lower (9.7%) in goats fed the ration with more CB (30%).

Fecal DM excretion was not affected (P>0.05) by quantity or physical form of CB. Dry feces were 281.8 y 272.4 g/d in goats fed rations with 15 and 30% CB, and 284.7 and 269.5 g/day for rations containing whole or ground CB. DM digestibility was not affected (P>0.05) by level of CB in the ration. For goats fed rations with 15 y 30% CB, DM digestibility was 72.4 y 71.9%, respectively. Grinding CB did not improved (P>0.05) DM digestibility. DM digestibility was 71.9 y 72.4% for whole and ground CB, respectively. Although Van Soest (1994) suggests an 18% reduction in the nutritive value of CB, in this study, DM digestibility of rations with 15 and 30% CB, were not different.

Mastication includes both eating and rumination (Table 5). The time (min/day) spent eating rations with 15 and 20% CB (194 vs. 168 min) was not different (P>0.05). Eating time of whole (179 min/d) or ground (183 min/d) CB was not different (P>0.05). Time spent ruminating depends primarily on level of DM intake and the fiber content of the ration (Barros et al., 1986).

Peer-reviewed paper: 8th International Conference on Goats

Table 2 DM intake and digestibility of Alpine goats fed rations with two levels of corn bran (QU) and two physical forms, whole or ground

	Quantity		Physical form			P		
	15%	20%	Whole	Ground	SE	QU	PF	QU x PF
Body weight, kg	23.2	25.0	24.4	23.9	0.93	0.35	0.78	0.81
DM intake								
g/d	1022	967	1015	975	39.6	0.50	0.63	0.78
$g/kg^{0.75}$	96.6	87.2	93.4	90.4	3.15	0.16	0.65	0.89
Fecal excretion, g/d	281.8	272.4	284.7	269.5	11.5	0.69	0.52	0.33
DM digestibility, %	72.4	71.9	71.9	72.4	0.55	0.67	0.67	0.16

Time spent ruminating was greater ($p<0.05$) for goats fed the ration with 15% (397 min/d) than with goats fed the 30% (338 min/d) CB ration (Table 3). Apparently, the greater time spent ruminating with goats fed the 15% CB ration was due to a greater DM intake. Goats fed the 15% CB ration spent 17% more time ruminating than those that fed the 30% CB ration. Grinding the CB did not significantly reduce ($P>0.05$) time spent ruminating. Total time spent masticating was reduced ($P<0.05$) when CB in the ration was increased from 15 a 30%. However, grinding CB did not affect ($P>0.05$) total mastication time. Rumen acidosis is defined as a drastic reduction in rumen pH in response to an excessive fermentation of non-structural carbohydrates. Mastication of feed causes a massive flow of saliva into the rumen, preventing fluctuations of rumen pH (Owens et al., 1998).

Table 3 Time dedicated to mastication activities of Alpine goats fed rations with two levels of corn bran (QU) and two physical forms (PF), whole or ground

Item	Quantity		Physical form			Effects; p<		
	15%	30%	Whole	Ground	SE	QU	PF	QU x PF
Mastication, min/day								
Eating	194	168	179	183	11.3	0.28	0.85	0.85
Rumínating	397	338	380	354	13.7	0.05	0.37	0.70
Total	591	506	559	538	16.8	0.03	0.54	0.66

The VFA concentrations in rumen fluid of goats are presented in Table 4. Increasing CB in the ration from 15 to 30% increased ($P\leq0.05$) concentrations (mmoles) of total VFA from 85.5 to 112.1, of acetate from 55.7 to 72.6, of propionate from 19.9 to 26.1, and butyrate from 10 to 13.1. Grinding CB had no effect ($P>0.05$) on the total VFA production (101.7 and 95.9 mmoles for whole and ground CB, respectively).

Percent molar propionate increased ($P<0.05$) from 19.9 to 26.1 mmoles, whereas other VFA did not change (acetate, 65.1 vs. 64.8; butyrate, 11.7 vs. 11.8). Grinding CB had no effect ($P>0.05$) on the molar percent of VFA in rumen fluid. For goats eating rations with whole and ground CB, molar percent was: acetate, 66.0 vs. 63.9; propionate, 22.6 vs. 23.3; and butyrate, 11.5 vs. 11.9; respectively.

Conclusions

In this study, no differences were observed ($P>0.05$) in DM intake of goats fed rations with 15 or 30% corn bran (96.6 vs. 87.2 $g/kg^{0.75}$), or DM digestibility (71.9 vs 72.4%). These results contrast with those reported by Van Soest (1994) in applying a discount in the nutritive value of corn bran of 18%. On the other hand, grinding improved intake and digestibility of corn bran. However, goats fed the ration with 30% CB ruminated 17% more time than those fed the 15% CB ration. Increasing CB from 15 to 30% in the ration increased acetate, propionate, butyrate and total VFA concentrations in rumen fluid. Molar percent propionate increased as corn bran increased in the ration. Grinding CB did not affect molar percent VFA in rumen fluid. These results suggest that levels of up to 30% CB can be included in goat rations, without affecting nutritive value.

Peer-reviewed paper: 8th International Conference on Goats

Table 4 Volatile fatty acid concentrations in rumen fluid of American Alpine goats fed rations with two levels of corn bran (QU) and two physical forms (PF), whole or ground

	Quantity		Physical form			Effects		
	15%	30%	Whole	Ground	SE	QU	PF	QU x PF
Concentration, mmol								
Acetate	55.7	72.6	67.1	61.2	3.7	0.04	0.43	0.43
Propionate	19.9	26.1	22.6	23.3	1.4	0.05	0.82	0.22
Butyrate	10.0	13.1	11.6	11.5	0.6	0.03	0.91	0.29
Total AGV	85.5	112.1	101.7	95.9	5.5	0.03	0.60	0.31
Molar percent								
Acetate	65.1	64.8	66.0	63.9	0.54	0.77	0.08	0.13
Propionate	19.9	26.1	22.6	23.3	1.42	0.05	0.82	0.22
Butyrate	11.7	11.8	11.5	11.9	0.33	0.93	0.56	0.90

References

AOAC. 1997. Oficial Methods of Analisis (16th Ed.). Association of Official Analytical Chemists, Arlington, VA.

Barros, N.N., J.R. Kawas, L.C.L. Freire, J.A. Araujo Filho, J.M. Shelton and W.L. Johnson. 1986. Digestibility and Intake of Various Native and Introduced Forages by Goats and Hair Sheep in Northeast Brazil. In: Goats and Sheep in Northeast Brazil-Proceedings of the First Workshop of the Small Ruminant Collaborative Research Support Program. Centro Nacional de pesquisa de Caprinos, Sobral, Ceará, Brazil. p. 219-226.

Goering, H. K., and P. J. Van Soest. 1970. Forage fiber analyses (apparatus, reagents, procedures, and some applications). Agric. Handbook Nº 379. ARS, USDA, Washington, D. C.

Goetsch, A.L., Galyean, M.L., 1983. Influence of feeding frequency on passage of fluid arid particulate markers in steers fed a concentrate diet. Can. J. Anim. Sci. 63, 727-730.

Kawas, J.R. 1990. Goat Producción in México and Central América. In: Proceedings of the International Goat Production Symposium. Florida A&M University. Tallahassee, Florida, p. 42-46.

Owens, F.N., D.S. Secrist, W.J. Hill, and D.R. Gill. 1998. Acidosis in cattle: A Review. J. Anim. Sci. 76,275.

Van Soest, P.J. 1994. Nutritional Ecology of the Ruminant. 2nd ed. Cornell University. Cornell University Press.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Effect of live yeast culture supplementation on rumen fermentation in lactating dairy goats

S. Giger-Reverdin[1#], D. Sauvant[1], J. Tessier[1], G. Bertin[2] and P. Morand-Fehr[1]
[1]UMR INRA INA P-G, Physiologie de la Nutrition et Alimentation, 16 rue Claude Bernard, 75005 Paris, France
[2]ALLTECH France, 2-4 avenue du 6 juin 1944, 95190 Goussainville, France

Abstract

Addition of yeast to dairy cow diets might be beneficial for milk production. Therefore, data concerning goats are scarce, especially those on the role of yeast on rumen metabolism. Thus, four goats, according to a cross-over design received successively two diets with or without living yeasts. Animals were in mid-lactation and received a total mixed diet *ad libitum*. For the yeast diet (Y), each goat received twice a day 5 g of *Saccharomyces cerevisiae* CBS 493.94. Samples of ruminal content were taken every 2 hours for 8 hours after the morning feeding. Yeast addition did not have any statistical effect either on feeding pattern or on concentrations of volatile fatty acids, ammonia, lactate or soluble carbohydrate in ruminal fluid. The pH was numerically higher for the yeast diet compared to the control. Ruminal buffering (BC) capacity of the Y diet was significantly higher than that of the control. The BC increased as pH decreased. Dietary effects and ruminal soluble carbohydrate concentrations explained part of the residual of the equation linking buffering capacity and pH. Yeast addition also avoided some lactate peaks in the first hours of fermentation. This experiment clearly pointed out that the *Saccharomyces cerevisiae* CBS 493.94 yeast has an effect on ruminal metabolism when considering its BC and might have a smoothing effect on the appearance of lactate peaks or on a decreased pH. These effects are of particular interest for those diets which might induce acidosis such as some diets rich in rapidly fermentable energy given to high producing dairy goats in early lactation.

Keywords: *Saccharomyces Cerevisiae* yeast, rumen digestion, buffering capacity, dairy goats
[#]Corresponding author. E-mail: giger@inapg.inra.fr

Introduction

Several experiments using dairy cows or goats have shown that yeast addition to the diet might increase milk production (Gunther, 1990; Piva *et al.*, 1993; Adams *et al.*, 1995; Putnam *et al.*, 1997; Nocek *et al.*, 2003) while other studies did not find any difference (Arambel & Kent, 1990; Chiquette, 1995; Kamalamma *et al.*, 1996; Salama *et al.*, 2002). Studies where yeast has been supplemented to dairy goat diets are limited, in particular, studies where the ruminal mode of action of yeast has been studied (Flachowsky *et al.*, 1993; Hadjipanayiotou *et al.*, 1997; Salama *et al.*, 2002). Furthermore, parameters such as buffering capacity (BC) of ruminal content and lactate concentrations have been either seldom or never measured. These parameters are of particular interest when animals receive diets that might induce acidosis such as diets rich in rapidly fermentable carbohydrates given to high producing dairy goats in early lactation.

Material and Methods

Four rumen fistulated goats received successively either the control diet (C) or the Yeast diet (Y) in a cross-over experimental design. For the Yeast diet, each goat received 5 g of *Saccharomyces cerevisiae* CBS 493.94 [Alltech Company, Nicholasville, Kentucky, USA] twice a day with a dosing gun. Animals were in mid-lactation and milked twice a day. They received *ad lib.* a total mixed diet containing on a dry matter (DM) basis: 40% maize silage, 10% dehydrated lucerne and 50% of a concentrate (10% wheat bran, 18% maize gluten meal, 10% lupine seeds, 28% sugar beet pulp, 29% citrus pulp, 2% molasses and 3% mineral and vitamins mixture). Water was available *ad lib*.

After an adaptation of three weeks to the diet, samples of ruminal content were taken every 2 hours for 8 hours after the morning feeding from the dorsal part of the rumen of each goat. About 100 mL were immediately filtered through cheesecloth, pH was recorded and thereafter the BC by means of titration of 20 mL of rumen juice with 1N acetic acid (Giger-Reverdin *et al.*, 2000) which was performed until the pH decreased from its initial value to 4. The evolution in pH was expressed as an exponential function of the quantity of acetic acid added (in meq H^+): $pH = \mathbf{a} - \mathbf{b}\ eqH + \mathbf{c}\ \exp^{(-\mathbf{d}\ eq\ H)}$

Peer-reviewed paper: 8th International Conference on Goats

Buffering capacity, or the inverse of the derivative function at the initial pH, is equal to 1/(**b** + (**c** * **d**)). Samples were kept at –20 °C until analysed for volatile fatty acids, soluble carbohydrates, ammonia and lactate concentrations. Statistical analyses were performed according to the "proc mixed" procedure of SAS® in order to take into account the repeated effect on a same day for a given goat. The diet and sampling time effects and their interactions were tested for each variate.

Results and Discussion

Yeast addition did not affect DM intake (DMI) (g DMI per kg body-weight (DMI BW^{-1})) at any sampling time or any of the rumen parameters measured, except for buffering capacity.

Table 1 Effect of yeast culture supplementation on dry matter intake (DMI) and rumen fermentation parameters

	Control diet	Yeast diet	Diet effect	Time effect
DMI/body weight (g/kg)	32.8	31.3	NS	P < 0.0001
PH	6.09	6.15	NS	P < 0.03
Buffering capacity	0.0299[a]	0.0448[b]	P < 0.001	NS
Volatile fatty acids (mmole/L)	152	153	NS	P < 0.01
Ammonia (g/L)	0.0795	0.0867	NS	P < 0.001
Lactate (mmole/L)	0.455	0.207	NS	NS
Soluble carbohydrates(g/L)	4.27	4.67	NS	P < 0.01

[a, b,] Row means with common superscripts do not differ (P > 0.05)

Compared to the control diet, pH was numerically higher with the yeast addition. This tendency is in agreement with other researchers that did not find any impact of yeast on ruminal metabolism (Erasmus *et al.*, 1992; Doreau & Jouany, 1998), while others recorded that yeast increased pH (Kumar *et al.*, 1997; Roa *et al.*, 1997). There was no lactate peak with the yeast supplemented diet that explained the lower lactate value of goats receiving the Y diet compared to goats receiving the C diet. Yeast might have had a smoothing effect on lactate peaks appearance, which is in agreement with other results (Williams *et al.*, 1991). The small increase in soluble carbohydrate concentration suggests that yeast might act on carbohydrate metabolism in the rumen. Furthermore, BC was higher with the yeast diet compared to the control diet (Figure 1).

Buffering capacity increased as pH decreased:

$$BC = 0.187 - 0.0244\ pH \qquad (r^2 = 0.437,\ n = 32,\ RSD = 0.008484)$$

Dietary effect explained part of the residual of this equation (P < 0.001), such as the ruminal soluble carbohydrates concentration (P < 0.01).

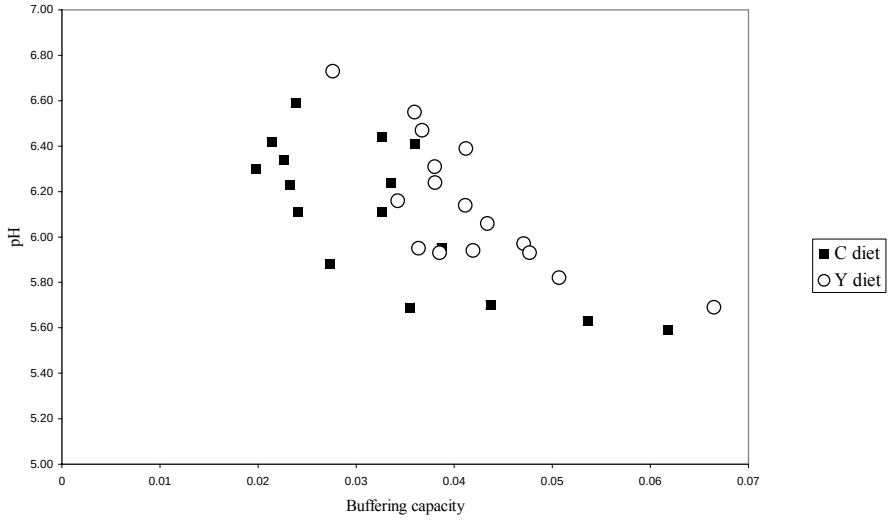


Figure 1 Dietary effect on buffering capacity and pH

Conclusion

The *Saccharomyces cerevisiae* CBS 493.94 yeast improved BC of the rumen significantly and tended indicate level of significance to an increase in pH and decrease lactate concentrations. This effect might be more significant for diets higher in NSC than the one tested. These effects are of particular significance for diets which might induce acidosis such as diets rich in rapidly fermentable carbohydrates given to high producing dairy goats in early lactation.

References

Adams, A.L., Harris, B., Jr., Horn, H.H.v. & Wilcox, C.J., 1995. Effects of varying forage types on milk production responses to whole cottonseed, tallow, and yeast. J. Dairy Sci. 78, 573-581.

Arambel, M.J. & Kent, B.A., 1990. Effect of yeast culture on nutrient digestibility and milk yield response in early- to midlactation dairy cows. J. Dairy Sci. 73, 1560-1563.

Chiquette, J., 1995. *Saccharomyces cerevisiae* and *Aspergillus oryzae*, used alone or in combination, as a feed supplement for beef and dairy cattle. Can. J. Anim. Sci. 75, 405-415.

Doreau, M. & Jouany, J.P., 1998. Effect of a *Saccharomyces cerevisiae* culture on nutrient digestion in lactating dairy cows. J. Dairy Sci. 81, 3214-3221.

Erasmus, L.J., Botha, P.M. & Kistner, A., 1992. Effect of yeast culture supplement on production, rumen fermentation, and duodenal nitrogen flow in dairy cows. J. Dairy Sci. 75, 3056-3065.

Flachowsky, G., Tiroke, K. & Matthey, M., 1993. Influence of yeast (*Saccharomyces cerevisiae* as Yea-Sacc or Levaferm) on in sacco dry matter degradability and ruminal parameters of variously fed small ruminants. Archives of Anim. Nutr. 42, 159-169.

Giger-Reverdin, S., Maaroufi, C., Jarnot, L., Müller, R., Bontems, V. & Sauvant, D., 2000. The influence of pea grinding and dietary nitrogen content on buffering capacity of diets offered to lactating goats. (Influence de la granulométrie du pois et du niveau azoté du régime sur son pouvoir tampon pour des chèvres en lactation). In: 7th International conference on Goats, Tours (France). 2000/05/15-18, Eds. Institut de l'Elevage and INRA. pp 86-88.

Gunther, K.D., 1990. Lebende Hefekulturen als Zusatzstoff in der Milchviehfütterung. (Live yeast cultures as additives in dairy cattle feeds). Kraftfutter, 168-172.

Hadjipanayiotou, M., Antoniou, I. & Photiou, A., 1997. Effects of the inclusion of yeast culture on the performance of dairy ewes and goats and the degradation of feedstuffs. Livest. Prod. Sci. 48, 129-134.

Kamalamma, U., Krishnamoorthy, U. & Krishnappa, P., 1996. Effect of feeding yeast culture (Yea-sacc1026) on rumen fermentation *in vitro* and production performance in crossbred dairy cows. Anim. Feed Sci. Technol. 57, 247-256.

Kumar, U., Sareen, V.K. & Singh, S., 1997. Effect of yeast culture supplement on ruminal microbial populations and metabolism in buffalo calves fed a high roughage diet. J. Sci. Food Agric. 73, 231-236.

Nocek, J.E., Kautz, W.P., Leedle, J.A.Z. & Block, E., 2003. Direct-fed microbial supplementation on the performance of dairy cattle during the transition period. J. Dairy Sci. 86, 331-335.

Piva, G., Belladonna, S., Fusconi, G. & Sicbaldi, F., 1993. Effects of yeast on dairy cow performance, ruminal fermentation, blood components, and milk manufacturing properties. J. Dairy Sci. 76, 2717-2722.

Putnam, D.E., Schwab, C.G., Socha, M.T., Whitehouse, N.L., Kierstead, N.A. & Garthwaite, B.D., 1997. Effect of yeast culture in the diets of early lactation dairy cows on ruminal fermentation and passage of nitrogen fractions and amino acids to the small intestine. J. Dairy Sci. 80, 374-384.

Roa, V.M.L., Barcena-Gama, J.R., Gonzalez, M., S., Mendoza, M., G., Ortega, C.M.E. & Garcia, B.C., 1997. Effect of fiber source and a yeast culture (Saccharomyces cerevisiae1026) on digestion and the environment in the rumen of cattle. Anim. Feed Sci. Technol. 64, 327-336.

Salama, A.A.K., Caja, G., Garin, D., Albanell, E., Such, X. & Casals, R., 2002. Effects of adding a mixture of malate and yeast culture *(Saccharomyces cerevisiae)* on milk production of Murciano-Granadina dairy goats. Anim. Res. 51, 295-303.

Williams, P.E., Tait, C.A., Innes, G.M. & Newbold, C.J., 1991. Effects of the inclusion of yeast culture (Saccharomyces cerevisiae plus growth medium) in the diet of dairy cows on milk yield and forage degradation and fermentation patterns in the rumen of steers. J. Anim. Sci. 69, 3016-3026.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Certain qualitative characteristics of *Boscia foetida* at different sites in South Africa

C.J. Havenga[#], W.A. van Niekerk, N.F.G. Rethman[1] and R.J. Coertze
Department of Animal and Wildlife Sciences, University of Pretoria, Pretoria 0002, South Africa
[1]Department of Plant Production and Soil Science, University of Pretoria, Pretoria 0002, South Africa

Abstract

The aim of this study was to quantify the suitability of *Boscia foetida* as a fodder source for goats. Samples of leaves and twigs were taken in the Northern Cape and Limpopo provinces. The concentrations of Ca, Mg, and Mn in leaves and stems were sufficient for production, but both leaves and stems lack in P, Cu and Zn. Crude protein values ranged from 96 g /kg DM for stems to 187 g /kg DM for leaves. Neutral detergent fibre and acid detergent lignin values ranged from 507 g /kg DM and 136 g /kg DM for leaves to 760 g /kg DM and 222 g /kg DM for stems respectively. The *in vitro* digestible organic matter concentrations varied between 203 g /kg DM to 479 g /kg DM for stems and leaves respectively. The results indicated that *Boscia foetida* will make a useful contribution to most of the nutrient requirements of goats.

Keywords: *Boscia foetida*, crude protein, NDF, ADL, *in vitro* digestibility, minerals
[#]Corresponding author. E-mail: christa@tuks.co.za

Introduction

Overgrazing and poor management led to erosion and desertification in arid and semi-arid areas, resulting in the reduction of income and destabilization of rural communities. *Boscia* spp. (Shepherd's tree) has been identified as a fodder source well adapted to the arid and semi-arid regions of South Africa. According to Le Riche & Van der Walt (1999) it is one of the most important forage trees in the Kalahari. *Boscia* trees are important for animal production due to their deep root system which enables them to take up minerals and access ground water during droughts (Topps, 1992). According to Lu (1988) it is well established that goats can survive and indeed flourish in areas where cattle and sheep cannot. The objective of this paper is to report on the suitability of *Boscia* spp. as a fodder source for goats.

Materials and Methods

Nine samples (trees) of edible material (twigs up to 4mm in diameter, and leaves) of *Boscia foetida* were collected at three sites in South Africa during February 2003. Samples were taken from mature trees. The sites were Kenhardt, Northern Cape Province, situated at 21°14'E; 29°36'S at an altitude of 789m with an average rainfall of 155 mm; Klein Pella, Northern Cape Province, situated at 19°15'E; 29°03'S at an altitude of 836m with an average rainfall of 89mm; and Marken, Limpopo Province, situated at 23°58'E; 27°58'S at an altitude of 849m with an average rainfall of 445mm. The samples were air dried, leaves and stems were separated, milled and then analysed for the following: *In vitro* digestible organic matter (IVDOM) according to the method of Tilly & Terry (1963) as modified by Engels & Van der Merwe (1967), crude protein (CP) and macro and trace minerals (AOAC, 2000), neutral detergent fibre (NDF) (Robertson & Van Soest, 1981) and acid detergent lignin (ADL) (Goering & Van Soest, 1970).

An analysis of variance with the Proc GLM model (SAS, 1994) was used to determine the significance between different areas, leaves and stems. Least square means and standard deviations (s.d.) were calculated. Significance of difference (5%) between means was determined by multiple comparisons using Bonferroni's test (Samuels, 1989).

Peer-reviewed paper: 8th International Conference on Goats

Results and Discussion

Table 1 Mean (±s.d.) chemical composition of *Boscia foetida* at different sites (g /kg) DM

Site		CP	NDF	ADL	***IVDOM***
Marken	leaf	183^{a} (46.3)	507^{b} (63.6)	168^{a} (10.4)	458^{a} (4.8)
	stem	150_{2} (17.0)	760_{2} (15.5)	222_{1} (10.5)	215_{1} (1.6)
Kenhardt	leaf	133^{b} (6.0)	575^{b} (17.1)	136^{a} (9.6)	462^{a} (1.2)
	stem	96_{1} (8.8)	648_{1} (7.1)	159_{1} (7.5)	228_{1} (3.2)
Pella	leaf	187^{a} (6.8)	536^{b} (67.4)	153^{a} (4.0)	479^{a} (5.5)
	stem	109_{1} (11.5)	641_{1} (11.5)	201_{1} (40.5)	203_{1} (4.1)

Column for leaves (a,b) and stems (1,2) means with common scripts do not differ significantly (P > 0.05)

The CP concentration of stems varied from 96 g /kg at Kenhardt to 150 g /kg at Marken (P<0.05). The highest CP concentration for leaves (187 g /kg) was recorded at Klein Pella and it was significantly higher than the CP concentration of leaves collected at Kenhardt (133 g /kg). The CP concentration of *Combretum* spp. foliage ranged from 62 g to 125 g /kg DM and that of *Colophospermum mopane* from 99 to 169 g /kg DM (Lukhele & Van Ryssen, 2003). These compared favourably with that of the reported *Boscia* leaves. Neutral detergent fibre concentrations in *B. foetida* leaves were higher than the range reported by Lukhele & Van Ryssen (2003) for *Combretum* spp. (279 g – 409 g /kg DM) while the ADL concentrations in *B. foetida* leaves were also higher than the reported values of Lukhele & Van Ryssen (2003) for the *Combretum* spp. and *C. mopane.* High NDF and ADL values of *B. foetida* will most probably have a negative influence on digestibility and intake of such material by grazing herbivores. The higher IVDOM values of the *Boscia* leaves, in comparison to stems, are important. It is reported that leaves have a shorter rumen retention time compared to stems (Minson, 1982), which may permit more dry matter to be consumed if mainly leaves are browsed. According to Tetthen, (1974) as cited by NRC (1981), goats are selective feeders and will select leaf material before browsing on stems of a specific fodder.
The Ca, P, Mg, Cu, Zn and Mn concentrations are presented in Table 2.

Table 2 Mean (±s.d.) macro mineral (g /kg DM) and trace mineral (mg /kg DM) concentrations of *Boscia foetida* at three sites

		Ca	P	Mg	Cu	Zn	Mn
Marken	leaf	5.5^{a} (2.1)	0.89^{a} (0.4)	3.8^{a} (0.3)	9.8^{a} (5.0)	13.0^{a} (1.7)	114^{a} (13.8)
	stem	3.2_{1} (0.8)	0.60_{1} (0.2)	0.9_{1} (0.1)	8.2_{1} (1.7)	13.4_{1} (3.2)	29.3_{1} (8.3)
Kenhardt	leaf	6.2^{a} (0.1)	0.56^{a} (0.1)	1.0^{b} (0.1)	3.0^{b} (0.1)	15.3^{a} (4.0)	133^{a} (14.4)
	stem	6.3_{2} (0.2)	0.63_{1} (0.1)	1.0_{1} (0.1)	3.0_{2} (0.1)	36.3_{2} (8.1)	35.0_{1} (7.0)
Pella	leaf	6.0^{a} (1.9)	0.83^{a} (0.1)	2.7^{a} (0.1)	5.7^{b} (1.9)	24.0^{b} (11.1)	78^{b} (11.0)
	stem	5.1_{2} (1.0)	0.71_{1} (0.2)	1.0_{1} (0.2)	4.9_{2} (0.6)	42.0_{2} (15.1)	22.0_{1} (12.2)

Column for leaves (a,b) and stems (1,2) means with common superscripts do not differ significantly (P > 0.05)

The Ca, P and Mg concentrations of *B. foetida,* were generally higher in leaves than in stems. Although the Ca concentrations were lower than those reported for *B. albitrunca* (11.1 g /kg-14.4 g /kg) by Groenewald *et al.* (1967) as cited by Boyazoglu (1997), Ca and Mg concentrations of *B. foetida* foliage were still higher than growth requirements of goats (Underwood, 1981; AFRC, 1998). The P concentrations were, however, too low (AFRC, 1998).
B. foetida leaves contained sufficient Cu concentrations at Marken for maintenance requirements of goats, but not at Klein Pella and Kenhardt (AFRC, 1998). The Mn concentrations at all sites were sufficient to meet maintenance requirements, but not that of Zn (AFRC, 1998).

Conclusion

The plant leaves had an acceptable level of digestibility . Although reported by numerous authors to be palatable (Palgrave, 1981; Le Riche & Van der Walt, 1999) it is unlikely that it would be the sole source

of browse for goats, since there are a number of other sources, such as *Acacia* spp., *Ehretia rigida* and *Ziziphus mucronata* in the areas where *Boscia* spp. normally grow.

B. foetida contains sufficient concentrations of Ca, Mg and Mn for the requirements of goats but lack in P, Cu and Zn. The wide Ca:P ratio may present a problem, but ruminants can tolerate a relatively wide Ca:P ratio in the diet, provided that the P intake is high (Underwood, 1981).

Acknowledgement

This research was supported in part under Grant No. TA-MOU-99-C16-091 funded by the U.S.-Israel Cooperative Development Research Program, Bureau for Economic Growth, Agriculture and Trade, U.S. Agency for International Development.

References

AFRC, 1998. The nutrition of Goats. Report no 10., CAB International. Pp. 69-85.

AOAC, 2000. Official methods of analysis (16th ed.). Association of Official Analytical Chemists, Inc., Arlington, Virginia, USA.

Boyazoglu, P.A., 1997. Animal Nutrition. J.L. van Schaik Publishers, Pretoria, South Africa. Pp. 282-283.

Engels, E.A.N. & Van der Merwe, F.J., 1967. Application of an *in vitro* technique to South African forages with special reference to the effect of certain factors on the result. S. Afr. J. Agric. Sci. 10, 983-995.

Goering, H.K. & Van Soest. P.J., 1970. Forage fiber analysis (apparatus, reagents, procedures and some applications). U.S.D.A.-A.R.S. Agriculture Handbook no.379, Government Printing Office, Washington, D.C.

Lu, C.D., 1988. Grazing behaviour and diet selection of goats. In: Proceedings of the 1st Regional Goat Conference. Tallahasee, Florida, USA; Florida A and M University. Pp. 56.

Le Riche, E. & Van der Walt, P., 1999. The Kalahari and its plants. Info Naturae. Pretoria.

Lukhele, M.S. & Van Ryssen, J.B.J., 2003. The chemical composition and nutritive value of the foliage of four subtropical tree species in South Africa for ruminants. S.A.J. Anim. Sci. 33 (2), 132-141.

Minson, D.J., 1982. Effects of chemical and physical composition of herbage eaten upon intake. In: Nutritional Limits to Animal Production from Pastures. Ed. Hacker, J.B., C.A.B. Farnham Royal, U.K. Pp.167-182.

NRC, 1981. Nutrient Requirements of Goats: Angora, dairy and meat goats in temperate and tropical countries. National Academy Press. Washington, D.C.

Palgrave, J. C., 1981. Trees of Southern Africa. Struik Publishers. Cape Town.

Robertson, J.B. & Van Soest, P.J., 1981. The detergent system of analysis and its application to human foods. In: The Analysis of Dietary Fiber in Food. Eds. James, W.P.T. & Theander, O. Marcel Dekker, New York. Pp. 123-158.

Samuels, M.L., 1989. Statistics for the life sciences. Collier MacMillan Publishers, London.

SAS, 1994. Statistical Analysis Systems User's Guide. Statistics Version 6. SAS Inst., Inc. Cary, NC., USA.

Topps, J.H., 1992. Potential composition and use of legume shrubs and trees as fodder for livestock in the tropics. J. Agric. Sci. Camb. 118, 1-8.

Underwood, E.J., 1981. The Mineral Nutrition of Livestock, 3rd ed. CABI Publishing. Pp. 3-106.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Qualitative evaluation of *Cenchrus ciliaris* cv. Molopo and Gayndah as foggage

S.S. Jacobs, W.A. van Niekerk# and R.J. Coertze
Department of Animal and Wildlife Sciences, University of Pretoria, Pretoria 0002, South Africa

Abstract

The aim of the study was to determine the qualitative value of *Cenchrus ciliaris* cv. Molopo and Gayndah utilized by small ruminants as a foggage. Molopo material had crude protein (CP) concentrations that varied from 76 to 101g /kg DM and Gayndah CP concentrations ranging from 78 to 135g /kg DM over a five week period. Molopo had *in vitro* digestible organic matter (IVDOM) values that ranged from 556 to 604g /kg DM and Gayndah IVDOM values that ranged from 532 to 642g /kg DM. The neutral detergent fibre (NDF) concentration of Molopo varied from 647 to 716g /kg DM and the acid detergent lignin (ADL) concentration from 56 to 64g /kg DM. Gayndah had NDF concentrations that ranged from 547 to 711g /kg DM and ADL concentrations from 60 to 86g /kg DM. The quality of the selected material was slightly better than values reported for foggages of tropical grasses.

Keywords: *Cenchrus ciliaris,* Molopo, Gayndah, foggage
#Corresponding author. E-mail: willem.vanniekerk@up.ac.za

Introduction

Major parts of South Africa suffer from a dry autumn and winter. This poses a problem to stock farmers in the management of their fodder flow. A way to overcome this problem is the use of foggage over this dry period until enough plant material is available after the first rains. It is well documented that a decrease in quality and intake will occur with advancing stage of maturity (Relling *et al*., 2001; Van Niekerk *et al*., 2002). The selection of a grass type that maintains it's quality as a foggage is therefore important. In the literature there is a paucity of information on qualitative values of *C. ciliaris* cv. Molopo and Gayndah as a foggage. The aim of this study was to evaluate the quality of material selected of two types of *C. ciliaris,* Molopo and Gayndah, utilized as a foggage.

Materials and Methods

The study was conducted at the Hatfield Experimental Farm of the University of Pretoria, South Africa. The site is situated at 028.11°E, 25.44°S at an altitude of 1 372m, with an average annual rainfall of 674mm and a dry autumn and winter. The soil at the experimental site is classified as a sandy-loam with a $pH_{(H20)}$ of 4.2, P, K, Ca, Mg and Na concentration of 29, 73, 158, 38 and 11mg /kg respectively.

Cenchrus ciliaris cv. Molopo and Gayndah pastures were established under dry land conditions and fertilized with 2:3:4 (30) at a rate of 100kg /ha two years before the trial was conducted. One year after establishment and with the onset of the rainy season, 300kg of limestone ammonium nitrate (28% N) was applied to both pastures. The pastures were mowed during the second half of February and fertilized with 75kg N/ha. Twelve esophageal fistulated whethers were randomly allocated to paddocks of 2.2ha. The experiment ran over five weeks in mid-winter.

Dry matter and crude protein (CP) concentrations were determined according to AOAC (2000), neutral detergent fibre (NDF) concentration according to the method of Robertson & Van Soest (1981) and acid detergent lignin (ADL) according to Goering & Van Soest (1970). *In vitro* digestible organic matter (IVDOM) was done according to the method of Tilley & Terry (1963) as modified by Engels & Van der Merwe (1967).

An analysis of variance for unbalanced data with Proc GLM (SAS, 1994) was used. Least square means and standard deviations (s.d.) were calculated. The level of significance between least square means was tested with the Bonferroni's test (Samuels, 1989).

Results and Discussion

Goats commonly selected grasses and herbaceous flowering plants (Tettheh, 1974 as cited by NRC, 1981). As pasture quality decrease with maturity (Relling *et al*., 2001; Van Niekerk *et al*., 2002), quality parameters should be relatively low in the case of a foggage (standing hay).

Peer-reviewed paper: 8th International Conference on Goats

Table 1 Mean (±s.d.) chemical composition of esophageal samples of *Cenchrus ciliaris* cv. Molopo and Gayndah during winter

Parameter		Molopo	Gayndah
CP (g /kg)			
	Week 1	93[a] (8)	122[b] (36)
	Week 2	101[a] (14)	109[a] (10)
	Week 3	84[a] (5)	89[a] (4)
	Week 4	76[a] (5)	78[a] (7)
	Week 5	94[a] (12)	135[b] (2)
IVDOM, %			
	Week 1	568[a] (25)	624[a] (69)
	Week 2	604[a] (17)	608[a] (48)
	Week 3	556[a] (42)	549[a] (29)
	Week 4	558[a] (37)	532[a] (65)
	Week 5	591[a] (61)	642[a] (20)
NDF (g /kg)			
	Week 1	680[a] (28)	660[a] (27)
	Week 2	647[a] (50)	675[a] (19)
	Week 3	716[a] (13)	708[a] (46)
	Week 4	681[a] (31)	711[a] (35)
	Week 5	671[a] (31)	547[b] (56)
ADL (g /kg)			
	Week 1	63[a] (11)	60[a] (12)
	Week 2	57[a] (9)	66[a] (8)
	Week 3	64[a] (6)	70[a] (6)
	Week 4	57[a] (9)	86[b] (11)
	Week 5	56[a] (15)	61[a] (6)

Row (a,b) means with common superscripts do not differ ($P > 0.05$)

The CP values of Gayndah were significantly higher than CP values of Molopo during week 1 and 5 of the grazing period. The concentration of CP didn't decrease beneath 6% where feed intake will be reduced leading to a combined deficiency of energy and protein (NRC, 1981). Muir & Abrao (1999) reported similar CP values for *C. ciliaris*. No significant differences in IVDOM concentrations could be found between Molopo and Gayndah during the grazing period. The IVDOM values in this study were similar to IVDOM values reported by Shinde *et al*. (1996) for *C. ciliaris.*

Gayndah had significant lower NDF concentrations in Week 5. The lower NDF value of Gayndah suggested the selection of green plant growth (O'Reagain & Owen-Smith, 1996) and the higher CP and IVDOM during the same week supported this. The NDF concentration in this study was slightly lower than concentrations reported by Mero & Udèn, (1998) for 6 and 10 week regrowth of *C. ciliaris*. Molopo had a significant lower ADL concentration in Week 4 than Gayndah. Relling *et al*. (2001) reported that NDF and ADL concentrations will increase with advanced maturity, as can be expected of a foggage. These high NDF and ADL values were therefore expected. The ADL values in this study were lower than values reported for *C. ciliaris* in the literature (Shinde *et al.*, 1996; Mero & Udèn, 1998).

Conclusion

Quality parameters for *C. ciliaris* cv. Molopo and Gayndah selected were low but probably not low enough to limit intake. The differences between Molopo and Gayndah plant material were not constant enough to decide which type will be better suited as foggage for utilization by small stock. The quality of material selected was however slightly better than values one would expect for foggages of tropical grasses.

References

AOAC, 2000. Official methods of analysis of the Association of Official Analytical Chemists. Inc. Arlington, Virginia, U.S.A.

Engels, E.A.N. & Van der Merwe, F.J., 1967. Application of an *in vitro* technique to South African forages with special reference to the effect of certain factors on the result. S. Afr. J. Agric. Sci. 10, 983-995.

Goering, H.K. & Van Soest, P.J., 1970. Forage fibre analysis (apparatus, reagents, procedures and some applications). U.S.D.A.-A.R.S. Agricultural handbook no. 379, Government Printing Office, Washington, D.C.

Mero, R.N. & Udèn, P., 1998. Promising tropical grasses and legumes as feed resources in Central Tanzania III: Effect of feeding level on digestibility and voluntary intake of four grasses by sheep. Anim. Feed Sci. Tech. 70, 79-95.

Muir, J.P. & Abrao, L., 1999. Agronomic evaluation of 10 cultivated grasses in semi-arid Mozambique. Trop. Grassl. 33, 34-39.

NRC, 1981. Nutrient Requirements of Goats: Angora, Dairy and Meat Goats in Temperate and Tropical Countries. National Academy Press. Washington, D.C.

O'Reagain, P.J. & Owen-Smith, R.N., 1996. Effect of species composition and sward structure on dietary quality in cattle and sheep grazing South African sourveld. J. Agric. Sci., Camb. 127, 261-270.

Relling, E.A., Van Niekerk, W.A., Coertze, R.J. & Rethman, N.F.G., 2001. An evaluation of nitrogen fertilized *Panicum maximum* cv. Gatton: 2. The influence of stage of maturity on diet selection, intake and rumen fermentation in sheep. S. Afr. J. Anim. Sci. 31, 85-91.

Robertson, J.B. & Van Soest, P.J., 1981. The detergent system of analysis and its application to human foods. In: The Analysis of Dietary Fiber in Food. Eds. James, W.P.T. & Theander, O., Marcel Dekker, New York. Pp. 123-158.

Samuels, M.L., 1989. Statistics for the Life Sciences. Collier Macmillan Publishers, London.

SAS, 1994. Statistical Analysis Systems User's Guide. Statistics Version 6. SAS Inst., Inc. Cary, NC., USA.

Shinde, A.K., Sankhyan, S.K., Karim, S.A., Singh, N.P. & Patnayak, B.C., 1996. Nutrient intake, its utilization, and performance of sheep and goats on semi arid *Cenchrus ciliaris* pasture. Wrld. Rev. Anim. Prod. 31 (1-2), 35-40.

Van Niekerk, W.A., Taute, A. & Coertze, R.J., 2002. An evaluation of nitrogen fertilized *Panicum maximum* cv. Gatton at different stages of maturity during autumn: 2. Diet selection, intake, rumen fermentation and partial digestion by sheep. S. Afr. J. Anim. Sci. 32 (3), 217-224.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Seasonal variations in chemical composition and dry matter degradability of the forage consumed by goats in a highly deteriorated rangeland of North Mexico

A.S. Juárez[1#], R. Montoya[1], G. Nevarez[1] and M.A. Cerrillo[1]
[1] Universidad Juárez del Estado de Durango. Facultad de Medicina Veterinaria y Zootecnia. División de Estudios de Posgrado. Carretera Durango-Mezquital km 11.5 Durango, Dgo. Mexico

Abstract

The aim of this study was to determine the seasonal variations in chemical composition and dry matter (DM) degradability of the diet of grazing goats on a thorn scrubland in a semi-arid region of Durango, México. Extrusa samples from four oesophageal fistulated goats (33 kg liveweight) were used. The samples were obtained two consecutive days each month from October 1992 to September, 1993. Approximately five g of sample DM were incubated in the rumen of three sheep fed alfalfa hay *ad lib.* (120 g/kg CP; 400 g/kg NDF) for 0, 3, 6, 12, 24, 48, 72 and 96 h. Degradability data were fitted to the model: $P = a+b\ (1 - e^{-ct})$. Then, the immediately soluble fraction *a*, the insoluble but rumen degradable fraction *b*, the potential degradation *a* + *b*, the degradation rate *c* and the effective degradability (ED) were determined. The data were analyzed according to a completely randomized experimental design. Annual means of crude protein (CP), CP intake (CPI) and metabolisable energy intake (MEI) (90.0 g/kg, 47.8 g/d and 2.8 MJ/d, respectively), were insufficient to meet the maintenance requirements of goats. Degradation parameters differed between the studied seasons. Mean values for *a*, *b* and *c* were 41.0%, 45.1% and 2.7%/h, respectively and are considered low, whereas mean value for ED (63.5%) is moderate. Results indicated that the low values of CPI and MEI as well as the *c* fraction may negatively influence body condition and reproductive activity of the animals.

Keywords: In situ, degradability, grazing goats, semi-arid region
[#] Corresponding author. E-mail: ajuarez52@yahoo.com.mx

Introduction

Goat production is relevant in pastures where rainfall and forage availability is scarce. In such areas, characterized as arid and semi-arid, goats provide the main if not the sole economical income to farmers (Devendra, 2001). Therefore, it is important to evaluate the quality of the diet consumed by goats in order to improve any feeding constraints. Forage evaluation implies the description of the feedstuffs with respect to their capacity to sustain diverse kinds and levels of production (France *et al*., 2000). Thus, to improve the quality of the forage consumed by range animals, it is necessary to obtain information on the nutritional value of the diet in relation to the requirements (Preston & Leng, 1989). An approach to determine the nutritional potential of the forage consumed by grazing animals is the utilization of the in situ method. The objective of this study was to determine the seasonal variations in chemical composition and dry matter (DM) degradability parameters of the diet consumed by goats grazing a thorn scrubland in a semiarid region of North Mexico.

Material and Methods

The study was conducted in a highly deteriorated vegetative community characterized as thorn scrubland. The site was located at 24° 04' and 25° 15' NL and 103° 23' and 104° 37' WL with a dry climate, altitude from 1435 to 1982 mosl, mean annual temperature of 21 °C and rainfall of 278 mm per annum. The vegetative community was composed only by 18 vegetative species. *Jatropha dioica*, locally known as sagregado, was the most common species (Molina & Fresnillo, 1992). Extrusa samples were obtained from four oesophageal fistulated goats (33 kg liveweight) (Stevens *et al*., 1985). The sampling was performed two consecutive days each month, morning (11:30) and afternoon (15:30), for periods of 45 minutes during 12 months (October 1992-September 1993). The samples were stored on ice, dried in an air forced oven for 48 h and milled through 1 and 2 mm screen for chemical analyses and *in situ* degradability determinations, respectively. The samples of all four animals were further composited to obtain a representative extrusa

Peer-reviewed paper: 8th International Conference on Goats

sample of each month. Organic matter intake (OMI) was calculated by: OMI = OM faecal production/1- diet digestibility (Handl & Rittenhouse, 1975). To estimate diet digestibility, the pepsin (24h)-cellulase (24h) enzymatic procedure was utilized (Aufrère, 1982). Diet crude protein (CP) and organic matter (OM) were determined according to AOAC (1985) and digestible energy (DE) and metabolisable energy (ME) according to Kearl (1982). Cell wall contents were determined according to Van Soest *et al*. (1991). About five g of dry oesophageal extrusa were incubated *in situ* in the rumen of three sheep fed lucerne hay *ad lib.* (120 g CP/kg; 400 g NDF/kg) for 0, 3, 7, 12, 24, 48, 72 and 96 h. The data were fitted to the exponential equation: $P = a + b\ (1 - e^{-ct})$ (Ørskov & McDonald, 1979), then, the immediately soluble fraction *a*, the insoluble but rumen degradable fraction *b*, the potential degradation $a + b$, the degradation rate *c* at time *t*, were determined. The effective degradability was calculated considering a rate of passage of 2%/h using $a + ((b * c)/(c + 0.02))$ (AFRC, 1993). Data were analyzed using ANOVA for a completely randomized block design. Degradation parameters were obtained by PROC NLIN, and analyzed by PROC GLM. Mean differences were determined using Tukey's test (SAS, 1997).

Results and Discussion

The CP content differed between seasons ($P < 0.05$), with an annual mean of 90 g/kg (Table 1). The higher value for NDF ($P < 0.05$) was registered in winter (512.2 g/kg) and the lower value in spring (407.0 g/kg); the same trend was observed for ADF with values of 422.0 and 255 g/kg for winter and spring, respectively. Differences ($P < 0.05$) were registered in lignin concentration between seasons; the annual mean for this variable was 148.0 g/kg. The annual mean OM digestibility (OMD) was 43.9% and differed between seasons ($P < 0.05$). The higher value was obtained in spring (54.5%) when the animals consumed elevated amounts of cactae species which have a digestibility of higher than 67% (Granados & Castañeda, 1991). The values for DE and ME in the diet were higher ($P < 0.05$) in spring (DE = 8.3 and ME = 6.7 MJ/kg) than in the other seasons. The ME intake (MEI) was lower (2.8 MJ/d) than the requirements for maintenance of goats (NRC, 1981). The CPI maintenance requirements for 33 kg grazing goats are 74 g/d (NRC, 1981). In this study CPI was 43.0, 41.0, 40.0 and 67.0 g/d during autumn, winter, spring and summer, respectively. Only during summer (July-September) did the goats almost approached (67 g/d), their CP requirements for maintenance (NRC, 1981). Low values registered for MEI and CPI contributed to the poor body condition and low reproductive performance of the animals in the study area.

Table 1 Chemical composition (DM basis) and energy and crude protein intake by goats grazing a thorn scrubland in North Mexico

	Seasons					
Item	Autumn	Winter	Spring	Summer	Mean	se *
Crude protein (g/kg)	71.0^{b}	65.1^{b}	62.1^{b}	161.0^{a}	90.0	0.54
Neutral detergent fiber (g/kg)	465.0^{b}	512.2^{a}	407.0^{c}	456.0^{b}	468.0	0.67
Acid detergent fiber (g/kg)	385.0^{a}	422.0^{a}	255.0^{c}	342.0^{c}	351.0	0.92
Lignin (g/kg)	197.1^{a}	137.0^{b}	98.0^{c}	16.1^{b}	148.0	0.55
Organic matter digestibility (%)	40.7^{bc}	38.4^{c}	54.5^{a}	42.3^{b}	43.9	1.00
Digestible energy (MJ/kg)	6.2^{bc}	5.8^{c}	8.3^{a}	6.3^{bc}	6.7	0.04
Metabolizable energy (MJ/kg)	4.2^{bc}	4.2^{bc}	6.7^{a}	4.6^{b}	4.9	0.04
Metabolizable energy intake (MJ/d)	2.5^{b}	2.5^{b}	4.5^{a}	1.9^{c}	2.8	0.04
Crude protein intake (g/d)	43.0	41.0	40.0	67.0	47.8	1.91

$^{a, b, c, d}$ Row means with common superscript do not differ ($P > 0.05$)
* se= Standard error of the mean

The degradation parameters of the diet consumed by the goats during the various seasons are presented in Table 2. Differences were registered between seasons ($P < 0.05$) in all the fractions. The fraction *a* (lost during washing of bags at zero time) in winter (41.3%), spring (44.6%) and summer (41.0%) were higher than that registered in autumn (37.3%). High values for this fraction, which constitute 64.5% of the *ED*, appear to be explained by high levels of cell soluble compounds in browse (Schacht, 1992). The fraction *b* (slowly degraded in the rumen) was higher ($P < 0.05$) in spring (49.0%) and summer (62.7%) than in autumn (35.0%) and winter (33.6%). The degradation rate (*c*, %/h) was higher ($P < 0.05$) in autumn (4.5%/h)

Peer-reviewed paper: 8th International Conference on Goats

than in spring (1.7%/h), summer (1.5%/h) and winter (2.9%/h). The *PD* was higher ($P < 0.05$) in spring (93.5%) and summer (90.3%) than in winter (74.8%) and autumn (72.3%). The *ED* was different ($P < 0.05$) between seasons; the annual mean was 63.5%. Higher values were registered in spring (67.2%) and summer (64.9%). Lower values for this fraction were 61.5% for both autumn and winter. The relevance of the *c* fraction is based on the fact that it represents the rate at which the food is degraded in the rumen and its effect on the rate of passage of the food through the rumen and on intake (Khazaal *et al*., 1995).

Table 2 Dry matter degradation parameters of the diet of goats grazing a thorn scrubland in North Mexico

	Seasons					
Parameters	Autumn	Winter	Spring	Summer	Mean	se *
A	37.3[b]	41.3[a]	44.6[a]	41.0[a]	41.0	1.4
B	35.0[c]	33.6[c]	49.0[b]	62.7[a]	45.1	11.3
C	4.5[a]	2.9[ab]	1.7[b]	1.5[b]	2.7	0.1
PD	72.3[b]	74.8[ab]	93.5[a]	90.3[a]	82.2	3.0
ED	61.0[b]	61.1[b]	67.2[a]	64.9[a]	63.5	1.2

[a, b, c, d] Row means with common superscript do not differ ($P > 0.05$)
a = Highly degradable fraction (%); *b* = Slowly degradable fraction (%); *c* = Degradation rate (%/h);
PD = Potential degradation (%); *ED* = Effective degradability (%); * se = Standard error of the mean

Moreover, the *ED* is a function of *a*, *b*, *c* and the rate of passage of *b* fraction through the rumen (Ørskov & Mc Donald, 1979). In consequence, the rate of passage exerts a direct effect on the digestion process, absorption of nutrients and forage intake. Results from this study in relation to the degradation rate *c* (2.7%/h) are lower than those reported by Alvarez (2003) in a scrubland community (4.7 %/h).

Conclusions

The mean level and intake of CP of the diet throughout the year (90.0 g/kg and 47.8 g/d) as well as the ME intake (2.8 MJ/d) on the highly deteriorated rangeland were inadequate to meet the maintenance requirements of goats. The degradation rate (*c* = 2.7 %/h; annual mean) is low compared to results reported in vegetative communities in other semi-arid regions, and *ED* (63.5%) is moderate. Although the *a* fraction constituted an elevated proportion of *ED* (64.5%), low intakes of CP, and ME, and low degradation rate *c*, may have contributed to the poor body condition and lack of reproductive activity of the goats observed in the study area.

Acknowledgements

The support provided by ANKOM Technology Inc. (Macedonia, NY USA) is fully appreciated. The authors are also grateful to PROADU (SEP-Mexico) for financial support.

References

AFRC, 1993. Energy and Protein Requirements of Ruminants. CAB International, Wallingford, Oxon OX10 8DE, UK.

Alvarez, G.R.A., 2003. Degradabilidad in situ de la materia seca del forraje consumido por caprinos en un matorral mediano subespinoso durante dos años consecutivos. Tesis de maestría. FMVZ-UJED. Durango, Dgo. México. 32 pp.

AOAC, 1985. Official methods of analysis (12th ed.). Association of Official Analytical Chemists, Inc., Washington, D.C. USA.

Aufrère, J., 1982. Prediction of forage digestibility by an enzymatic method. Ann. Zootech. 31, 111-119.

Devendra, C., 2001. Small ruminants: Imperatives for productivity enhancement improved livelihoods and rural growth. A review. Asian-Aust. J. Anim. Sci. 14, 1483-1496.

France, J. Theodorou, M.K., Lowman, R.S. & Beever, D.E., 2000. Feed evaluation for animal production. In Feeding systems and feed evaluation models. Eds. Theodorou, M.K. & France, J., CABI Publishing. pp. 1-9.

Granados, S.D. & Castañeda, A.P., 1991. El nopal: Historia, Fisiología, genética e importancia frutícola. Ed. Trillas. Universidad Autónoma Chapingo. México.

Handl, W.P. & Rittenhouse, L.R., 1975. A comparison of three methods of estimating digestibility for determining intake of grazing cattle. J. Range Manage. 28, 414-416.

Khazaal, K., Dentino, M.T., Ribeiro, J.M. & Órskov, E.R., 1995. Prediction of apparent digestibility and voluntary intake of hays fed to sheep: Comparison between using fibre components, in vitro digestibility or characteristics of gas production or nylon bag degradation. Anim. Sci. 61, 527-538.

Kearl, L.C., 1982. Nutrient requirements of ruminants in developing countries. International Feedstuffs Institute, Utah Agric. EXP. Station. Utah State University Logan 84 322, USA. 381 pp.

Molina, M.C. & Fresnillo, D.E, 1992. Atributos de la vegetación del matorral mediano subespinoso de dos sitios de agostadero en Cuencamé, Durango. In: memorias de la Reunión Nacional de Investigación pecuaria. Chihuahua, México. p. 3.

NRC, 1981. Nutrient requirements of goats. Angora, Dairy and Meat Goats in temperate and tropical countries. N° 15. National Academy Press, Washington, D.C., USA.

Ørskov, E.R. & McDonald, L., 1979. The estimation of protein degradability in the rumen from incubation measurements weighted according to the rate of passage. J. Agric. Sci., Camb. 92, 499-503.

Preston, T.R. & Leng, R.A., 1989. Adecuando los sistemas de producción pecuaria a los recursos disponibles: Aspectos básicos y aplicados del nuevo enfoque sobre nutrición de rumiantes en el trópico. CONDRIT. Ltda. Cali, Colombia. 312 pp.

SAS, 1997. Applied Statistics and the SAS Programming Language. (4th ed.). Prentice Hall, Upper Saddle River, New Jersey 07458, USA.

Schacht, W.H., 1992. Shrub ecology, nutritive value, and palatability. In: Proc. of the International Conference on Meat Goat Production, Management and Marketing. Eds. Paschal, J.C. & Hanselka, C.W., Laredo, Texas. USA. pp. 92-102**.**

Stevens, E.J., Thomson, G.G. & O'Connor, K.F., 1985. A modified procedure for esophageal fistulation of sheep. J. Range Manage. 38, 88-89.

Van Soest, P.J., Robertson, J.B. & Lewis, B.A., 1991. Methods for dietary, neutral detergent fiber, and non starch polysaccharides in relation to animal nutrition. Symposium: carbohydrate methodology, metabolism, and nutritional implications in dairy cattle. J. Dairy Sci. 74, 3583-3597.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Faecal NIRS to monitor the diet of Mediterranean goats

S. Landau#, T. Glasser, L. Dvash and A. Perevolotsky
Department of Natural Resources and Agronomy, Agricultural Research Organization,
The Volcani Center, P.O. Box 6, Bet Dagan 50250, Israel

Abstract

A method to elucidate the diet of goats in ligneous environments is needed. Twelve Damascus yearlings were subjected to 12 test periods in which days 1-7 were for adaptation, intake was recorded on days 8-10 and faeces were grab-sampled on days 9-10, resulting in 143 pairs of diets and faeces. Diets consisted of hay and concentrate given in different ratios (n = 60), or combinations of three species browsed by goats (*Pistacia lentiscus, Phyllirea latifolia,* and *Pinus Brutia)* and concentrate (n = 83). Faeces were scanned in the 1,100-2,500 nm range by aids of a Near Infrared Spectrometer. Chemical and botanical percentage (% of DM) and actual (g/d) intake values were then fitted to reflectance values. Values for R^2 and the standard error of cross validation (SECV), used as estimates of calibration quality for component percentages were: CP, 0.98, 0.5; NDF, 0.94, 1.5; *in vitro* DMD, 0.98, 2.0; PEG-binding tannin, 0.96, 1.0; hay, 0.99, 5.5; concentrate, 0.95, 4.5; total browse, 0.97, 6.1; *P. lentiscus*, 0.95, 7.1; *P. latifolia*, 0.94, 7.0; and *P. brutia*, 0.95, 6.5. Values for R^2 and SECV of intake (g/d) were: DM, 0.83, 126; CP, 0.75, 12; NDF, 0.79, 56; *in vitro* digestible DM, 0.74, 58; PEG-binding tannin, 0.92, 20; hay, 0.97, 67; concentrate, 0.95, 41; total browse, 0.87, 180; *P. lentiscus*, 0.93, 106; *P. latifolia*, 0.85, 194; and *P. brutia*, 0.85, 151. Chemical composition (% DM) can be predicted from faeces spectra as accurately as from direct analyses of feeds. Predictions of nutrient and botanical intake (g/d) are less accurate but still relevant for monitoring purposes.

Keywords: Ruminant nutrition, range management, near infrared, Mediterranean pasture, grazing
#Corresponding author. E-mail: vclandau@agri.gov.il

Introduction

Goats are used for brush control and ecological management of Mediterranean scrubland (Perevolotsky & Seligman, 1998). Farmers are willing to cooperate with communities in this important role at the condition that profitability is not impaired, i.e. the diets of goats are compatible with their production goals. They need a method to evaluate the daily intake of nutrients in order to supplement the animals, if needed. In heterogeneous environments, this information can be acquired by time-consuming observations and hand-clipped reconstituted diets (Kababya *et al*., 1998), but such technology is not relevant for farm conditions. In addition, it provides group and not individual data on goat nutrition. The n-alkane method can provide reliable information, provided that individual correction is made for alkane recovery in the faeces (Brosh *et al*., 2003), but analytical costs make it irrelevant for farm studies.

The importance of faecal chemical composition in understanding nitrogen and energy status was demonstrated by Nunez-Hernandez *et al*. (1992). The chemical information concealed in faeces can provide information on the chemical (Leite & Stuth, 1995) and botanical (Walker *et al*., 2002) composition of intake in goats. The Near Infrared Spectrometry (NIRS) methodology offers many advantages over standard methods used for dietary evaluation, and, in particular, low cost, chemical-free, rapid, and non-destructive analyses. In a pioneering study with oesophageal-fistulated goats, using NIR spectrometry of faeces, Leite & Stuth (1995) succeeded in explaining 94% and 93% of the variation in dietary crude protein (CP) and *in vitro* (Tilley & Terry, 1961) digestibility (% of dry matter, DM), with respective accuracies of 1.1 and 2.0%. A further step was achieved by Coates (2000) who developed prediction equations for the DM intake (DMI) and digestible DMI (DDMI) in terms of g/d/kg BW in penned cattle.

In the frame of a program aimed at establishing methodologies to monitor Mediterranean ecosystems, this study was a preliminary step to establish NIRS calibrations for dietary composition and intake in ranging goats.

Materials and Methods

Twelve Damascus yearling goats (mean weight of 38.5±0.7 kg) were used for this study that was conducted at the south of the Carmel ridge, Israel. The goat facility consisted of roofed individual dust-floor pens and of a roofed collective corral where animals were placed in between tests. Pen dimensions were 1.7

Peer-reviewed paper: 8th International Conference on Goats

X 1.7 m, i.e. large enough to allow goats not to alter their daily patterns of intake or activity. Pens were close together in order to reduce the cage effect on behaviour. Each pen was outfitted with a 15 L water bucket and a trough divided into two compartments for concentrate and hay separation. A shelf was placed under each trough in order to facilitate residue collection. Diets consisted of hay and concentrate given in different ratios, or combinations of three species browsed by goats (*Pistacia lentiscus, Phyllirea latifolia,* and *Pinus Brutia)* and concentrate (Table 1).

Table 1 Composition of diets during the tests

Period	Dietary components	Dry matter (DM) intake (g/d)	Percentage of component in diet (% of DM)
1	Lucerne hay	746	79.5
	Concentrate	195	20.5
2	Lucerne hay	709	74.4
	Concentrate	243	26.5
3	Lucerne hay	423	57.2
	Concentrate	322	42.8
4	Lucerne hay	535	75.1
	Concentrate	177	24.9
5a	*P. lentiscus*	724	61.8
	Concentrate	442	38.2
5b	*P. latifolia*	589	56.2
	Concentrate	442	43.8
6a	*P. lentiscus*	560	55.2
	Concentrate	442	44.8
6b	*P. latifolia*	734	61.5
	Concentrate	442	38.5
7a	*P. lentiscus*	931	72.7
	Concentrate	348	27.3
7b	*P. latifolia*	1311	78.8
	Concentrate	348	21.2
8	*P. lentiscus*	246	19.7
	P. latifolia	646	52.2
	Concentrate	348	28.1
9	*P. brutia*	895	71.0
	Concentrate	364	29.0
10	Clover hay	406	57.8
	Concentrate	321	42.2
11	*P. brutia*	317	29.8
	P. lentiscus	466	44.1
	Concentrate	277	26.1
12	*P. brutia*	301	23.7
	P. lentiscus	233	18.7
	P. latifolia	429	35.0
	Concentrate	278	22.6

Faeces samples were packed into sample cells with a near-infrared transparent quartz cover glass and scanned between 1104-2492 nm in 2 nm increments using a Foss NIRSystems 5000 NIR reflectance (R) monochromator spectrometer (Foss Tecator, Hoganas, Sweden). Raw spectral data was transformed by using the Standard Normal Variate (SNV) and detrend procedure against scattering distortion (Barnes *et al.,* 1989). The calibration of Log (1/R) against wavelengths was carried out, using the (1, 4, 4, 1) procedure, i.e., first derivative of transformed spectra, 4 nm gaps and 4 nm smoothening value, or the (2, 6, 6, 2) procedure, in order to overcome particle size and light scatter distortions (ISI, 1999). The (2,6,6,2) procedure was also used. Calibration equations were developed on the treated spectral data, using the Modified Partial Least-Squares using WinISI II software (ISI, 1999). Before data analysis was performed, outliers were identified and removed (ISI, 1999). In order to widen the range of attribute in calibrations, up to 20% "zero" samples were added in calibrations sets, e.g. 12 samples of faeces from diets that did not contain hay were added to 60 samples from diets that did contain hay for calibration of hay percentage in diets.

Peer-reviewed paper: 8th International Conference on Goats

The ability of the calibration equation to predict external samples from the same population was assayed by cross-validation, using a rotating 1/6 of the samples for six times as an "internal" subset for the cross-validation procedure. The statistical measures of the calibration equation prediction ability and accuracy were the coefficient of determination (R^2) and the Standard Error of Cross Validation (SECV).

Browse branches were cut daily. Diets were weighed and distributed once every morning. The study consisted of twelve 10-day tests. On the morning of the day 6, pens were thoroughly cleaned of any residues before the distribution of rations. On days 7-10, residues were collected every morning before feeding and weighed. Feeds were weighed on a scale with ±0.5 g accuracy. On days 9-10, faeces were grab-collected at three different times in the morning, midday and evening in order to reach better heterogeneity of digestion stages. Mean intake of days 6-9 was calculated as the daily intake value of each goat. This procedure resulted in 144 pairs of faeces and diet of which one had missing information on diet intake and was not used for calibration purposes. The calibration data consisted of 60 pairs resulting from hay-and-concentrate diets and 83 diets comprising browse species. All samples (feed and faeces) were air-dried at 60 °C during 48 hours in a ventilated oven and ground to pass a 1 mm sieve. Samples were re-dried at 60 °C for one hour and desiccated at ambient temperature for 1 hour before scanning. Crude protein, neutral detergent fiber (NDF) and acid detergent fiber (ADF) were analyzed in diets according to AOAC (1984). *In vitro* digestibility of dry matter (IVDMD) was according to Tilley & Terry (1961). PEG-binding tannins were assessed as described by Landau *et al*. (2004). All these attributes in percentages, botanical composition and intake values were used as reference values in the NIRS calibrations.

Results and Discussion

Table 2 Prediction of chemical dietary attributes in diets (% of DM) and intake (g/d) for the whole data set (n=143). PEG-binding tannins have been calibrated for the browse data (n=83) only. First[1]- or second[2]-derivatized spectra were used for calibration

		Reference values			Calibration performance		
Constituent	Outliers	Mean	s.d.	Range	R^2	SEC	SECV
% of DM							
CP[2]	7	12.2	2.9	7.7-16.9	0.98	0.4	0.53
NDF[2]	5	37.9	5.6	28.5-50.1	0.94	1.4	1.53
DDM[2]	9	60	10.8	41.3-80	0.98	1.65	1.98
PEG-binding tannins[2]	2	6.15	4.5	0.29-15.6	0.96	0.85	1.07
g/d							
DM[2]	7	1031	249	552-1874	0.83	101.7	126.4
CP[2]	7	121	21.2	61-193	0.75	10.5	12.3
NDF[2]	4	386	96	179-690	0.79	44.3	55.8
DDM[2]	7	599	95.3	352-950	0.74	48.2	57.8
Tannin[1]	6	4	306	0.26-12.4	0.93	0.79	1

DDM – digestible dry matter

The calibrations of dietary chemical attributes in percentages were of high linearity (all R^2 above 0.94, Table 2). Accuracy and linearity values for CP and DDM (%) are higher than those by Leite & Stuth (1995). This could be because the same animals provided diet estimates and faecal spectra in our study, whereas diets were obtained from fistulated animals while free-grazing non-fistulated counterparts contributed the faeces. In addition, the calibrations were based on a limited number of discrete wavelengths, whereas monochromators and chemometry software, such as that provided by ISI (1999) enable NIRS prediction

Peer-reviewed paper: 8th International Conference on Goats

equations based on greater number of wavelengths (700) in the whole NIR region. Interestingly, the quality of the prediction of chemical composition is as good from faecal spectra as from feed spectra, as noted before by Lyons & Stuth (1992). Garcia-Ciudad *et al.* (1993) reported a R^2 value of 0.95 and SECV's of 1 and 2% for CP and NDF, respectively. We get similar accuracy in our lab for composite vegetation collected on pastures. Landau *et al*. (2004) reported accuracy of 1.6% in the prediction of PEG-binding directly assessed in browse, compared with 1.1% in this study when established from faecal spectra. In other words, our study corroborates the view that the assessment of dietary value from faeces is as accurate as from feed components, but feed components is unknown in ranging animals and faeces are always available.

Calibrations of the intake of nutrients were less linear and accurate than those of percentages (Table 2), as noted before by Coates (2000) in cattle. Expression of reference values on kg BW or kg $BW^{0.75}$ basis did not improve calibrations, compared with absolute daily (g/d) values. Even though prediction of intake values are relatively uncertain, two calibrations have special nutritional value. Dietary CP is the first limiting factor in ranging animals. In many situations prediction of CP intake with an accuracy of 12 g/d allows to decide to supplement goats or not to. Similarly, the prediction of PEG-binding tannin at the accuracy of 1 g/d reflects the intake of browse, and can help to decide whether or not to supplement goats with PEG in order to alleviate the effects of tannin (Landau *et al*., 2000).

The prediction of botanical percentages (Table 3) is of high linearity ($R^2 > 0.94$), but the accuracy of prediction is less than for chemical attributes in the diet (Table 2). The accuracy reached here is similar to that achieved by Walker *et al.* (2002) for the prediction of percent sagebrush (determination of one species, in mixtures of three) in sheep by faecal NIRS and by Brosh *et al.* (2003) with n-alkanes, after correction for alkane recovery. However, it must be reminded that the method proposed here requires no extraction, and no individual correction for marker recovery. Predictions of the intake of individual botanical species had unexpectedly relatively high R^2 values and accuracies high enough for monitoring purposes.

Table 3 Prediction of botanical components in diets (% of DM) and their intake (g/d) in the whole data set (n=143). PEG-binding tannins have been calibrated for the browse data (n=83) only. R^2 and the standard errors of calibration (SEC) and of cross-validation (SECV) serve as estimates of prediction quality. First[1]-or second[2]-derivatized spectra were used for calibration

Constituent			Reference values			Calibration performance		
Component	n	Outliers	Mean	S.D	Range	R^2	SEC	SECV
Percent of DM								
Hay[2]	72	0	56.7	34.8	0-100	0.99	3.6	5.5
Concentrate[1]	143	5	31.1	17	0-76	0.95	3.7	4.5
Total browse[1]	100	3	58.6	27	0-83	0.97	4.6	6.1
Pistacia lentiscus[2]	65	0	32.7	23.9	0-76.5	0.95	5.4	7.1
Phylirea latifolia[2]	49	1	45.2	23.6	0-81.4	0.94	5.6	7.0
Pinus brutia[1]	43	1	35.5	25.5	0-78	0.95	5.7	6.5
g/d								
Hay[2]	72	0	460	298	0-989	0.97	47.6	67
Concentrate[1]	143	5	309	150	0-577	0.95	33.7	40.6
Total browse[2]	100	0	709	380	0-1526	0.87	137	180
Pistacia lentiscus[1]	65	1	376	289	0-1130	0.93	76.5	106
Philyrea latifolia[2]	49	0	573	379	0-1526	0.85	146	194
Pinus brutia[2]	43	0	422	340	0-1186	0.85	130	151

Peer-reviewed paper: 8th International Conference on Goats

Conclusion

It seems that the faecal NIRS method may provide a "fast and clean" practical and accurate for farm-use process for estimating diet attributes of diets consumed by goats. The prediction of botanical components by faecal NIRS is novel for goats. One of the major practical advantages of faecal NIRS is the ability to monitor individuals as well as the whole herd. By monitoring individual animals the farmer can obtain information about efficiency of the individual animal and consider this information in further management decisions. Even though the calibrations presented here can be considered a methodical breakthrough in our ability to reach dietary information in goats, their robustness has still to be ascertained under field conditions.

References

AOAC, 1984. Official methods of analysis (14th ed.). Association of Official Analytical Chemists, Inc., Arlington, Virginia, USA.

Coates, D.B. 2000. Predicting diet digestibility and crude protein content from the faeces of grazing cattle. Final report project cs.253, CSIRO Tropical Agriculture, Davis Laboratory, Townsville Q 4814, Australia.

Barnes, R.J., Dhanoa, M.S. & Loster, S.J., 1989. Standard normal variance transformation and de-trending of near-infrared diffuse reflectance spectra. Appl. Spectrosc. 43, 722-777.

ISI, (1999). WinISI, the complete software solution for routine analysis, robust calibrations and networking. Version 1.02A. Infrasoft International. Port Matilda. PA.

Garcia-Ciudad, A., Garcia-Criado, B. & Perez-Corona, M.E., 1993. Applications of near infrared reflectance spectroscopy to chemical analysis of heterogeneous and botanically complex grassland samples. J. Sci. Food Agric. 63, 419-426.

Kababya, D., Perevolotsky, A., Bruckental, I. & Landau, S., 1998. Selection of diets by dual-purpose Mamber goats in Mediterranean woodland. J. Agric. Sci., Camb. 131, 221-228.

Landau, S., Dvash, L., Decandia, M., Cabiddu, A., Shapiro, F., Molle, G. & Silanikove, N., 2004. Determination of poly(ethylene-glycol)-binding to browse foliage, as an assay of tannin, by Near Infrared Reflectance spectroscopy. J. Agric. Food Chem. (in press)

Landau, S., Perevolotsky, A., Bonfil, D., Barkai, D. & Silanikove, N., 2000. Utilization of low quality resources by small ruminants in Mediterranean agro-pastoral systems: the case of browse and aftermath cereal stubble. Livest. Prod. Sci. 64, 39-49.

Leite, E.R. & Stuth, J.W. 1995. Fecal NIRS equations to assess diet quality of free-ranging goats. Small Rumin. Res. 15, 223-230.

Lyons, R.K. & Stuth, J.W. 1992. Fecal NIRS equations for predicting diet quality of free-ranging cattle. J. Range Manage. 45, 238-244.

Nunes-Hernandez, G., Holechek, J.L., Arthun, D., Tembo, A., Walace, J.D., Galyean, M.L., Cardenas & Valdes, R.. 1992. Evaluation of fecal indicators for assessing energy and nitrogen status of cattle and goats. J. Range Manage. 45, 143-147.

Perevolotsky, A. & Seligman, N.G., 1998. Role of grazing in Mediterranean rangeland ecosystems. Bio. Sci. 48, 1007-1017.

Tilley, J.M.A. & Terry, R.A., 1961. A two-stage technique for the in vitro digestion of forage crops. J. Br. Grassld. Soc. 18, 104-111.

Walker, J.W., Mccoy, S.D., Launchbagh, K.L., Fraker, M.J. & Powell. J., 2002. Calibrating fecal NIRS equations for predicting botanical composition of diets. J. Range Manage. 55, 374-382.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Influence of various levels of metabolizable energy on chemical composition of whole carcass and non-carcass portion of goats and sheep

O. Mahgoub[1#] and C.D. Lu[2]

[1] Department of Animal & Veterinary Sciences, College of Agricultural and Marine Sciences, Sultan Qaboos University, P.O. Box 34, Al-Khod 123, Sultanate of Oman, [2] Office of Vice Chancellor for Academic Affairs, University of Hawaii at Hilo, 200 W. Kawili Street, Hilo, HI 96720-4091

Abstract

Two comparative slaughter studies using 24 male goats and 40 Omani male lambs were carried out to determine the effects of various levels of metabolizable energy (ME) on chemical composition of carcass and non-carcass portions. Eighteen goats and 30 lambs were divided randomly into four groups. Group 1 (6 goats and 10 lambs) was slaughtered at the onset of the trial, while the remaining groups were fed with one of the three ME diet levels of 8.67, 9.95 and 11.22 MJ/kg DM from weaning until slaughter. The feeding trial continued for 141 d for goats and 123 d for sheep. Dietary energy density had a significant effect on the slaughter weight in both sheep and goats. Carcass water and fat percentages were affected significantly by the dietary energy density. Non-carcass water, protein and fat were also affected significantly by the dietary energy density. With increasing age and body weight (comparing the initial slaughter group and those slaughtered at the end of the trial), content of water, crude protein and ash decreased whereas that of fat increased in carcass portions of both goat and sheep. Goat carcasses contained more water than sheep. On a dry matter basis, goat carcasses contained significantly lower fat and ash but higher protein levels than sheep. This emphasises the ability of goats to produce leaner carcasses than sheep, which is a preferable meat characteristic to consumers. Responses to dietary energy manipulation were quite different between goats and sheep in terms of carcass and non-carcass composition as interactions between species and diet were significant.

Keywords: Energy levels, chemical composition, carcass
Corresponding author. E-mail address: osmahgob@squ.edu.om; chrislu@hawaii.edu

Introduction

Goat and sheep are significant meat producing animals with goats being more important in the less developed parts of the world. There are about 768 million goats and 1,028 billion sheep in the world. Oman has 998,000 goats and 354,000 sheep (FAO, 2004). In the tropics, especially for animals raised under traditional systems, energy intake fluctuates according to the season and the ability of owners to provide supplementary feeding. This should have an impact on the meat production as animals may use more energy going for grazing at long distance than gaining energy from poor range feed.

The objectives of this study were to investigate the effects of various levels of metabolizable energy (ME) on chemical composition of carcass and non-carcass portions of Omani goats and sheep.

Materials & Methods

Two separate experiments using 40 Omani male lambs and 24 male goats were carried out at the Sultan Qaboos University Agricultural Experiment Station. Animals were randomly assigned after weaning to one of the four treatment groups (10 sheep and 6 goats per treatment). Animals in Treatment Group 1 were slaughtered at the onset of the experiment for initial carcass composition. Animals in the remaining three groups were assigned randomly to one of three dietary treatments containing 8.67, 9.95 or 11.22 MJ ME/kg of dry matter (DM). The ingredients and chemical analysis of the diets, which were offered as a total mixed ration, are presented in Table 1. Lambs and kids stayed with their dams and fed creep feed *ad lib.* from birth to weaning at an average age of 80 days. From weaning to slaughter, lambs were individually housed in pens (1×2 m) and fed the respective experimental diets until slaughter at 140 days for goats and 123 days for sheep. Animals were weighed weekly. A digestibility trial was carried out using four lambs of each treatment for a 2-week adjustment and 1-week collection period to determine digestible and metabolizable energy. Feed, faecal and urine samples were collected daily to determine their energy content. At slaughter, blood was collected in plastic trays and transferred into plastic bags. Non-carcass components included blood, head, feet, skin, liver, spleen, heart, lungs and trachea, empty digestive tract, pancreas, non-

Peer-reviewed paper: 8th International Conference on Goats

carcass fat depots (kidney, pelvic and scrotal) and testicles. The total weight of non-carcass organs and tissues was determined and they were stored frozen in plastic bags at –20 ºC. Digestive tract contents were calculated as the difference between full and empty digestive tract. The carcass was wrapped in a polyethylene bag and stored at –20 ºC. Carcasses were split along the midline with a band saw. Both the frozen left half carcass and non-carcass portion were ground separately in a whole carcass grinder. The product was further ground in a meat grinder fitted with a finer screen and well mixed before samples were collected for chemical analysis. Proximate analysis was carried out on the minced samples for DM, crude protein (CP), ether extract (EE) and ash according to the methods of AOAC (2000). Experimental data were analysed using General Linear Model procedures of analysis of variance (SAS, 1991).

Results and Discussion

The three formulated experimental diets were iso-nitrogenous. By design, there was an inverse relationship between dietary energy density and ADF and NDF content (Table 1). This is a direct result of higher forage (Rhodesgrass hay) and a lower concentrate (barley grain) percentage in the lower energy diets. The ration composition was comparable to the standard rations of sheep and goats and met the nutritional requirements for growing goats and sheep (NRC, 1981; 1985).

Table 1 Ration formulation and chemical composition of diets containing three levels of metabolizable energy (ME) fed to Omani goats and sheep

Item	Dietary energy concentration		
	Low	Medium	High
Ingredients, g/kg			
Rhodesgrass hay	600	400	200
Barley grain	190	400	400
Maize grain	-	17	226
Soyabean meal (44%CP)	170	173	134
Maize oil	12	10	8
Limestone	8	10	12
Vitamin/mineral premix	10	10	10
Sodium bicarbonate	10	10	10
Chemical composition, g/kg DM			
Crude protein	162	160	160
Neutral detergent fibre	443	341	237
Acid detergent fibre	258	186	124
Ash	79	69	62
Calcium	8.9	8.9	8.8
Phosphorus	1.9	2.3	2.8

The digestibility for the DM, as expected, was inversely correlated with the fibre content of the diet. A similar pattern was observed with digestibility of DE and ME (54.19, 54.91 and 59.79% for low-, medium-, and high-ME diets, respectively). The ratio between DE and ME for low-, medium-, and high-energy diets was 0.82, 0.82 and 0.81 respectively. This is similar to that suggested for diets which does not contain high grain component by NRC for temperate animals (NRC, 1985).

Table 2 Dry matter and energy digestibility of iso-nitrogenous diets containing low-, medium-, and high-energy concentrations

Item	Dietary energy concentration			Pooled
	Low	Medium	High	s.e.
Digestible dry matter, %	66.9 [b]	68.7 [a,b]	73.9 [a]	0.59
Gross energy (MJ/kg DM)	18.2 [b]	18.7 [a]	18.9 [a]	0.13
Digestible energy				
Digestion coefficient, %	66.8 [b]	67.2 [a,b]	73.3 [a]	0.43
Diet concentration (MJ/kg)	12.2 [c]	12.6 [b]	13.9 [a]	0.08

[a,b,c] Means in the same row without a common letter in their superscripts differ significantly (P< 0.05)

Peer-reviewed paper: 8th International Conference on Goats

Goats were older but lower in body weight at slaughter than sheep although they stayed longer on trial (141 *vs* 123 days). According to Lu & Pochoiba (1981), growth rate of Omani goats was about half of that of Alpine and Nubian goats. We speculated that growing goats might have been less adaptive than sheep to confinement as they grew at a slower rate than sheep (Mahgoub & Lodge, 1998). There was a trend of increasing body weight with increasing ME levels. However, this was more marked in sheep than in goats. High ME level goats were 13% heavier whereas high ME sheep were 26% heavier than corresponding animals of low ME diet by the end of each study (Table 3). This implied that Omani sheep better adapted to improved management conditions, which may be an important consideration for management decisions for small ruminant farmers in the tropics.

With increasing age and body weight (comparing the initial slaughter group and those slaughtered later in the trial) water, crude protein and ash content decreased whereas that of fat increased in carcasses of both goats and sheep. Goat carcasses contained higher water than sheep (Table 3). On a dry matter basis, goat carcasses contained a lower fat and ash, but higher protein content than sheep. This emphasises the ability of goats to produce leaner carcasses than sheep, which is a preferable meat characteristic to consumers.

There was a trend of increasing fat content and a decreasing protein and ash content with increasing levels of ME in carcasses of goats and sheep. These results are in line with native Sabi sheep in Zimbabwe (Kusina *et al.,* 1991). Compared with Sabi sheep, Omani sheep and the goats studied, were slaughtered at approximately two-thirds of their mature weight. This implies that the most variable and late maturing carcass component, fat, is still at early stages of maturity, which explains the lack of significance in statistical differences in carcass composition.

Goats and sheep fed the high-energy diet had higher fat levels than those fed the low-energy diet in the non-carcass portion. Non-carcass fat matures earlier (Butterfield, 1988) and therefore, effects of energy density are more likely to be observed than the late maturing carcass fat. For both carcass and non-carcass portions, CP decreased whereas fat increased. This is in line with findings in sheep (Butterfield, 1988) as fat is a late maturing body tissue. Animals fed the low-energy diet had higher protein and lower fat content in the carcass portion than those fed medium- and high-energy diets. This is similar to findings reported in cattle (Ferrell *et al*., 1978) and in sheep (Ferrell *et al*., 1979). Interestingly, there was a trend of increasing ash content with increasing energy levels in the non-carcass portion in both sheep and goats. This is the opposite of the decreasing ash content observed for the carcass (Table 3). This might be attributed to the increased growth rates of the wool and hair.

Table 3 Mean chemical components of carcass and non-carcass portions in Omani goat and sheep fed various levels of metabolizable energy (ME)

Item	Goats					Sheep					Effect; P<		
	Reference	Low	Med	High	SEM	Ref	Low	Med	High	SEM	Spp	Diet	Spp×Diet
Trial period (d)		141	141	141			123	123	123				
Age (d)	152	269	269	268	3	74	191	195	194	3	0.001	0.001	NS
Slaughter wt (kg)	15.43	22.53	23.82	25.44	2.40	15.18	27.40	30.16	34.41	1.85	0.05	0.001	NS
Carcass (g/kg DM)													
Water	613	598	573	568	17	548	510	505	489	13	0.001	0.01	NS
Crude protein	452	472	398	401	21	347	346	310	299	17	0.001	NS	0.05
Fat	406	427	457	531	25	520	571	587	604	21	0.001	0.05	NS
Ash	91	66	58	33	12	81	85	74	76	9	0.05	NS	0.05
Non-carcass (g/kg DM)													
Water	598	616	598	580	11	639	550	540	525	9	0.001	0.001	0.001
Crude protein	416	452	425	402	17	485	358	347	387	14	0.05	0.001	0.001
Fat	416	384	453	455	19	396	452	476	505	15	0.05	0.01	0.001
Ash	95	87	95	91	12	79	62	77	94	9	0.001	NS	NS

Conclusions

Under the identical feeding and management conditions outlined in this study, sheep seem to be a faster growing species than goats. This study indicated that goat carcass and non-carcass portions contain

lower fat and higher protein than those of sheep. Increasing levels of dietary ME increased fat and reduced protein content of carcass and non-carcass portions in both sheep and goats.

References

AOAC, 2000. Official methods of analysis. (17th ed.). Association of Official Analytical Chemists. International. Gaithersburg, Maryland, 20877-2417. USA.

Butterfield, R.M. 1988. New concepts in sheep growth. University of Sydney, Australia.

FAO. 2004. FAOSTAT Home, FAO Homepage. Animal feed resources information system. (http://apps.fao.org/page/collections/subset=agriculture).

Ferrel, C.L., Crouse, J.D., Field, R.A. & Chant, J.L., 1979. Effects of sex, diet and stage of growth upon energy utilization by lambs. J. Anim. Sci. 49, 790-801.

Ferrel, C.L., Kolmeier, R.H., Crouse, J.D. & Hudson, G., 1978. Influence of dietary energy, protein and biological type of steer upon rate of gain and carcass characteristics. J. Anim. Sci. 46, 255.

Kusina, N.T., Hale, D.H., Chesworth, J.M. & Mutisi, C. 1991. Effect of the amount of dietary energy on growth and body composition of Sabi lambs. In: Isotope aided studies on goat and sheep production in the Tropics. International Atomic Energy Agency, Vienna.

Lu, C.D. & Potchoiba, M.J., 1990. Feed intake and weight gain of growing goats fed diets of various energy and protein levels. J. Anim. Sci. 68, 1751-1759.

Mahgoub, O. & Lodge, G.A. 1998. A comparative study on growth, body composition and carcass tissue distribution in Omani sheep and goats. J. Agric. Sci., Camb. 131, 329-340.

NRC, 1981. Nutrient Requirements of Goats. National Academy Press, Washington, D.C. USA. National Research Council. 1985. Nutrient Requirements of Sheep. 6th revised edition. National Academy Press, Washington, D.C. USA.(not in alphabetic order)

SAS, 1991. Statistical Analysis Systems user's Guide: Statistics (Version 5) SAS Institute Inc., Cary, North Carolina, USA.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Effects of intravenous infusion of trans-10,cis-12 or cis-9, trans-11 conjugated linoleic acid (CLA) on milk fat synthesis and composition in dairy goats during mid-lactation

Ph Schmidely
UMR Physiologie de la Nutrition et Alimentation, INRA-INAPG, 16 rue Claude Bernard, Paris, France

Abstract

The effects of an intravenous infusion of trans-10, cis-12 or cis-9, trans-11 conjugated linoleic acid (CLA) were evaluated during 2 consecutive days on milk fat synthesis and fatty acid profile of milk fat in dairy goats. Neither milk yield, nor milk fat content were modified by any of the CLA isomers. The concentration of each CLA was not increased after each infusion. Milk fatty acid profile was not affected by any of the tested CLA's, except an increase in the proportion of linoleic acid. This suggests that goats and cows respond in a different manner regarding mammary metabolism of these fatty acids.

Keywords: conjugated linoleic acids, milk fat, milk composition, goat.
#Corresponding author; E-mail: schmidel@inapg.inra.fr

Introduction.

Conjugated linoleic acid (CLA) are positional and geometrical isomers of linoleic acid (cis-9, cis-12 Δ C18:2) found mainly in dairy products of ruminants. Numerous research studies have recently focused on these fatty acids (FA) because of their putative or demonstrated health benefits in animal or human models (Martin & Valeille, 2003). Moreover, in dairy cows, the cis-9, trans-11 isomer (rumenic acid) and more probably the trans-10, cis-12 isomer have been shown to be potent inhibitors of milk fat synthesis when infused in the abomasum (Baumgard *et al*., 2000).

In dairy goats, very little data is available on the concentrations of the CLA in milk fat (Schmidely *et al*., 2002) and it has been suggested (Chilliard *et al*., 2003) that the mammary metabolism of these FA could differ between goats and cows. As an intravenous infusion of CLA produced the same drop in fat content as an abomasal infusion in cows (Viswanadha *et al*., 2003), we studied the effect of the intravenous infusion of these two CLA isomers separately on milk fat yield and composition in dairy goats.

Materials and Methods

Four multiparous dairy goats (150 ± 15 DIM) were fed a TMR for ad libitum consumption twice daily. The total mixed ration (TMR) was formulated to contain 35% alfalfa hay,25% sugar beet pulp, and 40% concentrate on a dry matter (DM) basis. , The CP, ADF, and EE contents (DM)of the diet were 16%, 21.8%, and 4.1% respectively with a Net Energy for lactation value of 1615 Kcal/kg DM.

Each goat was infused for 2 days, alternatively with one of the CLA isomers in a random order, with a 2-day washout(clearance?) period between the 2 infusions to minimize any carry-over effect of the infused CLA. The infusions of CLA commenced at 09h00 after the morning milking and 1h after the morning feeding and lasted 8 hours. The CLA were diluted in 200 mL of pure 10% Intralipid and were infused through catheters inserted in the jugular vein. The dose of cis-9, trans-11 CLA and trans-10, cis-12 CLA were 1 g / d and 0.2 g/d respectively, which was estimated to approximately double their proportion in milk fat.

Milk samples were collected at each milking the day before, during and after infusions. For both morning and evening milking the evaluation criteria were the change from baseline in milk yield, milk fat content and milk fatty acid profile, after a 2-day infusion. Baselines were defined as the measurements assessed prior to infusion, at morning and evening milking respectively. Changes from baseline were compared to 0 using a sign-rank test (Proc Univariate of SAS). Data is(presented as means ± SEM(standard error of the means)Results

Milk yield, milk fat content, and cis-9, trans-11 CLA concentration in milk fat were 1440 (± 70) g/d , 43 (±2) g/L and 0.48 (± 0.06) g/100 g milk fat before cis-9, trans-11 CLA infusion and 1415 (± 88) g/d and 37 (±2) g/L and 0.51 (± 0.06) g/100 g fat before trans-10, cis-12 CLA infusion. Trans-10, cis-12 CLA was not detected in any milk sample before the infusions.

Peer-reviewed paper: 8th International Conference on Goats

Infusion of the trans-10, cis-12 CLA or of the cis-9, trans-11 CLA isomers had no effect on milk yield or fat yield at morning or evening milking (Table 1). Milk fat content was not affected by the infusions of CLA. However, after the infusion of cis-9, trans-11 CLA, 2 goats exhibited a sharp decrease in milk fat content at the evening milking (-15 and –12 g/L).

The infusion of the two CLA isomers did not result in increased concentrations of these isomers in milk fat. (Table 2). In particular, no trans-10, cis-12 CLA was detected in the milk of the goats infused with this FA. Short chain FA (C6:0 and C8:0), medium chain FA (from C10:0 to C16:0) and stearic acid concentrations were not altered by any FA infused, regardless of whether it was samples from morning or evening milking (data not shown). Trans vaccenic acid (trans-11 C18:1) was decreased by rumenic acid infusion only at morning milking. The most consistent change after infusion of each CLA was the increase in linoleic acid, at e both milkings. Simultaneously, the linolenic acid concentration in milk fat was increased but only significantly by the cis-9, trans-11 CLA infusion.

Discussion

In dairy cows, abomasal and blood infusions of mixtures of CLA or pure CLA proved the trans-10, cis-9 CLA to be a potent inhibitor of milk fat synthesis, and such a response was obtained with 3 mg /kg body weight with a 5-day infusion period (Viswanadha *et al*., 2003), a dose equivalent to that used in our study. Moreover, the dose used for cis-9, trans-11 CLA in our study (17 mg/kg body weight) was higher to that infused in the abomasum by Chouinard *et al*., (1999), who observed a reduction in milk fat content and milk fat yield. However, in our study, we did not observed any change in the milk fat content of dairy goats. The infusion of these CLA isomers induced a reduction in mammary synthesis of short-chain and medium chain FA (Chouinard *et al*., 1999; Viswanadah *et al*., 2003), which is in contrast to our results. Furthermore, we observed an increase in the milk fat percentage of linoleic acid (and to a lesser extent for linolenic acid) after the infusion of the two CLA isomers. This is in contrast with results obtained in cows and is probably reflecting a greater uptake of this long-chain unsaturated FA after the CLA infusion. This could be an indication that some differences in mammary metabolism for these conjugated FA do occur between goats and cows as suggested by Chilliard *et al*., (2003). However, difference in duration and in frequency of infusion between those cow studies and our study could also be responsible of this lack of response to CLA in goats.

Table 1 The effect of intravenous infusion of trans 10,cis 12 or cis 9 trans 11 conjugated linoleic acid (CLA) on milk yield,fat content and fat yield in dairy goats[1]

Infusion	cis-9, trans-11 CLA		trans-10, cis-12 CLA	
Milking	Morning	Evening	Morning	Evening
Milk yield, g / milking	-269 ± 130 (NS)	+100 ± 42 (NS)	-131 ± 76 (NS)	+25 ± 58 (NS)
Fat yield, g / milking	-6.6 ± 6.1 (NS)	-6.4 ± 7.1 (NS)	+1.9 ± 2.5 (NS)	+6.0 ± 6.1 (NS)
Fat content , g/L	+1.12 ± 3.1 (NS)	-8.5 ± 4.5 (NS)	+2.5 ± 0.8 (NS)	+3.3 ± 5.0 (NS)

[1]. Data are presented as means ± SEM (n = 4). NS: effect of infusion non significant.

Table 2 Variations in fatty acid profile (g/100 g of fatty acids) of milk fat at morning and evening milkings in dairy goats intravenously infused with trans-10, cis-12 or cis-9, trans-11 conjugated linoleic acid (CLA)[1,2]

Infusion	cis-9, trans-11 CLA		trans-10, cis-12 CLA	
Milking	Morning	Evening	Morning	Evening
cis-9 C18:1	+1.16 ± 0.36 (NS)	+0.46 ± 0.70 (NS)	-0.78 ± 0.3 (NS)	+0.35 ± 0.35 (NS)
trans-11 C18 :1	-0.21 ± 0.02 (†)	-0.33 ± 0.34 (NS)	-0.12 ± 0.09 (NS)	0.01 ± 0.13 (NS)
cis-9, trans-11 CLA	-0.08 ± 0.03 (NS)	-0.03 ± 0.08 (NS)	-0.10 ± 0.09 (NS)	+0.02 ± 0.04 (NS)
trans-10, cis-12 CLA	ND	ND	ND	ND
cis-9, cis-12 C18:2	+0.95 ± 0.25 (†)	+0.71 ± 0.24 (†)	+1.00 ± 0.13 (†)	+1 ± 0.2 (†)
cis-9, cis12, cis-15 C18:3	+0.05 ± 0.01 (†)	+0.12 ± 0.03 (†)	0.10 ± 0.03 (NS)	+0.10 ± 0.10 (NS)

[1]. Data are presented as means ± SEM (n = 4). NS: non significant. † : $P < 0.10$
[2].ND : not detected.

Conclusion

Short-term intravenous infusion of cis-9, trans-11 or trans-10, cis-12 CLA isomers failed to induce a decrease in milk fat yield or milk fat content in mid lactation dairy goats. Further studies are needed to confirm this, perhaps utilising higher doses of CLA.

Peer-reviewed paper: 8th International Conference on Goats

References

Baumgard, L.B., B. Corl, D. Dwyer, A. Saebo & D.E. Bauman. 2000. Am. J. Physiol. 278, R179-R184.
Chilliard, Y., A. Ferlay, J. Rouel & G. Lamberet. 2003. J. Dairy Sci. 86, 1751-1770.
Chouinard, P.Y., L. Corneau, A. Saebo & D.E. Bauman. 1999. J. Dairy Sci., 82, 2737-2745.
Martin, J.C. & K. Valeille. 2003. Reprod. Nutr. Develop. 42, 525-636.
Schmidely, Ph., P. Bas, A. Rouzeau & D. Sauvant. 2002. Renc. Rech. Ruminants, 9, 366 (Abstr).
Viswanadha, S. J.G. Giesy, T.H. Hanson & M.A. McGuire. J. Dairy Sci. 86, 3229-3236.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Preference of grazing goats for cool-season annual clovers

T.H. Terrill[1#], W.F. Whitehead[1], G. Durham[2], C.S. Hoveland[2], B.P. Singh[1] and S. Gelaye[1]
[1]Fort Valley State University, Fort Valley, GA 31030, USA
[2]The University of Georgia, Athens, GA 30602, USA

Abstract

Information on improved forages for goat grazing is lacking for the southern USA. Two cafeteria-style grazing trials were completed to determine preference of meat-type goats for cool-season annual clovers in Georgia. In both experiments, 8 replicates of 6 plots of clover cultivars were established, individually fenced, and grazed by Spanish goats for 48 hours during two grazing periods. Forage preference was determined by weighing strips of forage cut from plots pre- and post-grazing (Experiment 1) and by ocular scoring (1=no grazing to 10=completely grazed) after 4, 24, and 48 hours grazing (Experiment 2). In Experiment 1, 'Dixie' and 'AU Robin' crimson clover (*Trifolium incarnatum* L.) were most preferred, 'AU Sunrise' crimson clover and 'Yuchi' arrowleaf clover (*Trifolium vesiculosum* Savi) were intermediate, and 'Segrest' ball clover (*Trifolium nigrescens* Viv.) and 'R18' rose clover (*Trifolium hirtum* All.) were least preferred. Forage preference was not influenced by dry matter yield, fibre content or protein concentration. In Experiment 2, Dixie and AU Sunrise crimson clover were most preferred in the first cutting, 3 arrowleaf clover types and 'Americus' hairy vetch (*Vicia villosa* Roth) were intermediate and R18 rose clover was least preferred. When the crimson clover plots were not available for the second grazing period, the goats most preferred Yuchi arrowleaf clover, with 'BYMV' arrowleaf clover and hairy vetch intermediate, and rose clover least preferred. Crimson clover appears to be a useful forage for winter-spring grazing of goats in the southern USA.

Keywords: Grazing preference, goats, clover
[#]Corresponding author. Email: terrillt@fvsu.edu.

Introduction

Production of goats is increasing in the southern USA because of high ethnic demand for goat meat and milk products and the relatively low cost of breeding stock. Although goats are considered predominantly browsers under range conditions, they can be productive when grazing high-quality forages (Stevens *et al*., 1993). Annual clovers provide high-quality winter and spring grazing for beef cattle and sheep in the South. New Zealand data on white clover (*Trifolium repens* L.) suggests that goats do not relish this plant as much as sheep (Clark *et al*., 1982), but little data are available on goat's willingness to consume different clover types in the USA. The objective of these experiments was to determine the grazing preferences of goats for annual clovers.

Materials and Methods

Two cafeteria-style grazing experiments were completed at the Fort Valley State University Agricultural Research Station, Fort Valley, GA., USA, from fall, 1999, through spring, 2001. For both experiments, 10 replicates of 6 clover cultivars were planted into 3.05 m x 3.05 m plots (November 10, 1999, and November 11, 2000 for Experiments 1 and 2, respectively) using a cone-type plot planter. Clover types studied in Experiment 1 included Dixie, AU Robin, and AU Sunrise crimson clover, Yuchi arrowleaf clover, Segrest ball clover, and R18 rose clover, while Dixie and AU Sunrise crimson, Yuchi arrowleaf with and without Apron fungicide coating, BYMV arrowleaf and R18 rose clover were tested in Experiment 2. Plots of Americus hairy vetch were also added for Experiment 2. For both tests, each block of plots was individually fenced, weeds were removed by hand, and rubber water pans were added prior to grazing. For two periods in each year (March 22-24 and April 12-14, 2000; March 26-28 and May 14-16, 2001), 32 Spanish does (3-4 yr old, Experiment 1) or 40 yearling Spanish-Boer cross castrated male kids (Experiment 2) grazed the plots for 48 hours. Before starting the trials, the goats were allowed to graze the first two blocks of forage plots as a single group for 48 hours to familiarize them with the forages and allow preferences to be established. After the adjustment period, the does or kids were stratified by weight and randomly assigned to the remaining 8 blocks, and grazing was initiated. In Experiment 1, a 0.76 m x 3.05 m

Peer-reviewed paper: 8th International Conference on Goats

strip of forage was cut out of the middle of each plot pre- and post-grazing, weighed fresh and subsampled for determination of dry matter (DM) yield, quality components, and calculation of total forage DM consumed from each plot. Forage subsamples were dried at 50 °C for 48 hours, ground to 1 mm particle size, and analyzed for crude protein (CP) (AOAC, 1990), neutral detergent fibre (NDF) and acid detergent fibre (ADF) (Goering & Van Soest, 1970). For Experiment 2, all plots were visually evaluated to determine extent of pasture use after 4 hours, 24 hours and 48 hours grazing. Two observers assigned each plot an ocular preference score (Shewmaker *et al*., 1997) from 1 (no grazing) to 10 (completely grazed).

Preference (DM consumed) and forage quality data for Experiment 1 were analyzed as a randomized block, while preference data from Experiment 2 (ocular preference score after 4, 24, and 48 hours grazing) were analyzed as a randomized block with repeated measures analysis using a GLM procedure (SAS, 1992).

Results

In Experiment 1, forage availability at the initial grazing was highest for AU Robin crimson, R18 rose, and Dixie crimson clovers, intermediate for Yuchi arrowleaf, and lowest for AU Sunrise crimson and Segrest ball clover (1137, 1023, 982, 491, 298, and 255 kg/ha, respectively). For the second grazing period, forage availability ranged from 838 to 446 kg/ha, with highest to lowest ranking for arrowleaf, ball, rose, Dixie crimson, AU Robin crimson, and AU Sunrise crimson clover, respectively. Crude protein and fibre concentrations also differed ($P < 0.05$) among the clover cultivars, with the cultivars ranking differently during each grazing period. During the initial grazing, forage CP, NDF, and ADF ranged from 24.2 to 18.5, 32.2 to 25.3, and 21.1 to 17.6%, respectively, while these constituents ranged from 23.4 to 18.2, 42.8 to 26.6, and 30.3 to 17.4%, respectively, in the second grazing period.

Despite differences in forage availability and quality indices in each grazing period, there was no effect of cutting date on DM consumed for the different clover cultivars, so data from the two grazing periods in experiment 1 were pooled. Total DM consumed by the goats averaged 372, 368, 322, 218, 145, and 100 g for Au Robin crimson, Dixie crimson, AU Sunrise crimson, arrowleaf, rose, and ball clovers, respectively. Consumption of Dixie and AU Robin crimson clover was significantly higher than for ball ($P < 0.05$) or rose ($P < 0.07$) clover.

Table 1 Preference of Boer-Spanish cross goat yearlings for cool-season annual clovers

	First cutting (3/22-3/24/01)			Second cutting 5/14-5/16/01)		
	Grazing time					
Forage	4 hr	24 hr	48 hr	4 hr	24 hr	48 hr
	- - - - - - - - - - Ocular preference score[1] - - - - - - - - - -					
R18 rose clover	1.30[a]	2.1[a]	3.2[a]	1.0[a]	2.3[a]	4.7[a]
BYMV arrowleaf clover	2.16[ab]	3.3[b]	5.0[b]	2.8[b]	5.2[b]	7.0[bc]
Fungicide-coated Yuchi arrowleaf	2.21[bc]	3.7[b]	5.8[b]	4.0[c]	6.7[c]	8.3[cd]
Yuchi arrowleaf	2.50[bc]	3.8[b]	5.4[b]	4.5[c]	6.9[c]	8.8[d]
Dixie crimson clover	3.00[c]	5.9[c]	7.6[c]	NA[2]	NA	NA
Sunrise crimson clover	2.58[bc]	5.3[c]	8.2[c]	NA	NA	NA
Americus hairy vetch	2.63[bc]	3.5[b]	5.6[b]	3.9[c]	5.6[c]	6.8[b]
Standard error	0.29	0.36	0.44	0.32	0.45	0.57

[1]Ocular preference score 1-10, 1=no grazing; 2=<2%, 3=2-5%, 4=5-10%, 5=10-25%, 6=25-40%, 7=40-60%, 8=60-75%, 9=75-90%, and 10=completely grazed.
[2]NA=forage not available.
[a,b,c,d]Column means with unlike superscripts differ significantly ($P < 0.05$).

In the initial grazing period in Experiment 2, yearling kids also preferred ($P < 0.05$) the crimson clover cultivars over the arrowleaf clover types and hairy vetch, with rose clover least preferred (Table 1). With no

Peer-reviewed paper: 8th International Conference on Goats

crimson clover available during the second grazing period, the kids preferred Yuchi arrowleaf clover without fungicide coating significantly ($P < 0.05$) more than BYMV arrowleaf, with rose clover preferred the least.

Discussion

Both mature and growing goats showed a preference for crimson clover over other clover types, and preference was not related to DM availability, CP or fibre in the different forages. Dixie crimson clover was lower in fibre and intermediate in CP concentration and DM yield, but was most preferred by the goats. Shewmaker *et al*. (1997) reported little relationship between DM yield and preference of grazing beef cattle for different cultivars of endophyte-free tall fescue (*Festuca arundinacea* Schreb.). These authors also reported higher repeatability and time savings for an ocular scoring technique compared with cutting before and after grazing to establish forage preferences of grazing animals. We confirmed these results in the current study. The coefficient of variation (CV) for the ocular preference scoring technique used in the second experiment averaged 34%, while the CV for cutting before and after grazing to establish preference (Experiment 1) was 49%. Although no direct comparison of the two techniques was done in the current investigation, the ocular preference scoring technique was much easier and appears to be an effective means of establishing grazing preference of goats.

Conclusions

Crimson clover was preferred by goats over other clover types and may be suitable as high-quality winter-spring pasture for goat production in the southern USA. Although less preferred than crimson, arrowleaf clover has a longer grazing season in this region and may also have potential for goat grazing. Further research is needed with these species to determine performance of goats grazing annual clover as a component of the diet.

References

AOAC, 1990. Official methods of analysis (25th ed.). Association of Official Analytical Chemists, Inc. Arlington, VA, USA.

Clark, D.A., Lambert M. G., Rolston, M .P. & Dymock, N., 1982. Diet selection by goats and sheep on hill country. Proc. N.Z. Soc. Anim. Prod. 42, 155-157.

Goering, H.K., & Van Soest, P.J., 1970. Forage fiber analyses (apparatus, reagents, procedures, and some applications). Agric. Handb. 379, U.S. Gov. Print. Office, Washington, D.C.

SAS, 1992. Statistical Analysis Systems user's guide, Version 6.07 SAS Institute, Inc., Carey, North Carolina, USA.

Shewmaker, G.E., Mayland, H.F. & Hansen, S.B., 1997. Cattle grazing preference among eight endophyte-free tall fescue cultivars. Agron. J. 89, 695-701.

Stevens, D.R., Casey, M. J., Baxter, G. S. & Miller, K. B., 1993. A response of angora-type goats to increases of legume and chicory content in mixed pastures. Proc. XVII Int. Grassl. Cong., 1300-1301.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

The determination of digestibility of *Atriplex nummularia* cv. De Kock (Oldman's saltbush) using different *in vitro* techniques

A. van der Baan, W.A.van Niekerk#, N.F.G Rethman[1] and R.J.Coertze
Department of Animal and Wildlife Sciences, University of Pretoria, Pretoria 0002, South Africa
[1]Department of Plant Production and Soil Science, University of Pretoria, Pretoria 0002, South Africa

Abstract

The main disadvantages of the rumen fluid *in vitro* technique are the cost and welfare issues of keeping cannulated animals. The purpose of the study was to find an accurate alternative *in vitro* technique to determine organic matter digestibility (OMD) of *Atriplex nummularia* supplemented with two energy sources. The *in vitro* faeces technique of El Shaer *et al*. (1987) is an easier and cheaper alternative to the classic rumen fluid *in vitro* technique of Tilley & Terry (1963), as modified by Engels & Van der Merwe (1967). The *in vitro* gas production technique of Piennaar (1994), the cellulase *in vitro* techniques of De Boever *et al.* (1986) and the modified Wageningen one, were not as accurate determining OMD as the *in vivo* technique.

Keywords: *in vitro* techniques, rumen and faeces inoculum, gas production, cellulase, *Atriplex*
#Corresponding author. E-mail: willem.vanniekerk@up.ac.za

Introduction

In vivo determinations of digestibility in ruminants are expensive, labour intensive and time consuming. This creates a need for a simple, cheap and reliable laboratory technique to evaluate the nutritive value of forages for ruminant animals. The cost and animal-welfare considerations also make the use of animals less desirable. An increasing human population and demand for animal products creates the need for the evaluation of new animal feedstuffs and improved varieties of traditional ones (Williams, 2000).

Most *in vitro* digestibility techniques rely on fermentation of feeds with buffered rumen fluid. In order to obtain rumen fluid, ruminally cannulated animals are required, which are expensive to maintain and in some circumstances unavailable (El-Meadaway *et al*., 1998). Another disadvantage of using rumen inocula is that a uniform diet should be fed if the inocula are to have constant activity (Akhter *et al*., 1999).

The objective of the study was to determine which of the *in vitro* techniques provide the best prediction of the organic matter digestibility (OMD) of *Atriplex nummularia* cv. De Kock, supplemented with different levels of maize and barley.

Materials and Methods

Atriplex nummularia cv. De Kock was harvested between the end of March and the beginning of April 2001, sun dried and sorted into edible and non-edible material. Edible material was defined as leaf and stems with a diameter of 6mm and less. After sorting, the material was milled through a hammermill with a 25mm sieve size.

Atriplex nummularia cv. De Kock, was supplemented with three levels (15%, 30%, 45%) of either maize and barley. The two energy sources used, differed in their fermentation rates. Maize is a slower fermentable and barley a faster fermentable energy source. A standard digestibility trial with five wethers was conducted to obtain the *in vivo* organic matter digestibility.

The following *in vitro* techniques were used:

a) The *in vitro* rumen fluid technique (RFT) (Tilley & Terry, 1963, as modified by Engels & Van der Merwe, 1967)
b) The *in vitro* faeces fluid technique (FFT) (El Shaer *et al*., 1987)
c) The *in vitro* gasproduction technique (GPT) (Pienaar, 1994)
d) The *in vitro* cellulase technique (CTdB) (De Boever *et al*., 1988)
e) The *in vitro* cellulase technique (CTWI) (Wageningen Institute of Animal Science, The Netherlands).

Peer-reviewed paper: 8th International Conference on Goats

An analysis of variance with the Proc GLM model (SAS, 1994) was used to determine the significance between the different techniques. Means and standard deviations (s.d.) were calculated. Significance of difference (5%) between means was determined with Bonferroni's test (Samuels, 1989).

Results and Discussion

Table 1 The organic matter digestibility (%) (s.d.) of *A. nummularia* cv. De Kock, supplemented with different levels of maize and barley, using different techniques

	Treatment					
Levels	**RFT**	**FFT**	**GPT**	**CTdB**	**CTWI**	***In vivo***
Atriplex (*A.*) 0%	39.5^{a}(±0.9)	38.2^{a}(±3.3)	30.8^{b} (±1.2)	34.0^{ab}(±0.3)	36.9^{a}(±1.2)	34.3^{ab} (±10.2)
A.+15%Maize	60.8^{a}(±0.1)	60.1^{a}(±2.5)	37.2^{b}(±0.1)	44.2^{b}(±1.6)	48.8^{b}(±0.1)	54.7^{a}(±7.0)
A.+ 15%Barley	62.4^{a}(±10.6)	62.3^{a}(±1.5)	35.4^{b}(±0.1)	46.7^{b}(±1.5)	47.1^{b}(±0.5)	61.3^{a}(±5.8)
A.+ 30%Maize	64.9^{a}(±2.0)	63.2^{a}(±0.9)	50.1^{b}(±2.4)	56.6^{b}(±1.0)	48.7^{b}(±0.3)	55.7^{b}(±14.1)
A.+ 30%Barley	69.6^{a}(±0.4)	68.1^{a}(±6.4)	44.6^{b}(±0.7)	53.1^{b}(±0.4)	47.1^{b}(±0.4)	62.4^{a}(±8.4)
A.+ 45%Maize	68.3^{a}(±0.1)	66.3^{a}(±1.8)	58.0^{b}(±0.7)	61.3^{ab}(±0.9)	59.0^{b}(±1.2)	64.0^{ab}(±8.5)
A.+ 45%Barley	72.5^{a}(±10.1)	73.3^{a}(±4.7)	54.1^{b}(±0.5)	61.2^{ab}(±0.7)	58.7^{ab}(±0.9)	67.0^{a}(±7.0)

^{abc}Row means with common superscripts do not differ (P > 0.05)

No differences (P > 0.05) were found between the rumen- and faeces inoculum *in vitro* techniques, but they did differ from the gas production and cellulase techniques (P < 0.05). There was also no difference between the gas production and cellulase techniques (P > 0.05). The OMD of the RFT and FFT techniques did not differ from the *in vivo* OMD values (P < 0.05).

There are several possibilities for the difference between the *in vivo* and *in vitro* OMD. 1. Practical mistakes could have been made. 2. The simulation of the rumen motility *in vitro* is often difficult and it may be that all the feed particles did not have the same exposure to the microorganisms, as it would have in the rumen of an animal. The different rumen pools is also not fully represented *in vitro*. 3. The fermentation characteristics and microbial constitution of the rumen inocula differ, between the animal used for the *in vivo* digestibility trial and the animals used for rumen inocula collection. 4. With *in vivo* digestibility the time of digestion is not known, and therefor the time of rumen and gastric digestion *in vitro* could have been too long or too short.

Conclusion

The results of the this study demonstrated that both the rumen- and faeces inoculum *in vitro* techniques can be used to determine the OMD of *A. nummularia* cv. De Kock, supplemented with an energy concentrate (slower and faster fermentable) up to 45%. This confirms that the *in vitro* faeces technique of El Shaer *et el*. (1987) is an easier and cheaper alternative to the classic rumen fluid *in vitro* technique of Tilley & Terry (1963), as modified by Engels & Van der Merwe (1967) to determine the OMD of ruminant feeds. The gas production and cellulase *in vitro* techniques resulted in lower OMD values than the *in vivo* technique.

Acknowledgement

This research was supported in part under Grant No. TA-MOU-99-C16-091 funded by the U.S.-Israel Cooperative Development Research Program, Bureau for Economic Growth, Agriculture and Trade, U.S. Agency for International Development.

References

Akhter, S., Owen, E., Theodorou, M.K., Butler, E.A. & Minson, D.J., 1999. Bovine faeces as a source of micro-organisms for the *in vitro* digestibility assay of forages. Grass For. Sci. 54, 219-224.

De Boever, B.G., Cottyn, J.L., Andries, J.I., Buysse, F.X. & Vanacker, J.M., 1988. The use of a cellulase technique to predict digestibility, metabolisable and net energy of forages. Anim. Feed Sci. Tech. 19, 247-252.

Peer-reviewed paper: 8th International Conference on Goats

El-Meadaway, A., Mir, Z., Mir, P.S., Zaman, M.S. & Yanke, L.J., 1998. Relative efficacy of inocula from rumen fluid or faecal solution for determining *in vitro* digestibility and gas production. Can. J. Anim. Sci. 673-677.

El Shaer, H.M., Omed, H.M. & Chamberlain, A.G., 1987. Use of faecal organisms from sheep for the *in vitro* determination of digestibility. J. Agric. Sci. 109, 257-263.

Engels, E.A.N. & Van der Merwe, F.J., 1967. Application of an *in vitro* technique to South African forages with special references to the effect of certain factors on the results. S. Afr. J. Agric. Sci. 10, 983-995.

Pienaar, J.P., 1994. Theoretical and applied aspects of voluntary feed intake by ruminants, with special reference to the kinetics of rumen digestion. PhD. Thesis , University of Natal, Pietermaritzburg, South Africa.

Samuels, M.L., 1989. Statistics for the life sciences. Collier MacMillan Publishers, London.

SAS, 1994. Statistical Analysis Systems User's Guide. Statistics Version 6. SAS Inst., Inc. Cary, NC., USA.

Williams, B.A., 2000. Cumulative gas production techniques for forage evaluation. In: Forage Evaluation in Ruminant Nutrition. Eds. Givens, D.I., Owen, E., Omed, H.M. & Axford, R.F.E. CAB International, Wallingford. Pp. 189.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Comparison of chemical composition of *Atriplex* spp. grown under South African conditions with regard to site, species and plant parts

W.A. van Niekerk#, P.J. Vermaak, N.F.G. Rethman[1] and R.J. Coertze
Department of Animal and Wildlife Sciences, University of Pretoria, Pretoria 0002, South Africa
[1]Department of Plant Production and Soil Science, University of Pretoria, Pretoria 0002, South Africa

Abstract

The aim of this study was to evaluate the nutritional value of *Atriplex* spp. for small stock production. Selected plants were harvested and analysed for crude protein, *in vitro* digestibility and leaf to stem ratio. Significant differences were noted between leaves and stems as well as between sites for the three *Atriplex* spp. Significant seasonal effects were noted in terms of composition of leaves and stems between the two sampling seasons for *A. canescens* (Veld Reserve I) and *A. canescens* (Santa Rita) but not for *A. nummularia.*

Keywords: *Atriplex*, crude protein, *in vitro* digestibility
#Corresponding author. E-mail: willem.vanniekerk@up.ac.za

Introduction

Considerable information on the chemical composition and nutritional characteristics of the *Atriplex* spp. is available in the literature (Chatterton *et al*., 1971; Smit & Jacobs, 1978; Davis, 1981). However such information on *Atriplex* spp. grown under South Africa conditions is lacking. The objective of this study was to determine the seasonal changes in chemical composition of leaves and stems of different *Atriplex* spp. as well as the difference in quality between localities in semi-arid areas in South Africa.

Materials and Methods

Mature *Atriplex* spp. were selected for this study from three sites in South Africa during March and July 2002. The sites were Hatfield, Pretoria, Gauteng; Mier, (Northern Cape) and Lovedale (Northern Cape). Samples collected from each species consisted of small branches with stems not larger than 5mm in diameter.

Mature leaves and twigs were collected from *A. nummularia, A. canescens* (Santa Rita) and *A. canescens* (Veld Reserve I). After collection the samples were dried at 60°C for 48 hours, the leaves separated from the stems and then ground through a 1-mm screen using a mill. By weighing the leaves and stems, a leaf to stem ratio was calculated. Organic matter digestibility (IVOMD) was estimated by the *in vitro* method described by Tilley & Terry (1963) as modified by Engels & Van der Merwe (1967). Crude protein (CP) concentration was determined by Kjeldahl (AOAC, 2000). Analyses of variance with the Proc GLM model (SAS, 1994) were used to determine the significance between different species of *Atriplex* in different locations, seasons and plant parts. Means and standard deviations (s.d.) were calculated. Significance of difference (5%) between means was determined by Bonferroni's test (Samuels, 1989).

Results and Discussion

The crude protein, IVOMD and leaf to stem ratio of the three *Atriplex* spp. collected at three different sites are presented in Table 1. The CP concentration varied from 9.38% in *A. canescens* (Veld Reserve 1) to 19.46% in *A. nummularia* (Mier). The CP values correspond well with those reported by Senock *et al.* (1991) for *A. canescens.* The CP concentration for all the species was the highest at Mier. In most cases there was a significant difference in the CP concentration for a specific species between sites. *A. nummularia* had the highest CP concentration at all the studied localities.

Except for *A. nummularia*, there were no significant differences in the IVOMD values for different localities. The IVOMD values for *A. nummularia* were in all cases higher ($P < 0.05$) than the other species. Significant differences were observed for leaf to stem ratios for different species and different sites. Except for *A. nummularia*, significant differences were observed between March (summer) and July (winter) with respect to the CP and IVOMD concentration of the species concerned (Table 2).

Peer-reviewed paper: 8th International Conference on Goats

Table 1 Differences in the mean (± s.d.) chemical composition (g /kg DM) and leaf to stem ratio of three *Atriplex* spp. between localities and species

Species		Location		
		Hatfield	Mier	Lovedale
A. canescens (Santa Rita)	CP	$110^{a}{}_{1}$ (±12)	$143^{b}{}_{1}$ (±14)	$126^{a}{}_{1}$ (±9.6)
	IVOMD	$467^{a}{}_{1}$ (±22)	$496^{a}{}_{1}$ (±10)	$474^{a}{}_{1}$ (±21)
	leaf to stem ratio	$53.49^{a}{}_{1}$ (±2.1)	$76.03^{b}{}_{1}$ (±2.4)	$59.60^{a}{}_{1}$ (±3.6)
A. canescens (Veld Reserve 1)	CP	$94^{a}{}_{1}$ (±11)	$149^{b}{}_{1}$ (±14)	$119^{c}{}_{1}$ (±10.1)
	IVOMD	$463^{a}{}_{1}$ (±24)	$503^{a}{}_{1}$ (±18)	$471^{a}{}_{1}$ (±26)
	leaf to stem ratio	$35.92^{a}{}_{2}$ (±1.8)	$56.55^{b}{}_{2}$ (±1.9)	$44.05^{ab}{}_{2}$ (±2.4)
A. nummularia	CP	$124^{a}{}_{2}$ (±11)	$195^{b}{}_{2}$ (±13)	$183^{b}{}_{2}$ (±14)
	IVOMD	$487^{a}{}_{1}$ (±26)	$599^{b}{}_{2}$ (±21)	$591^{b}{}_{2}$ (±25)
	leaf to stem ratio	$54.13^{a}{}_{1}$ (±1.4)	$68.45^{b}{}_{12}$ (±1.3)	$70.17^{b}{}_{1}$ (±1.5)

^{abc}Row means with common superscripts do not differ (P > 0.05)
^{12}Column means with common subscripts do not differ (P > 0.05)

The CP concentration of *A. nummularia* differed significantly from the other species in both seasons. The CP concentration of *A. canescens* (Santa Rita) and *A. canescens* (Veld Reserve 1) did not differ from each other.

The IVOMD of *A. nummularia* did not show significant differences compared to the other species with respect to seasonal trends and only the leaf to stem ratio of *A. canescens* (Veld Reserve1) showed significant differences in the two seasons studied. In addition, the stem to leaf ratio of the species concerned also differed significantly. The same trend was reported by Sparks (2003).

The results in Table 3 showed that the CP values for the leaves were in all cases significantly higher than the stems. The leaf and stem CP-values of *A. nummularia* were also significantly higher than the other species. The leaf IVOMD of all species was significantly higher than that of the corresponding stems. In addition the IVOMD of the leaves and stems of *A. nummularia* were higher than the other species studied. Peterson *et al*. (1987) noted also the same trend for fourwing saltbush.

Table 2 Differences in the mean (± s.d.) chemical composition (g /kg DM) and leaf to stem ratio of three *Atriplex* spp. between species and seasons

Species		Seasons	
		March (Summer)	July (Winter)
A. canescens (Santa Rita)	CP	$136^{a}{}_{1}$ (±11)	$119^{b}{}_{1}$ (±6)
	IVOMD	$515^{a}{}_{1}$ (±12)	$443^{b}{}_{1}$ (±13)
	leaf to stem ratio	$65.93^{a}{}_{1}$ (±2.1)	$60.15^{a}{}_{1}$ (2.6)
A. canescens (Veld Reserve 1)	CP	$129^{a}{}_{1}$ (±3)	$112^{b}{}_{1}$ (±6)
	IVOMD	$506^{a}{}_{1}$ (±16)	$452^{b}{}_{1}$ (±14)
	leaf to stem ratio	$54.75^{a}{}_{2}$ (±3.6)	$36.27^{b}{}_{2}$ (2.9)
A. nummularia	CP	$172^{a}{}_{2}$ (±11)	$163^{a}{}_{2}$ (±9)
	IVOMD	$562^{a}{}_{2}$ (±14)	$556^{a}{}_{2}$ (±11)
	leaf to stem ratio	$63.99^{a}{}_{1}$ (±2.0)	$64.50^{a}{}_{1}$ (±2.2)

^{abc}Row means with common superscripts do not differ (P > 0.05)
^{12}Column means with common subscripts do not differ (P > 0.05)

Peer-reviewed paper: 8th International Conference on Goats

Table 3 Differences in the mean (± s.d.) chemical composition (g /kg DM) of three *Atriplex* spp. between species and plant parts

Species		Plant part	
		Leaves	Stems
A. canescens (Santa Rita)	CP	171^{a}_{1} (±18)	82^{b}_{1} (±12)
	IVOMD	673^{a}_{1} (±18)	285^{b}_{1} (±36)
A. canescens (Veld Reserve 1)	CP	169^{a}_{1} (±16)	73^{b}_{1} (±16)
	IVOMD	705^{a}_{1} (±15)	233^{b}_{1} (±48)
A. nummularia	CP	217^{a}_{2} (±14)	117^{b}_{2} (±16)
	IVOMD	732^{a}_{12} (±30)	386^{b}_{2} (±21)

[abc]Row means with common superscripts do not differ (P > 0.05)
[1,2]Column means with common subscripts do not differ (P > 0.05)

Conclusion

Significant differences between leaves and stems, seasonal growth and location of the three species studied were noted, demonstrating the importance of these factors when planning fodder budgets.

Acknowledgement

This research was supported in part under Grant No. TA-MOU-99-C16-091 funded by the U.S.-Israel Cooperative Development Research Program, Bureau for Economic Growth, Agriculture and Trade, U.S. Agency for International Development.

References

AOAC, 2000. Official methods of analysis of the Association of Official Analytical Chemists. Inc. Arlington, Virginia, U.S.A.

Chatterton, N.J., Goodin, J.R., Mckell, C.M., Parker R.V. & Rible J.M., 1971. Monthly variation in the chemical composition of desert-saltbush. J. Range. Manage. 24, 37-40.

Davis, A.M., 1981. The oxalate, tannin, crude fibre, and crude protein composition of young plants of some *Atriplex* species. J. Range. Manage. 34(4), 329-331.

Engels, E.A.N. & Van der Merwe, F.J., 1967. Application of an *in vitro* technique to South African forages with special references to the effect of certain factors on the results. S.Afr. J. Agric. Sci. 10, 983-995.

Peterson, J.S., Necket, D.N., Potter, R.L. & Huston, J.E., 1987. Ecotypic variation in selected fourwing saltbush populations in Western Texas. J. Range Manage. 40, 361-366.

Samuels, M.L., 1989. Statistics for the life sciences. Collier MacMillan Publishers, London.

Senock, R.S., Barrow, J.R., Gibbens, R.P. & Herbel, C.H., 1991. Ecophysiology of the poloyploid shrub *Atriplex canescens* growing *in situ* in the Northern Caribean Desert. J. Arid Environ. 21, 45-57.

Smit, C.J. & Jacobs, G.A., 1978. Skeikundige samestelling van vier *Atriplex*-spesies. Agroanimalia (10), 1-5.

Sparks, C.F., 2003. Interspesies variation in nutritive value of certain drought tolerant fodder shrubs. M.Sc. (Agric.)-dissertation, University of Pretoria. South Africa.

SAS, 1994. Statistical Analysis Systems User's Guide. Statistics Version 6. SAS Inst., Inc. Cary, NC., USA.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Interspecies and location variation in oxalic acid concentrations in certain *Atriplex* species and *Cassia sturtii*

W.A. van Niekerk#, C.F. Sparks, N.F.G. Rethman[1] and R.J. Coertze
Department of Animal and Wildlife Sciences, University of Pretoria, Pretoria 0002, South Africa
[1]Department of Plant Production and Soil Science, University of Pretoria, Pretoria 0002, South Africa

Abstract

The aim of this study was to evaluate the interspecies variation in oxalic acid (OA) concentrations of leaves between *Atriplex canescens, A. halimus, A. nummularia* and *Cassia sturtii*. Significant differences in the oxalic acid concentration were noted between the three *Atriplex* spp. and *C. sturtii* at Hatfield. *C. sturtii* at Lovedale also had a significantly lower OA concentration than the *Atriplex* spp. No significant differences were noted between the *Atriplex* spp. at Lovedale, although the species at Lovedale contained significantly higher OA concentrations than at Hatfield. The OA concentrations recorded in this study were not considered to be toxic to grazing livestock.

Keywords: *Atriplex, Cassia sturtii,* oxalic acid, cation balance
#Corresponding author. E-mail: willem.vanniekerk@up.ac.za

Introduction

According to Marais (1997), the intake of excessive amounts of oxalate by mammals leads to clinical conditions such as chronic renal failure, calcium oxalate urolithiasis, hypocalcaemia, nutritional secondary hyperparathyroidism and death. Chronic oxalate poisoning in herbivores has a depressing effect on animal production. Acute toxicity usually affects small numbers of animals, but can occasionally cause the death of hundreds of head of livestock in a single incidence. Poisoning is most common when animals are not adapted and / or hungry. Acute toxicity has been recorded in cattle consuming pasture that contained oxalate at a concentration of 6.9%, while the lethal oxalic acid (OA) dose for sheep is approximately 1.1g /kg body weight. According to Marais (1997), sheep which were not adapted, died over a period of five days after exposure to young buffalo grass (*Cenchrus ciliaris*) with a soluble oxalate content of about 2.5%. Watson *et al*. (1987) also noted young *Atriplex* material containing high OA concentrations of up to 9.07%, and levels decreasing to 2.81% as the plants grew older. No information is available on the OA concentrations in young *C. sturtii* plants. The objective of this study was to evaluate the interspecies variation in OA concentrations in leaves between *Atriplex canescens, A. halimus, A. nummularia* and *C. sturtii.*

Materials and Methods

Leaves were collected from two experimental sites different in ecological conditions. Site one was at the Experimental Farm of the University of Pretoria, Gauteng, South Africa at an altitude of 1360m (coordinates 025°15'28.9"E, 25°45'03.6" S). It is a summer rainfall area with an average precipitation of 650mm per annum. The soil type is a Hutton form (MacVicar *et al*., 1977), well drained, slightly acidic and consists of a good nutrient status and an effective depth of 600 mm+. According to soil analysis, the soil $pH_{(H_2O)}$ was 5.7, P status 25mg /kg, K status 200mg /kg while the Ca, Mg and Na status were 800, 400 and 440mg /kg respectively.

Site two was at the farm Lovedale in the Kenhardt district, Northern Cape province, South Africa at an altitude of 1015m (coordinates 19°44'0.57" E, 29°18'58.8" S). It is a summer rainfall area with an average annual rainfall of approximately 130mm. The soil is also a Hutton form, slightly alkaline and consists of a good nutrient status. According to soil analysis, the soil $pH_{(H_2O)}$ was 8.4, P status 14mg /kg, K status 337mg /kg, while Ca, Mg and Na status were 3445, 136 and 179mg /kg respectively. This type is a shallow calcareous sandy soil with less than 10% clay and an effective depth of not more than 300mm. Leaves were collected from *Atriplex canescens* (Pursch.) cv. Santa Rita (Fourwing Saltbush) Origin: North America), *Atriplex halimus* L. (Origin: Asia, Mediterranean), *Atriplex nummularia* L. (Oldman Saltbush) (Origin: Australia) and *Cassia sturtii* (Origin: Australia).

Sample material randomly collected for each specie on both sites was from approximately five year old plants. Leaves (mostly mature) were dried in a force draught oven for 24 hours at 60°C and milled through a

Peer-reviewed paper: 8th International Conference on Goats

1 mm screen. Oxalic acid concentration was measured through colorimetric determination of OA as oxalyldihyrazidee, as described by Figenschou & Marais (2000) – (personal communication, Cedara Agricultural Research Institute, Kwa-Zulu Natal, South Africa). This method is quite different from the titration method of Moir (1953) for determining total oxalates. Oxalic acid was extracted from 0.5g of the milled plant material and measured against 10 ml of a standard pre-prepared OA solution. A series of steps were followed until a mixture with a blue colour was formed. A darker blue colour represented a higher oxalate concentration. The absorption of the mixture was read at 600nm on a COALAB (model dds CP500) colorimetric spectrophotometer. Calcium (Ca) and magnesium (Mg) concentrations were determined by atomic absorption spectrophotometry and sodium (Na) and potassium (K) concentrations by flame photometry (AOAC, 2000).

Three samples per specie per location were analysed. An analysis of variance with the Proc GLM model (SAS, 1994) was used to determine the significance between species, locations and first order interactions for the dependant variables. The level of significance between least square means was tested with the help of the Bonferroni's test according to Samuels (1989).

Results and Discussion

The OA concentration of the three *Atriplex* spp. at Hatfield and Lovedale was higher ($P < 0.05$) than that of *C. sturtii* (Table 1). All the species except *A. canescens*, had a lower ($P < 0.05$) OA concentration at Hatfield than at Lovedale.

Oxalic acid concentrations of 5.8% recorded by Wilson (1966) for *A. nummularia* were higher than values recorded in the present experiment. It could be that the author used younger plants during the experiment. According to Watson *et al*. (1987) the OA concentrations recorded in this experiment were not considered to be toxic to grazing livestock.

Table 1 Oxalic acid concentration (%) of leaf material for *Atriplex canescens, A. halimus, A. nummularia* and *Cassia sturtii* at two different locations (DM basis)

Location	Species			
	A. canescens	*A. halimus*	*A. nummularia*	*C. sturtii*
Hatfield	3.30_1^{c} (±0.12)*	2.66_1^{b} (±0.08)	3.26_1^{c} (±0.07)	0.85_1^{a} (±0.25)
Lovedale	3.50_1^{b} (±0.01)	3.44_2^{b} (±0.03)	3.51_2^{b} (±0.03)	1.11_2^{a} (±0.11)

Row (a,b,c) and column (1,2) means with common scripts do not differ ($P > 0.05$)
* Standard deviation

To explain the above results, it is important to be able to determine whether plants are calciophobes or calciotrophes (Wollenweber, 2002 – personal communication, Department of Plant Biology, The Danish Institute of Agricultural Sciences, Research Centre Flakkebjerg, Denmark). Calciophobes are enriched in oxalate as the dominant carboxylate binding Ca^{2+}contents and resulting in low free vascualar Ca^{2+}, whereas calciotrophes show high total and free Ca^{2+} contents (Ca^{2+} : K > 1) and less oxalate. These physiotypes – defining plants according to their eco-physiological properties – are quite constant and reveal information on how species adapt to their environment. According to Wollenweber (2002) – (personal communication), many eco-physiological studies have emphasised site-specific properties of the investigated plants (xero- *vs*. hygrophytes; glyco- *vs*. halophytes; acidophile *vs*. basiphile plants; calcifuge *vs*. calcicole plants). There is, however, a relationship between ecological and physiological aspects of plant metabolism, and certain physiological properties of plants (i.e. enzyme activities, ion ratios and ion balance) may be used for the interpretation of results from ecological studies. These considerations resulted in the formulation of the physiotype concept. A physiotype being a taxonomic unit with defined physiological properties (i.e. the ratio Ca^{2+} : K^+ or organic / inorganic ions – assessable *via* biochemical analysis of plant matter).

To determine the physiotypes of the species used for analysis, the percentages as noted in Table 1 and values determined for Ca, Mg, Na and K, in the study, were converted to micro-equivalents per g dry mass (not taking into account differences in biomass) and are represented in Table 2 and graphically in Figures 1 to 3.

Table 2 Percentages of Ca, Mg, Na, K and oxalate converted to micro-equivalents per g dry mass

Peer-reviewed paper: 8th International Conference on Goats

Location	Species	µeq /g DM Ca	Mg	Na	K	Oxalate	K / Ca
Hatfield	*A. canescens*	1 028	1 325	4	997	367	0.97
	A. halimus	1 073	1 670	814	1 154	295	1.08
	A. nummularia	778	798	1 103	844	362	1.08
	C. sturtii	773	165	1	289	94	0.37
Lovedale	*A. canescens*	1 013	683	35	1 133	389	1.12
	A. halimus	574	856	1 755	875	382	1.52
	A. nummularia	544	247	1 513	972	390	1.79
	C. sturtii	724	99	4	402	123	0.55

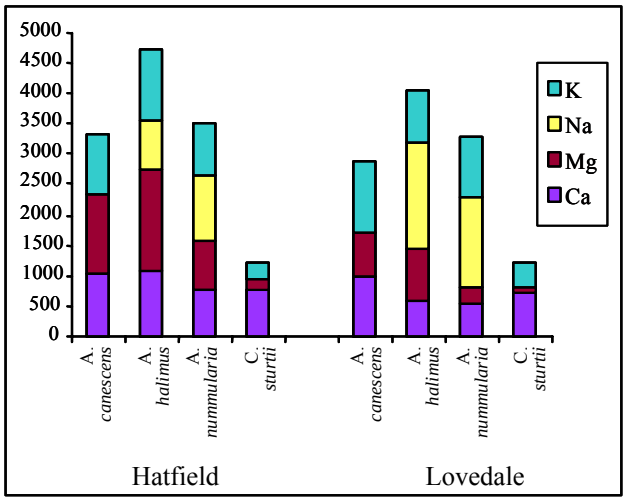


Fig 1. Comparison of cation balances at the two sites (Units: micro equivalents per g dry mass)

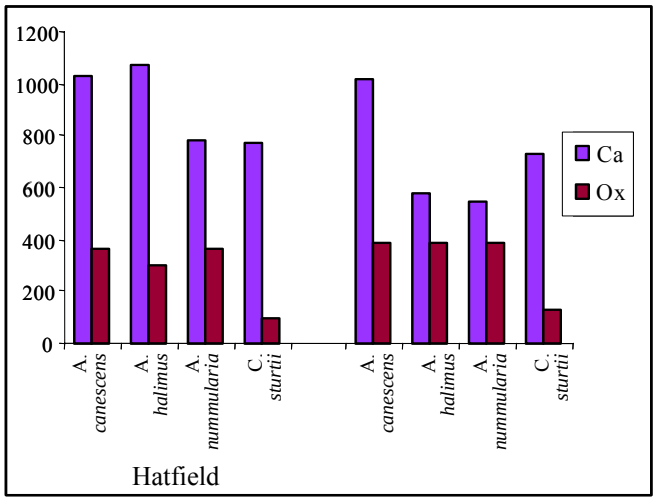
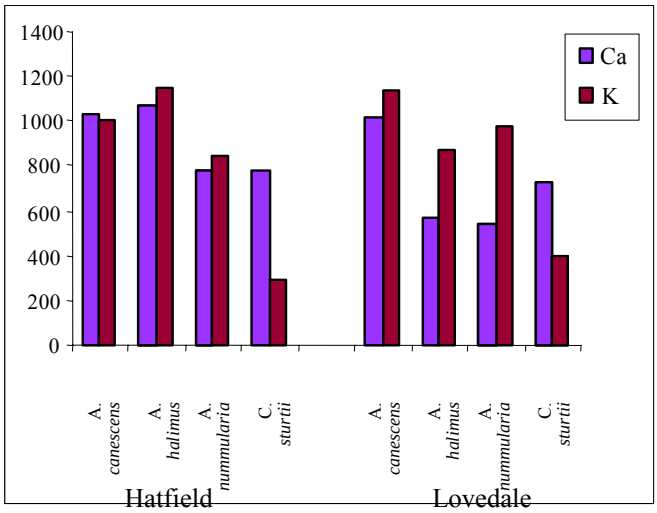


Fig 2. Comparison between Ca and oxalate concentrations at the two sites (Units: micro equivalents per g dry mass)

Fig 3. Comparison between Ca and K ratios at the two sites (Units: micro-equivalents per g dry mass)



From the cation concentration (Fig. 1), it can be seen that the highest cation concentration was in *A. halimus* at both sites, while it was the lowest in *C. sturtii*. Assuming that Ca is mainly bound by oxalate, the following was noted (Fig. 2): The Ca concentration was the highest in *A. canescens* at both sites. Lower

Peer-reviewed paper: 8th International Conference on Goats

values were observed at Lovedale. However, higher oxalate concentrations were noted which lead to low free Ca. *C. sturtii* in this case had a high value of free Ca, indicating that this is calciotrophic specie. A Ca:K ratio of almost equal to 1, was noted at Hatfield (Fig. 3), while the ratio was < 1 at Lovedale for the *Atriplex* spp. For *C. sturtii* a higher Ca than K concentration was noted, thus a further indication of the calciotrophic nature of *C. sturtii*.

Conclusion

The high total free Ca^{2+} and less oxalate concentration in *C. sturtii* indicating an unlikely possibility of oxalate poisoning to occur in animals grazing this plant. A possibility of poisoning is present in the *Atriplex* spp., especially in young plants where the oxalate levels may play a role irrespective of the Ca:K ratio (Watson *et al*., 1987).

Further work must be done on *C. sturtii* to determine the OA status at various stages of growth for this specie, since the status of younger plants is unknown and not found in any literature.

Acknowledgement

This research was supported in part under Grant No. TA-MOU-99-C16-091 funded by the U.S.-Israel Cooperative Development Research Program, Bureau for Economic Growth, Agriculture and Trade, U.S. Agency for International Development.

References

AOAC, 2000. Official methods of analysis of the Association of Official Analytical Chemists. Inc. Arlington, Virginia, U.S.A.

MacVicar C.N., De Villiers, J.N., Loxton, R.F., Verster, E., Lamprechts, J.J.N., Merryweather, F.R., Le Roux, J., van Rooyen, J.A. & Harmse, H.J., 1977. Soil classification: a binomial system for SA. Pretoria, 1st ed. Soil & Irrig. Res. Inst., Dept. Agric. Tech. Services.

Marais, J.P., 1997. Nitrate and oxalates. In: Handbook of plant and fungal toxicants. Ed. D'Mello, J.P.F., CRC Press. Boca Raton, New York.

Moir, K.W., 1953. The determination of oxalic acid in plants. Qld. J. Agric. Sci. 10, 1-3.

Samuals, M.L., 1989. Statistics for the life sciences. Collier MacMillan Publishers, London, p. 505.

SAS, 1994. Statistical Analysis Systems User's Guide. Statistics Version 6. SAS Inst., Inc. Cary, NC., USA.

Watson, M.C., O'Leary, J.W. & Glenn, E.P., 1987. The evaluation of *Atriplex lentiformes* (Torr.) S. Wats. and *Atriplex nummularia* Lindl. as irrigated forage crops. J. Arid. Environ. 13, 293-303.

Wilson, A.D., 1966. The value of *Atriplex* (Saltbush) and *Kochia* (Bluebush) species as food for sheep. Aust. J. Agric. Res. 17, 147-153.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Mineral composition of certain *Atriplex* species and *Cassia sturtii*

W.A. van Niekerk[#], C.F. Sparks, N.F.G. Rethman[1] and R.J. Coertze
Department of Animal and Wildlife Sciences, University of Pretoria, Pretoria 0002, South Africa
[1]Department of Plant Production and Soil Science, University of Pretoria, Pretoria 0002, South Africa

Abstract

The objective of this study was to quantify the macro and trace mineral concentrations of *Atriplex canescens*, *A. halimus, A. nummalaria* and *Cassia sturtii* at two different sites in South Africa. Differences in Ca, P, Mg, Se, Zn and Mn concentrations occurred between plants and sites ($P < 0.05$). Ca, Mg, Zn and Mn were present in sufficient concentration to meet nutrient requirements of small ruminants but P was deficient at Lovedale, Northern Cape and Se at Hatfield, Gauteng. The *Atriplex* spp. have in general higher macro and trace mineral concentrations at both sites than *C. sturtii.*

Keywords: *Atriplex*, *Cassia sturtii*, minerals
[#]Corresponding author. E-mail: willem.vanniekerk@up.ac.za

Introduction

Some *Atriplex* species can, in theory, measure up to the requirements of a production ration according to their chemical composition. However, the relative poor production results of small stock browsing *Atriplex* species can be attributed to the fact that plant material is unpalatable or unacceptable to them, or that intake for productive purposes is inadequate (Wilson, 1966). The purpose of this study was to evaluate the interspecies and area variation for macro and trace mineral concentrations between *Atriplex canescens, A. halimus, A. nummularia* and *Cassia sturtii*.

Materials and Methods

Leaves of *Atriplex canescens* (Pursch.) cv. Santa Rita (Fourwing Saltbush) (Origin: North America), *A. halimus* L. (Origin: Asia, Mediterranean), *A. nummularia* L. (Oldman Saltbush) (Origin: Australia) and *Cassia sturtii* (Origin: Australia) were collected from two experimental sites differing in ecological conditions. Site one was at the Experimental Farm of the University of Pretoria, Gauteng, South Africa (coordinates 025°15'28.9" E, 25°45'03.6" S). It is a summer rainfall area with a precipitation of 650mm per annum. The soil type is a Hutton form (MacVicar *et al*., 1977), well drained, slightly acidic and consists of a good nutrient status. The Hutton type is a deep clay-loam soil with approximately 25% clay and an effective depth of 600mm+. According to soil analysis, the soil $pH_{(H_2O)}$ was 5.7, the P status and K status were 250 and 200mg /kg respectively while Ca, Mg and Na status were 800, 400 and 40mg /kg respectively.

Site two was at the farm Lovedale in the Kenhardt district, Northern Cape province, South Africa (coordinates 019°44'0.57" E, 29°18'58.8" S). It is a summer rainfall area with an average annual rainfall of approximately 130mm. According to MacVicar *et al*. (1977), the soil type is also a Hutton form, slightly alkaline and consists of a good nutrient status ($pH_{(H_2O)}$ 8.4, P, K, Ca, Mg and Na status of 14, 337, 3445, 136 and 179mg /kg respectively).

Sample material randomly collected for each specie (3 samples per specie per site with two replications) was from approximately five year old plants. Samples of each plant of the same specie in each replication was kept apart and not pooled. Samples were dried in a force draught oven for 24 hours at 60°C and milled through a 1mm screen of a Beaver mill for chemical analysis to determine qualitative characteristics.

Atomic absorption spectrophotometry was used to determine calcium (Ca), magnesium (Mg), zinc (Zn), copper (Cu) and manganese (Mn) concentrations according to AOAC (2000). Phosphorus (P) concentration was determined colorimetrically (Parkinson & Allen, 1975) and Se concentration by using an atomic absorption spectrophotometer (Perkin-Elmer 2380).

A model was tested for each of the dependant variables. An analysis of variance with the Proc GLM model (SAS, 1994) was used to determine the significance between species, locations and first order interactions for the dependant variables. The level of significance between least square means (LSM) was tested with the Bonferroni's test (Samuels 1989).

Peer-reviewed paper: 8th International Conference on Goats

Results and Discussion

The macro and trace mineral concentrations are presented in Table 1. *A. halimus* had a higher Ca concentration at Hatfield then at Lovedale ($P < 0.05$), which doesn't correspond with the very high Ca concentration of the soil at Lovedale. *A. canescens* had also a higher Ca concentration than *A. nummularia* at Lovedale ($P < 0.05$). This contradicts the reports of both Smit & Jacobs (1978) and Khalik *et al.* (1986) who reported higher Ca concentrations in *A. nummularia* than in *A. canescens*. All the species exceeded the Ca requirements for goats (0.138%)) irrespective of site (NRC, 1981).

The P concentration of *A. nummularia* at both sites was higher than the concentrations in the other plants ($P < 0.05$), except for *A. canescens* at Lovedale. Except *A. canescens*, higher P concentrations were noted for all the plants at Hatfield compared to Lovedale ($P < 0.05$), which is in accordance with the higher P soil values of Hatfield. Concentrations of P found in this experiment were higher than the values reported by Khalil *et al.* (1986) for *A. nummularia* and *A. canescens,* but lower than reported for the same species by Jacobs & Smit (1977). Except for *C. sturtii, Atriplex* spp. at Hatfield supplied enough P for maintenance requirements of small stock (0.16%) (NRC, 1985). Although ruminants can tolerate a relatively wide Ca : P in the diet (Underwood & Suttle, 1999), the wide Ca:P ratios in this study (>10:1) may cause a reduction in P bioavailability and a P deficiency may occur (Underwood & Suttle, 1999).

The Mg concentrations of both *A. canescens* and *A. halimus* were higher then that of *A. nummularia* and *C. sturtii* at both sites ($P < 0.05$), with higher levels at Hatfield compared to Lovedale ($P < 0.05$), except for *C. sturtii*. This correlates well with the higher Mg soil concentration at Hatfield. According to the NRC (1981) Mg requirements of goats are well below the reported values.

Table 1 Mineral composition of major and trace elements in leaf material of *Atriplex canescens, A. halimus, A. nummularia* and *Cassia sturtii* at two different sites (DM basis)

Site	Minerals	Species			
		A. canescens	*A. halimus*	*A. nummularia*	*Cassia sturtii*
Hatfield	Ca (g /kg)	20.6_1^a (±4.3)*	21.5_2^a (±3.7)	15.6_1^a (±1.9)	15.5_1^a (±2.3)
	P (g /kg)	1.9_1^a (±0.2)	1.92_2^a (±0.3)	2.5_2^b (±0.3)	1.5_2^a (±0.1)
	Mg (g /kg)	16.1_2^c (±3.4)	20.3_2^c (±4.3)	9.7_2^b (±1.0)	2.0_1^a (±0.1)
	Se (µg/mg)	39_1^a (±20)	22_1^a (±8)	21_1^a (±8)	19_1^a (±4)
	Zn (mg/kg)	110_2^c (±18)	103_2^c (±27)	60_2^b (±15)	22_1^a (±2)
	Mn (mg/kg)	170_2^b (±59)	395_2^c (±49)	153_2^b (±59)	37_1^a (±2)
Lovedale	Ca (g /kg)	20.3_1^b (±1.8)	11.5_1^{ab} (±2.5)	10.9_1^a (±3.2)	14.5_1^{ab} (±1.0)
	P (g /kg)	1.6_1^{ab} (±0.1)	1.4_1^a (±0.1)	1.6_1^b (±0.1)	0.8_1^a (±0.1)
	Mg (g /kg)	8.3_1^{bc} (±0.4)	10.4_1^c (±0.4)	3.0_1^a (±0.4)	1.2_1^a (±0.1)
	Se (µg/mg)	257_2^a (±60)	105_2^a (±20)	401_2^a (±180)	314_2^a (±33)
	Zn (mg/kg)	13_1^a (±1)	11_1^a (±2)	14_1^a (±6)	13_1^a (±6)
	Mn (mg/kg)	91_1^a (±8)	116_1^a (±6)	62_1^a (±21)	40_1^a (±6)

[abc]Means within a row for the same mineral followed by the same letter are not significantly different ($P > 0.05$)
[1,2]Means within a column, for the same mineral in different locations followed by the same number are not significantly different ($P > 0.05$)
*Standard deviation

Peer-reviewed paper: 8th International Conference on Goats

Although no significant differences in Se concentrations were noted between the different plants at both sites, large differences occurred between the two sites ($P < 0.05$). The Se requirements of small stock is 0.1mg /kg DM (NRC, 1985). The concentrations of all the plants at Lovedale will fullfill in these requirements, but not the plants at Hatfield.

The concentration of Zn of the different plants at Lovedale didn't differ significantly, but differences occurred at Hatfield, where the *Atriplex* spp. had higher values than *C. sturtii* ($P < 0.05$). The Zn concentrations were also higher at Hatfield than at Lovedale ($P < 0.05$), most probably due to the calcareous soils at Lovedale. The inverse relationship between Ca and Zn is well noted (Underwood & Suttle, 1999). The Zn concentrations of plants at Lovedale were marginally above the Zn requirements for goats (10mg /kg) (NRC, 1981).

The Mn concentrations of the *Atriplex* spp. at Hatfield were higher ($P < 0.05$) than the Mn concentration of *C. sturtii*. No differences were noted for Lovedale. Except for *C. sturtii*, differences occurred between the two sites for all the *Atriplex* spp. ($P < 0.05$) The lower Mn concentrations at Lovedale may be due to the high Ca concentration in those soils (McDonald *et al*., 2002). According to the NRC (1985) sufficient Mn was present in all samples to meet the requirements of small stock.

Conclusion

The Ca, Mg, Zn and Mn concentrations were present at sufficient levels to fulfill in the requirements of small stock. The P concentration of all plants at Lovedale was marginal in terms of requirements and the Ca:P ratios of all plants may present a problem in terms of P utilization. Supplementation of P should be considered if these plants, irrespective of site, are being utilized by ruminants. Shortages of Se may occur at Hatfield and supplementation could be necessary. The *Atriplex* spp. had considerable higher macro and trace mineral concentrations at both sites than *C. sturtii*.

Acknowledgement

This research was supported in part under Grant No. TA-MOU-99-C16-091 funded by the U.S.-Israel Cooperative Development Research Program, Bureau for Economic Growth, Agriculture and Trade, U.S. Agency for International Development.

References

AOAC, 2000. Official methods of analysis of the Association of Official Analytical Chemists. 15th Edition. AOAC, Washington, D.C.

Khalil, J.K., Sawaya, W.N. & Hyder, S.Z., 1986. Nutrient composition of *Atriplex* leaves grown in Saudi Arabia. J. Range Manage. 39, 104-107.

Jacobs, G.A. & Smit, C.J., 1977. Utilization of four *Atriplex* species by sheep. Agroanimalia 9, 37-43.

MacVicar, C.N., De Villiers, J.N., Loxton, R.F., Verster, E., Lamprechts, J.J.N., Merryweather, F.R., Le Roux, J., Van Rooyen, J.A. & Harmse, H.J., 1977. Soil classification: a binomial system for SA. Pretoria, 1st ed. Soil & Irrig. Res. Inst. Dept. Agric. Tech. Services.

McDonald, P., Edwards, R.A., Greenhalgh, J.F.D. & Morgan, C.A., 2002. Animal Nutrition. 6th Edition. Prentice Hall.

NRC, 1981. The Nutrient Requirements of Domestic Animals. No. 15. Nutrient requirements of goats. National Research Council, National Academy of Sciences, Washington, D.C.

NRC, 1985. The Nutrient Requirements of Domestic Animals. Nutrient requirements of sheep. National Academy of Sciences, Washington, D.C.

Parkinson, J.A. & Allen, S.E., 1975. A wet exidation procedure suitable for the determination of nitrogen and mineral nutrients in biological material. Comm. Soil. Sci. and Plant Anal. 6, 1-11.

Samuals, M.L., 1989. Statistics for the life sciences. Collier MacMillan Publishers, London.

Smit, C.J. & Jacobs, G.A., 1978. Chemical composition of four *Atriplex* species. Agroanimalia. 10, 1-5.

SAS, 1994. Statistical Analysis Systems User's Guide. Statistics Version 6. SAS Inst., Inc. Cary, NC., USA.

Underwood, E.J. & Suttle, N.F., 1999. The Mineral Nutrition of Livestock. 3rd Ed. CABI, New York.

Wilson, A.D., 1966. The value of *Atriplex* (Saltbush) and *Kochia* (Bluebush) species as food for sheep. Aust. J. Agric. Res. 17, 147-153.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Qualitative characteristics of some *Atriplex* species and *Cassia sturtii* at two sites in South Africa

W.A. van Niekerk#, C.F. Sparks, N.F.G. Rethman[1] and R.J. Coertze
Department of Animal and Wildlife Sciences, University of Pretoria, Pretoria 0002, South Africa
[1]Department of Plant Production and Soil Science, University of Pretoria, Pretoria 0002, South Africa

Abstract

Leaves of three *Atriplex* spp. and *Cassia sturtii* grown in two different locations in South Africa were analysed for certain nutritive characteristics. Crude protein values ranged from 176 to 234g /kg DM for the *Atriplex* spp. and for *C. sturtii* from 114 to 147g /kg DM. The *in vitro* digestible organic matter concentrations for the *Atriplex* spp. varied from 718 to 773g /kg DM and for *C. sturtii* from 529 to 574g /kg DM. The neutral detergent fibre concentration ranged from 295 to 407g /kg DM for the *Atriplex* spp. and for *C. sturtii* from 223 to 250g /kg DM. Higher acid detergent lignin concentrations than expected were noted and varied for the *Atriplex* spp. from 98 to 139g /kg DM and for *C. sturtii* from 71 to 75g /kg DM. Both species proved to have a fair potential as fodder crops for livestock.

Keywords: *Atriplex*, *Cassia sturtii*, IVDOM, NDF, ADL
#Corresponding author. E-mail: willem.vanniekerk@up.ac.za

Introduction

According to Bransby (1988), the performance of ruminants is determined by the animal itself on the one hand, and by the properties of the feed on the other. Animal factors, which influence performance directly, are those related to efficiency of utilisation of absorbed nutrients by the body. These are in turn determined by characteristics such as breed, sex and physiological condition, inherent ability and by external environmental factors such as weather. Nutrient absorption by the body from the alimentary canal also influences animal performance directly. Although this process will be affected by animal and environmental factors it is determined largely, and influenced directly, by two properties of the feed namely, nutrient content and digestibility. The aim of this study was to evaluate the interspecies and location variation in chemical composition of certain qualitative parameters between *Atriplex canescens, A. halimus, A. nummularia* and *Cassia sturtii*.

Materials and Methods

Leaves were collected from two experimental sites differing in ecological conditions of *Atriplex canescens* (Pursch.) cv. Santa Rita (Fourwing Saltbush) (Origin: North America), *A. halimus* L. (Origin: Asia, Mediterranean), *A. nummularia* L. (Oldman Saltbush) (Origin: Australia) and *Cassia sturtii* (Origin: Australia). Site one was at the Experimental Farm of the University of Pretoria, Gauteng, South Africa (coordinates 025°15'28.9"E, 25°45'03.6" S). It is a summer rainfall area with a precipitation of 650mm per annum. The soil type is a Hutton form (MacVicar *et al*., 1977), well drained, slightly acidic and consists of a good nutrient status. The Hutton type is a deep clay-loam soil with approximately 25% clay and an effective depth of 600mm+. According to soil analysis, the soil $pH_{(H2O)}$ was 5.7, P, K, Ca, Mg and Na status were 25, 200, 800, 400 and 40 mg/kg respectively.

Site two was at the farm Lovedale in the Kenhardt district, Northern Cape province, South Africa (coordinates 019°44'0.57" E, 29°18'58.8" S). It is a summer rainfall area with an average annual rainfall of approximately 130mm. According to MacVicar *et al*. (1977), the soil type is also a Hutton form, slightly alkaline and consists of a good nutrient status ($pH_{(H2O)}$ 8.4, P, K, Ca, Mg and Na status of 14, 337, 3445, 136 and 179 respectively). This type is a shallow calcareous sandy soil with less than 10% clay and an effective depth of not more than 300mm.

Sample material randomly collected for each species on both sites was from approximately five year old plants. Samples of each plant of the same species in each replication were kept apart and not pooled. Samples were dried in a force draught oven for 24 hours at 60°C and milled through a 1mm screen of a Beaver mill for chemical analysis to determine qualitative measurement.

Crude protein (CP) and ash concentrations were determined according to AOAC (2000) and neutral detergent fibre (NDF) and acid detergent lignin (ADL) concentration according to the method of Van Soest

Peer-reviewed paper: 8th International Conference on Goats

& Wine (1967). *In vitro* digestible organic matter (IVDOM) was done according to the method of Tilley & Terry (1963) as modified by Engels & Van der Merwe (1967).

A model was tested for each of the dependant variables. An analysis of variance with the Proc GLM model (SAS, 1994) was used to determine the significance between species, locations and first order interactions for the dependant variables. The level of significance between least square means was tested with the help of the Bonferroni's test according to Samuels (1989).

Results and Discussion

Significant differences between the three *Atriplex* spp. and *C. sturtii* with respect to the nutritive value are evident, and also between the species at Hatfield and Lovedale (Table 1). A number of authors also reported high CP values for *A. nummularia*, as in this study (Smit & Jacobs, 1978; Khalil *et al.*, 1986; Malan, 2000). According to Welch & Monsen (1981), genetic variation plays an important role in the protein concentration in *Atriplex* spp., while season and soil fertility will also have a major effect on CP concentration (McArthur *et al*., 1981). It has to be kept in mind that up to 60% of the CP fraction in plants, may be non protein nitrogen (Benjamin *et al*., 1992).

Table 1 The CP, IVDOM, NDF and ADL concentration (g /kg DM) of leaf material for *Atriplex canescens, A. halimus, A. nummularia* and *Cassia sturtii* at two different locations (hand cut samples)

Location	Parameter	Species			
		A. canescens	A. halimus	A. nummularia	Cassia sturtii
Hatfield	CP	176_1^a (±22)*	187_1^a (±48)	208_1^a (±10)	147_1^a (±31)
	IVDOM	738_1^b (±9)	718_1^b (±45)	738_1^b (±19)	574_1^a (±65)
	NDF	378_2^c (±9)	328_2^b (±4)	407_2^c (±13)	250_1^a (±25)
	ADL	139_2^b (±6)	131_1^b (±9)	138_1^b (±12)	75_1^a (±5)
Lovedale	CP	198_1^b (±7)	206_1^a (±38)	234_1^b (±10)	114_1^a (±26)
	IVDOM	716_1^b (±20)	773_1^b (±4)	757_1^b (±42)	529_1^a (±88)
	NDF	295_1^b (±6)	297_1^b (±20)	332_1^b (±10)	223_1^a (±23)
	ADL	98_1^b (±1)	131_1^c (±3)	137_1^c (±2)	71_1^a (±06)

[abcd]Means within a row for the same parameter followed by the same letter are not significantly different (P > 0.05)
[1,2]Means within a column, for the same parameter in different locations followed by the same number are not significantly different (P > 0.05)
*Standard deviation

Due to significant interactions, no pooled results for site comparison is presented. No significant differences in IVDOM occured between the *Atriplex* spp. at both sites as well as between sites. *C. sturtii* had significant lower IVDOM values than the *Atriplex* spp. The same tendency was found for NDF. The values of Malan (2000) for *Atriplex* spp. supported these results. The IVDOM range of all the plants at both sites fell within the range (and even above) (up to 690g /kg) of *in vitro* DM digestibility noted for tropical browse plants (Sawe *et al*., 1998) and *in vivo* OM digestibilities in goats (Kibria *et al*., 1994). As NDF is more closely associated with intake then digestibility (Meissner *et al*., 1989) one can conclude from the relatively low NDF values of the leaves of both *Atriplex* spp. and *C. sturtii* in this experiment, that fairly high intakes by small stock should have been possible.

The ADL concentration of the *Atriplex* spp. at both sites was significant higher than that of *C. sturtii*. Only *A. canescens* differed significantly in terms of ADL concentration between the two sites. Acid detergent lignin values of 145g /kg reported by Kaitho *et al.* (1998) for *A. halimus* agreed with those reported in this experiment for the *Atriplex* spp. Lower values for *A. nummalaria* (93g /kg) were reported by Abou El Nasr *et al.* (1996).

Conclusion

All the species evaluated in this experiment proved to have a fair potential as fodder crops. High CP and IVDOM concentrations as well as fairly low NDF values are proof of this.

Peer-reviewed paper: 8th International Conference on Goats

Acknowledgement

This research was supported in part under Grant No. TA-MOU-99-C16-091 funded by the U.S.-Israel Cooperative Development Research Program, Bureau for Economic Growth, Agriculture and Trade, U.S. Agency for International Development.

References

Abou El Nasr, H.M., Kandil, H.M., El Kerdawy, E., Dawlat, A., Khamis, H.S. & El-Shaer, H.M., 1996. Value of processed saltbush and *Acacia* shrubs as feed fodders under arid conditions of Egypt. Small Rumin. Res. 24, 15-20.

AOAC, 2000. Official methods of analysis of the Association of Official Analytical Chemists. 15th Edition, AOAC, Washington D.C.

Benjamin, R.W., Oren, E., Katz, E. & Becker, K., 1992. The apparent digestibility of *Atriplex barclayana* and its effect on nitrogen balance in sheep. Anim. Prod. 54, 259-264.

Bransby, D.I., 1988. The value of veld and pasture as a nutritional feed. In: Veld and Pasture Management in South Africa. Ed. Tainton, N.M. University of Natal Press, Pietermaritzburg, South Africa. Pp. 173-214.

Engels, E.A.N. & Van der Merwe, F.J., 1967. Application of an *in vitro* technique to South African forages with special reference to the effect of certain factors on the results. S. Afr. J. Agric. Sci. 10, 983-995.

Kaitho, R.J., Nsahlai, I.V., Williams, B.A., Umunna, N.N., Tamminga, S. & Brucham, J., 1998. Relationships between preference, rumen degradability, gas production and chemical composition of browses. Agroforestry Systems. 39, 129-144.

Kibria, S.S., Nahar, T.N. & Mia, M.M., 1994. Tree leaves as alternative feed resource for Black Bengal goats under stall-fed conditions. Small Rumin. Res. 13, 217-222.

Khalil, J.K., Sawaya, W.N. & Hyder, S.Z., 1986. Nutrient composition of *Atriplex* leaves grown in Saudi Arabia. J. Range Manage. 39, 104-107.

MacVicar, C.N., De Villiers, J.N., Loxton, R.F., Verster, E., Lamprechts, J.J.N., Merryweather, F.R., Le Roux, J., Van Rooyen, J.A. & Harmse, H.J., 1977. Soil classification: a binomial system for SA, Pretoria, 1st ed. Soil & Irrig. Res. Inst., Dept. Agric. Tech. Services.

Malan, P.J., 2000. Selection and propagation of elite *Atriplex* material. M.Sc. (Agric) dissertation. University of Pretoria, South Africa.

McArthur, E.D., Stranathan, S.E. & Nollar, G.L., 1981. 'Rincon' fourwing saltbush – proven for better forage and reclamation. Rangelands. 6, 62-64.

Meissner, H.H., Van Niekerk, W.A., Spreeth, E.B. & Köster, H.H., 1989. Voluntary intake of several planted pastures by sheep and an assessment of NDF and IVDOM as possible predictors of intake. J. Grassl. Soc. South Africa. 6(3), 156-162.

Samuals, M.L., 1989. Statistics for the life sciences. Collier MacMillan Publishers, London.

Sawe, J.J., Tuitoek, J.K. & Ottaro, J.M., 1998. Evaluation of common tree leaves or pods as supplements for goats on range area of Kenya. Small Rumin. Res. 28, 321-327.

Smit, C.J. & Jacobs, G.A., 1978. Chemical composition of four *Atriplex* species. *Agroanimalia*. 10, 1-5.

SAS, 1994. Statistical Analysis Systems User's Guide. Statistics Version 6. SAS Inst., Inc. Cary, NC., USA.

Van Soest, P.J. & Wine, R.H., 1967. Use of detergents in the analysis of fibrous feeds. IV. Determination of plant cell wall components. J. Assoc. Off. Anal. Chem. 50, 50.

Welch, B.L. & Monsen, S.B., 1981. Winter crude protein among accessions of fourwing saltbush grown in a uniform garden. Great Basin Nat. 41, 343-346.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Ash from fireplaces at homestead in rural regions of South Africa as potential source of minerals to goats

J.B.J. van Ryssen# and H. Ndlovu
Department of Animal & Wildlife Sciences, University of Pretoria, Pretoria 0002, South Africa

Abstract

In this study the mineral composition of ash from fireplaces at rural homesteads was determined to establish if such ash could be a source of minerals to goats. The mineral composition of ash collected from homesteads in six different communal farming regions of South Africa was determined. The ash samples collected in the three northern regions of the country contained between 180 and 248 g Ca/kg dry ash, while those from the Eastern Cape Province contained low concentrations (8–45 g Ca/kg ash) and high concentrations of Si. It is concluded that wood was probably used as fire making material in the northern regions, while cattle manure was probably used in the Eastern Cape regions, though soil contamination could have contributed to the high Si concentrations. The concentration of the Fe and Zn in ash was high while that of the other elements in ash was relatively low and would probably contribute little to a goat's diet, considering the proportion of ash in a total diet. It is concluded that in some regions of the country goats would be able to ingest a substantial proportion of Ca when scavenging on ash heaps or receiving ash as a dietary supplement, while in other regions this will not be the case.

Keywords: Ash, element sources, maize cobs, cattle manure, wood
#Corresponding author. E-mail: jvryssen@up.ac.za

Introduction

In communal farming regions of Africa, goats are frequently scavenging for food and are quite likely to take in ash from household fires. It is well documented that wood ash is rich in Ca and has been used successfully as a fertilizer especially to ameliorate the acidity in soils (Demeyer *et al*., 2001). The product also showed promise as a mineral supplement to livestock in the tropics (Imbeah, 1999) and in the treating of low quality fibres to improve fibre utilization by ruminants (Nolte *et al*., 1987; Raminez *et al*., 1992). This study investigated to what extent ash from fireplaces at rural homesteads could be a source of minerals to goats when taken in inadvertently or be mixed with other feeds to supplement the minerals in the diet of the goat. The mineral composition of ash collected from homesteads in different regions of South Africa was determined. Different materials are used in South Africa to make fires. The mineral composition of ash in wood and bark from trees has been reported previously (Van Ryssen & Ndlovu, 2003). In response to the results on the composition of the homestead ash in this study, two other sources of fire making material, maize cobs and cattle dung, were collected and analysed for mineral element content.

Materials and Methods

Ash from fireplaces at homesteads was collected in six subsistence farming regions of South Africa, *viz*. the bushveld areas of the Limpopo, Mpumalanga and the northern eastern KwaZulu-Natal Provinces, as well as from the northern and southern Transkei and the Ciskei in the Eastern Cape Province. Samples were collected from five homesteads per region. The ash was sifted through a kitchen sieve to remove coarse coal particles. The mineral composition was also determined of the ash in maize cobs collected from three locations in subsistence farming areas and from three commercial farms, and in ash from cattle manure collected in subsistence farming areas in the Eastern Cape. The organic matter content of the ash was determined by combustion in a muffle furnace at 500 ^{o}C, and the remaining ash was analysed for macro- and micro-element concentrations. After dissolving the ash in HCl, the Ca, Mg, Fe, Cu, Mn and Zn concentrations were determined, using atomic absorption spectrophotometry, and Na and K, using flame emission spectrophotometry. The photometric method using molybdovanadate was used to measure the P concentration in the ash (AOAC, 1990). Silica and Al concentrations were measured, using the ICP-AES method. The ash samples within each region were pooled to measure the crystalline forms of the metals in the ash, using the standard Powder x-ray diffraction (XRD) technique on a Siemens D-501 automated diffractometer (Chung, 1974). Means were compared statistically using an ANOVA procedure (SAS, 1994).

Peer-reviewed paper: 8th International Conference on Goats

Results and Discussion

Van Ryssen & Ndlovu (2003) found that ash from wood and bark contained on average 280 and 340 g Ca/kg, respectively. In comparison, the Ca concentrations in the homestead ash from the three Northern bushveld regions of South Africa were slightly lower, between 180 and 248 g/kg (Table 1), suggesting that wood was probably the main source of fire making material in these areas. Imbeah (1999) reported that ash from wood fires collected from houses in Papua New Guinea contained 121 g Ca/kg ash, while Campbell (1990) stated that wood ash in general contains between 80 and 330 g Ca/kg. From the XRD test (Table 2) the Ca was mainly in the form of calcite ($CaCO_3$), in accordance with Demeyer *et al*. (2001), and in the same form as feed lime that is used in livestock nutrition (Bredon *et al*., 1987). Cereals such as maize and sorghum grains and their by-products contain low concentrations of Ca (Bredon *et al*., 1987). Ash could be used to supplement the Ca in such products. From an animal nutritional point of view the ash is not a good source of P, the most likely mineral element to be deficient in livestock feeds in the tropics. Also, at a hypothetical level of inclusion of 1-2% ash of the total diet, ash would not be a major source of any of the other elements, with the exception of Fe and Zn, especially if the elements are present in forms with a low bioavailability, such as oxides (Demeyer *et al*., 2001).

Table 1 Average (± s.e.) percentage organic matter (OM) and concentration of macro- and micro-elements in ash from rural homestead fires

	OM	Ca	P	Mg	K	Na	Si	Cu	Mn	Fe	Zn	Al
Region*	%	g/kg dry ash						mg/kg dry ash				
Limpopo	3.1	248	6.8	28.2	50.9	6.8	50	95	191	3850	2124	3582
	±1.4	±50	±2.3	±12.4	±23.2	±3.3	±32	±32	±130	±735	±2427	±1230
Mpu-	4.5	183	8.5	25.4	52.5	6.7	137	89	104	5853	308	5488
malanga	±1.8	±52	±4.2	±9.4	±9.3	±4.2	±67	±58	±60	±3131	±255	±1511
KwaZulu-	6.5	197	12.2	55.9	64.4	13.3	71	193	208	10551	619	6360
Natal	±2.3	±1.1	±0.5	±34.2	±10.1	±3.0	±17	±22	±32	±2947	±241	±1176
Ciskei	6.1	37	12.2	14.7	7.0	4.5	331	135	171	13887	644	7954
	±1.3	±2.8	±1.0	±0.8	±0.7	±0.4	±22	±21	±20	±1374	±243	±259
Southern	5.3	45	16.2	20.4	9.9	5.0	252	141	198	12881	429	7752
Transkei	±1.7	±9.1	±2.2	±2.9	±2.4	±0.9	±142	±14	±30	±7142	±44	±576
Northern	1.7	8.0	8.0	9.98	13.5	2.1	_	41	190	6077	321	_
Transkei	±0.4	±5.1	±3.0	±2.4	±6.7	±0.3		±12	±34	±1203	±60	
LSD	3.15	58.6	4.9	30.2	22.2	4.9	138	60	124	6838	1968	13.8

*Five samples per region; LSD – least significant difference ($P < 0.05$)

Table 2 Crystalline forms of elements in homestead ash, pooled per region, using x-ray diffraction (XRD) analysis (expressed semi-quantitatively as percentages of total*)

		KwaZulu-		Eastern Cape		
Crystalline form	Limpopo %	Natal %	Mpumalanga %	Ciskei %	Southern Transkei %	Northern Transkei %
Calcite ($CaCO_3$)	85.9	76.0	70	17	15	2
Quarts (SiO_2)	3.8	5.4	7	60	36	79
Hematite (Fe_2O_3)	0.7	1.7	0	0	0	0
Portlandite (Ca(OH))	1.3	1.8	2	0	0	0
Lime (CaO)	0.7	1.4	0	0	0	0
Siderite ($Fe(CO_3)$)	0.7	1.8	1	0	3	0
Dolomite ($CaMg(CO_3)_2$)	1.4	1.7	0	0	0	0

* Crystalline forms present in low proportions not presented

In the present study the ash from the three regions in the Eastern Cape contained only between 8 and 45 g Ca/kg ash. Considering the high concentrations of Si in the latter samples a possible reason for this could be soil contamination. However, different fire making material with different chemical compositions could have been used in these regions, such as maize cobs and cattle manure. The mineral composition of ash in maize cobs from commercial *vs.* communal farms were (g/kg dry ash): 9.9 and 8.2 Ca; 19.8 and 19.8 Mg; 8.3 and 2.5 Na, 586 and 415 Fe; 175* and 403* Zn (*$P < 0.01$), and in mg/kg dry ash: 246 and 210 Cu; 541and 497 Mn, respectively. According to these analyses more the 50% of the ash in maize cobs consisted

Peer-reviewed paper: 8th International Conference on Goats

of Fe and Zn. It is therefore most unlikely that maize cobs could have been the source of the homestead ash from the Eastern Cape which contained high concentrations of Si in the form of quartz (Table 2).

Although the cattle faeces were not collected at the same localities as the homestead ash, their mineral composition corresponded fairly well with that of the homestead ash from the Eastern Cape (Table 3). This could suggest that cattle manure was probably an important source of fire making material in the Eastern Cape and could explain the differences in composition of homestead ash between the Eastern Cape and the northern provinces of South Africa. Except for the Fe concentration, these mineral concentrations in the cattle faeces from the communal grazing areas in the Eastern Cape Province were less than 50% that in faeces from steers in feedlots (converted to an ash basis) in the USA, as reported by Fontenot (1991).

Table 3 Average mineral element composition in the ash (dry basis) in cattle faeces collected in communal grazing areas *vs*. the composition of the homestead ash collected in the Eastern Cape

Sources of ash	Ca g/kg	P g/kg	Mg g/kg	K g/kg	Na g/kg	Fe mg/kg	Zn mg/kg	Cu mg/kg
Cattle faeces	45.2	11.6	14.4	21.4[a]	12.2[a]	41371[a]	366	107
E. Cape Homesteads	29.8	12.1	15.0	10.1[b]	3.9[b]	10948[b]	465	106

Values with superscripts a-b signify differences at $P < 0.05$

Conclusions

The mineral composition of ash from homestead fireplaces can vary tremendously, depending on the fire making material. Therefore, although ash from some homesteads contains high concentrations of Ca which could be of nutritional significance to goats, homestead ash, in general, cannot be recommended as a mineral supplement to goats. If Ca has to be supplemented, it is advisable to burn wood specifically for that purpose rather than to collect ash from fireplaces.

References

AOAC, 1990. Official methods of analysis (15th ed.). Association of Official Analytical Chemists, Inc., Arlington, Virginia, USA.

Bredon, R.M., P.G. Stewart & T.J. Dugmore., 1987. A manual on the nutritive value and chemical composition of commonly used South African farm feeds. Natal Region, Dept. of Agriculture and Water Affairs. South Africa.

Campbell, A.G., 1990. Recycling and disposing of wood ash. Tappi J. 141-146. (no volume)

Chung, F.H., 1974. Quantitative interpretation of X-ray diffraction patterns of mixtures. I. Matrix flushing method for quantitative multicomponent analysis. J. Appl. Cryst. 7, 519-525.

Demeyer, A., Voundi Kkana, J.C. & Verloo, M.G., 2001.Characteristics of wood ash and influence of soil properties and nutrient uptake: an overview. Biores. Technol. 77, 287-295.

Imbeah, M., 1999. Wood ash as mineral supplement for growing lambs under village conditions in the tropics. Small Rumin. Res. 32, 191-194.

Fontenot, J.P., 1991. Recycling animal wastes by feeding to enhance environment quality. Prof. Anim. Scient. 7, 1-8.

Nolte, M.E., Cline, J.H., Dehority, B.A., Loerch, S.C. & Parker, C.F., 1987. Treatment of wheat straw with alkaline solutions prepared from wood ashes to improve fiber utilization by ruminants. J. Anim. Sci. 64, 669-677.

Ramirez, R.G., Cruz, F. & Gonzalez, C.C., 1992. Effects of treating corn stover with wood ashes and sodium hydroxide on nutrient digestibility by sheep and goats. Small Rumin. Res. 7, 225-233.

SAS, 1994. Statistical Analysis Systems user's guide, Version 6. SAS Institute, Inc., Carey, North Carolina.

Van Ryssen, J.B.J. & Ndlovu, H., 2003. Wood and homestead ash as potential source of minerals to livestock. Proc. 8th World Congress on Animal Production, Oct 2003. Porto Allegro, Brazil. ID 9713.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

A comparison of *Cassia sturtii, Tripteris sinuatum* and *Sutherlandia microphylla,* – three fodder shrubs applicable to revegetation of degraded rangeland in the Northern Cape Province

T.E. Wilcock[1], W.A. van Niekerk[2#], N.F.G. Rethman[1] and R.J. Coertze[2]
[1]Department of Plant Production and Soil Science, University of Pretoria, Pretoria, 0002, South Africa.
[2]Department of Animal and Wildlife Sciences, University of Pretoria, Pretoria, 0002, South Africa.

Abstract

Many arid and semi-arid areas have been degraded to bare patches and interventions are necessary to restore a productive state. Fodder shrubs, both exotic and indigenous, have been used for revegetation and reclamation. Ideally the species to be used should be adapted to arid conditions. This trial included one exotic (*Cassia sturtii*) and two indigenous (*Sutherlandia microphylla* and *Tripteris sinuatum*) species. The objective was to make a comparison of production and nutritional qualities over the growing season. *Sutherlandia* and *Tripteris* compared well, in terms of both production and quality, with *Cassia*.

Keywords: *Cassia sturtii*, *Sutherlandia microphylla*, *Tripteris sinuatum,* production, crude protein, *in vitro* DOM and ash
[#]Corresponding author. E-mail: willem.vanniekerk@up.ac.za

Introduction

In South Africa many arid and semi-arid areas have been degraded and in severe cases large bare patches developed (Van der Merwe & Kellner, 1999), which then eroded and exposing the lowest horizons of the soil profile and preventing the germination of seeds (Van der Merwe & Kellner, 1999). The vegetation will not recover with rest alone (Hoffman & Aswell, 2001) and the establishment of palatable fodder shrubs supply a fodder source during dry months (Kibon & Ørskov, 1993). This trial involves drought tolerant fodder species, *Cassia sturtii* (an exotic) and two indigenous species, *Tripteris sinuatum* and *Sutherlandia microphylla.* These shrubs are generally palatable and meet the nutritional needs of grazing animals (Le Roux *et al*., 1994).

The objective of this trial was to compare the three species, over time, in terms of production, leafiness and certain qualitative characteristics.

Materials and Methods

Twenty replicates per species were randomly allocated to plots. Five seedlings of a species were planted per plot. Four replicates per species were harvested (20 centimetres above ground level) randomly at each harvest date (7th July, 18th August, 29th September, 10th November and 22nd December 2003). The plant material was separated into leaf and stem material and then dried in a forced draught oven at 60° C for 24 hours. Plant production was based on dry matter yields. The percentage leaf material was also determined. Representative samples of the final harvest were analysed for *in vitro* digestible organic matter (IVDOM %) (Tilley & Terry, 1963) as modified by Engels & Van der Merwe (1967), crude protein (CP) (AOAC, 2000) and ash (AOAC, 2000).

An analysis of variance with the GLM model (SAS, 1994) was used to determine the significance of differences between species, leaves and stems and harvest dates. Means and standard deviations (s.d.) were calculated. Significance of difference ($P < 0.05$) between means were determined by the Bonferroni test (Samuels, 1989).

Results and Discussion

Sutherlandia had the highest DM yield (Figure 1). After the third harvest *Sutherlandia* exhibited a drastic increase in yield in comparison with the other species. Severe frost (experienced at the end of August 2003) affected both *Tripteris* and *Cassia*. *Cassia,* although affected by the frost, recovered quickly and an increase in yield was noted after 29th September. Although *Tripteris* produced more material in the initial harvests, the frost took its toll and recovery was slower. *Cassia* had a slow start and the lowest production over time. By the 22nd December production levels of *Cassia* were equivalent to those of *Tripteris.* There

Peer-reviewed paper: 8th International Conference on Goats

was also an increase in the amount of weeds in the camp and these too seemed to impact the growth of *Tripteris*.

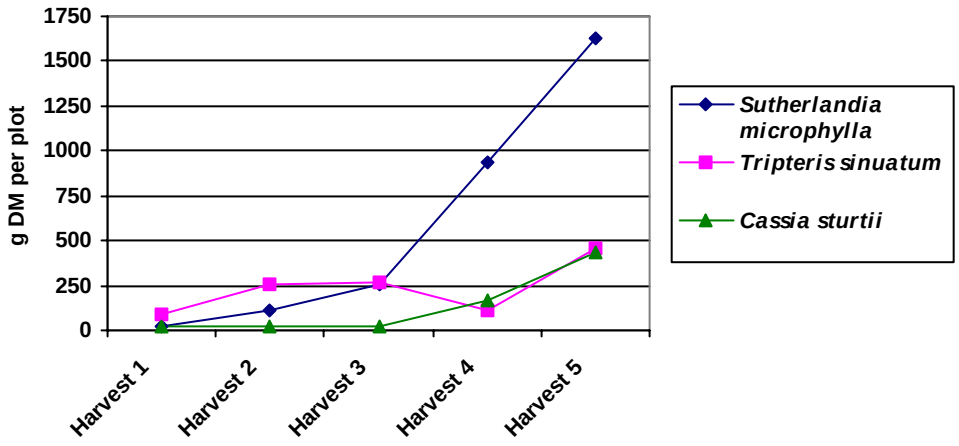


Figure 1 The dry matter production (g per plot) of different fodder shrub species at different harvest times

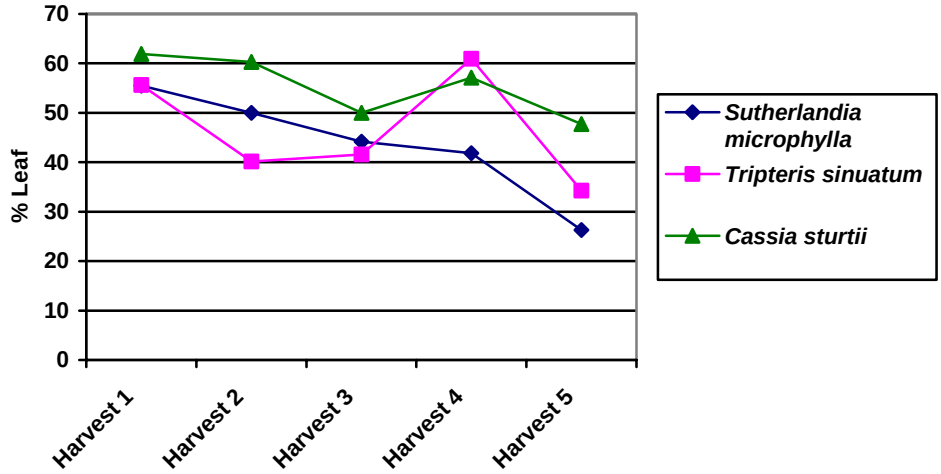


Figure 2 The percentage leaf in different species at different harvest dates

As the plants increased in size, a decrease in the percentage leaf material was observed (Figure 2). Of the three species the largest decrease was observed in *Sutherlandia*. *Cassia* had the highest percentage leaf. The drastic decrease in % leaf between November and December harvests in *Tripteris* may have been due to heavy weed infestation at that stage.

Harvest five was analysed for *in vitro* digestible organic matter (IVDOM), ash and crude protein (Table 1). The leaves of *Tripteris* and *Sutherlandia* had the highest CP and IVDOM ($P < 0.05$). *Cassia* stems had higher IVDOM than both *Tripteris* and *Sutherlandia* ($P < 0.05$), but no differences in the CP concentration between the different species ($P > 0.05$). Research conducted by Sparks (2003) indicated that *Cassia* was nutritionally inferior to *Atriplex nummularia*. The leaves of *Tripteris* had a higher % ash than both *Sutherlandia* and *Cassia* ($P < 0.05$). In all species higher IVDOM and CP concentrations were observed in the leaves than in the stems ($P < 0.05$).

Peer-reviewed paper: 8th International Conference on Goats

Table 1 Comparison of *in vitro* digestible organic matter (IVDOM), ash and crude protein (CP) concentration of different species, leaves and stems (± s.d.)

	Stems ≤ 3 mm	Leaves
Sutherlandia microphylla		
IVDOM, %	$38.9^{ab}{}_1$ (± 2.7)	$66.0^{b}{}_2$ (± 3.7)
Ash, %	$2.5^{a}{}_1$ (± 0.3)	$6.4^{a}{}_2$ (± 0.2)
CP, %	$8.8^{a}{}_1$ (± 0.9)	$22.5^{b}{}_2$ (± 1.9)
Tripteris sinuatum		
IVDOM, %	$33.0^{a}{}_1$ (± 4.9)	$66.8^{b}{}_2$ (± 1.2)
Ash, %	$10.5^{c}{}_1$ (± 1.4)	$18.4^{b}{}_2$ (± 1.7)
CP, %	$9.8^{a}{}_1$ (± 0.8)	$21.6^{b}{}_2$ (± 4.7)
Cassia sturtii		
IVDOM, %	$41.8^{b}{}_1$ (± 2.4)	$55.4^{a}{}_2$ (± 2.3)
Ash, %	$5.3^{b}{}_1$ (± 0.2)	$7.3^{a}{}_2$ (± 1.0)
CP, %	$7.6^{a}{}_1$ (± 1.0)	$14.7^{a}{}_2$ (± 1.1)

^{ab}Column means with common superscripts do not differ ($P > 0.05$)
$_{1,2}$Rows means with common subscripts do not differ ($P > 0.05$)

The NRC (1981) suggested that the CP maintenance requirement of a 50 kg doe is 7.5%. All three species fulfil in this requirement.

Conclusion

Both indigenous species have potential as fodder shrubs for revegetation projects. Although the establishment of such fodder shrubs is often not financially feasible for small scale farmers (Le Houérou, 2000), it is important that farming systems be used which are based on sustainable practices in order to restore degraded areas and maintain them at a satisfactory production level.

Acknowledgments

This research was supported in part under Grant No. TA-MOU-99-C16-091 funded by the U.S.-Israel Cooperative Development Research Program, Bureau for Economic Growth, Agriculture and Trade, U.S. Agency for International Development.

References

AOAC, 2000. Official methods of analysis of the Association of Official Analytical Chemists. Inc. Arlington, Virginia, USA.

Engels, E.A.N. & Van der Merwe, F.J., 1967. Application of an *in vitro* technique to South African forages with special reference to the effect of certain factors on the results. S. Afr. J. Agric. Sci. 10, 983-995.

Hoffman, M.T. & Aswell, A., 2001. Nature divided. Land degradation in South Africa. University of Cape Town Press, Cape Town. South Africa.

Kibon, A. & Ørskov, E.R., 1993. The use of degradation characteristics of browse plants to predict intake and digestibility by goats. *An. Prod*. 57, 247-251.

Le Houérou, H. N., 2000. Utilization of fodder trees and shrubs in the arid and semi-arid zones of west Asia and north Africa. *Arid Soil Res. Rehab*. 14 (2), 101-135.

Le Roux, P.M., Kotzé, C.D., Nel, G.P. & Glen, H.F., 1994. Bossieveld: Grazing plants of the Karoo and Karoo-like areas. Dept. of Agric., Pretoria, South Africa. CTP Book Printer, Cape Town, South Africa. Pp. 34-56.

NRC., 1981. Nutrient Requirements of Goats: Angora, Dairy and Meat goats in temperate and Tropical Countries. National Academy Press. Washington, D.C.

Samuels, M.L., 1989. Statics for the life sciences. Collier MacMillan Publishers, London.

Sparks, C.F., 2003. Interspecies variation in nutritive value of certain drought tolerant fodder shrubs. M.Sc. (Agric.) dissertation. University of Pretoria, South Africa.

SAS, 1994. Statistical Analysis Systems User's Guide. Statistics Version 6. SAS Inst., Inc. Cary, NC., USA.

Van der Merwe, J.P.A. & Kellner, K., 1999. Soil disturbance and increase in species diversity during rehabilitation of degraded arid rangelands. *J. Arid Environ*. 41, 323-333.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Factors effecting the profitability of different goat farm sizes in Hungary

T. Németh[1#], L. Branduse[2], M. Ábrahám[2] and S. Kukovics[2]
[1]Hungarian Goat Breeders' Association, Gesztenyés u. 1. H-2053 Herceghalom, Hungary
[2]Research Institute for Animal Breeding and Nutrition, Gesztenyés u. 1. H-2053 Herceghalom, Hungary

Abstract

The goat industry is the smallest among the so-called "big" domestic animal sectors in Hungary. At present the estimated size is about 60-70 thousand does, which are kept by approximately 7,000 holders. Not much information is available to evaluate the economic situation of the goat sector, thus a survey was carried out to find the answers to the following questions; What kinds of costs are relevant to the farms (like feedstuffs, labour, insurance and animal health) and what is their ratio to the total expenditure; What incomes are earned on the different farms (by the selling of milk, milk products, kids for slaughter, meat, manure, feed, and income from subsidies, etc.); What yields for each product (milk, progeny) are obtained. Based on the data collected, farms were divided into the following size categories: numbers of does between 1-10; 11-30; 31-50; 51-100, 101-150; 151-200; 201-300, and above 300 head. There were 92 farms included in the survey having more than eight thousand head of goats in total.

The level of production (milk and kids) was lower than expected in each farm size class. The average quantity of milk sold per doe did not reach 270 kg, and the average kidding rate was just above 150%. The most important income resource was the milk (and milk products) giving 75-80% of the total income of the farms. The income ratio from selling kids for slaughter did not exceed 18-20%. The biggest cost factors were feedstuff and labour.

According to the balance ratios the goat breeding and production were only profitable in the smallest categories and above the 50-head classes. Between them only negative results could be expected providing that the owner or the farmer produced for market. If the production is meant only for family consumption the cost factors and the profitability were not as important. On the commercial goat farms increase in milk yield and improvement in kidding percentage could improve profitability.

Keywords: Goat industry, goat profitablility, goat surveys, Hungary
[#]Corresponding author; E-mail: timea.nemeth@atk.hu

Introduction

The Hungarian goat population consists of sparse and relatively small herds. The average herd size is about 20 does and their offspring, varying in size between a few and 500 head (Kukovics *et al*., 2003). Estimated actual number of does is 60,000, but most of them are not registrated. No data has been collected regarding goat farmers and their economic success (productivity, costs, incomes) since 1999 (Németh *et al*., 2003), therefore a representative study including all farm size categories became important.

Materials and Methods

The study was carried out in collaboration with the Department of Small Ruminants, Research Institute for Animal Breeding and Nutrition and the Hungarian Goat Keepers and Breeders' Association. Farms were chosen for the study from the register of the Association according to the following aspects: farm (herd) size, breed, and locality within the country. Questionnaires were used to obtain information concerning size of the farm and herd, breed, utilization, feeding system and feed origin (self produced or purchased), animal health, employees and salaries, and data of expenses of these. Data of incomes from milk, dairy products, meat, breeding animals, dung and other sources were also collected. Ninety-two (92) of the questionnaires returned contained data on 8307 goats (5867 does). Categories of herd sizes were created for the study: farms keeping 1-10, 11-30, 31-50, 51-100, 101-150, 151-200, 201-300 and more than 300 goats.

There are eight (8) breeds; three (3) of them purebred from imported stocks (Alpine, Saanen, Boer), the others are native types and their registration into breeds, called, Hungarian Dairy White, Hungarian Dairy Brown and Hungarian Dairy Multicolour, started in 1999. All of these breeds were proportionally represented in the collected data. Collected data was captured, evaluated and analysed by means of Microsoft Excel 7.5.

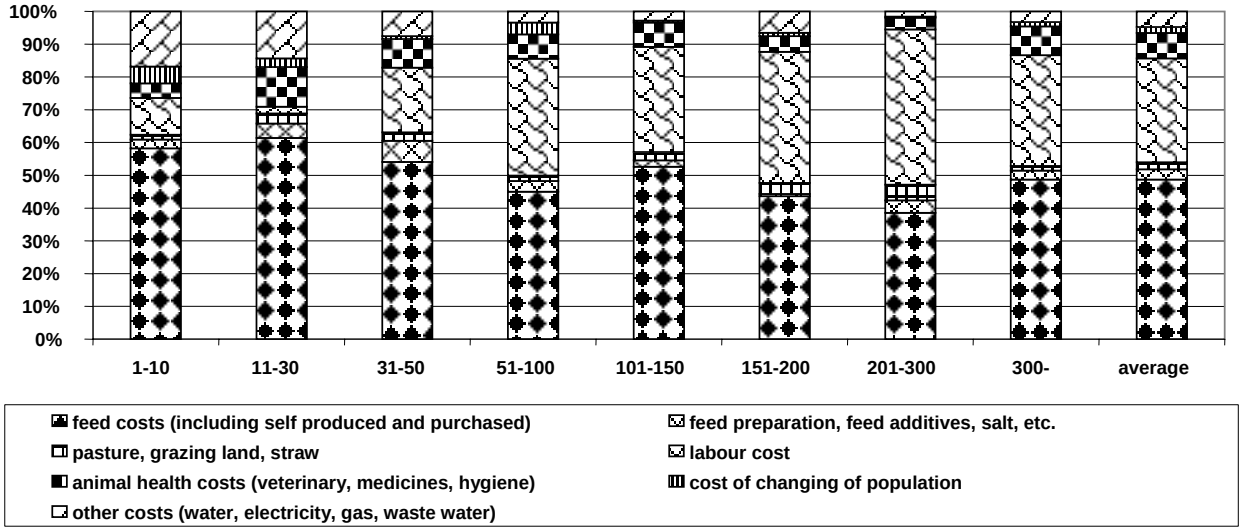
Peer-reviewed paper: 8th International Conference on Goats

Results and Discussion

A correlation was observed between the number of goats and the size of the area of land used. The average area increased up to the 101-150 goat category (from 0.07 to 32 ha) and then decreased. A surprizingly small size of land was used in the 201-300 category, which was similar to the 31-50 category (3.2 ha), probably indicating that most of the farms of this category use rented land.

The largest variable expense was that of feeding (Figure 1), representing more than 40% in almost all herd size categories. In the 201-300 head category feed expenses were a bit less than 40%. The proportion of purchased feed was significant in all size categories, found to be the highest in the 101-150 head category reaching 72%. Expenses of self produced feed were the highest (62%) in the 151-200 head category. On average, about 50% of feeding needs are covered from external sources. In general we can say that goat keepers were significantly dependent on external sources greatly influencing – increasing – variable expenses of animal keeping. Average feed expenses per goat and per doe were 9 903 and 16 259 HUF/year, respectively (1 USD = about 220 HUF).

Figure 1. Distribution of the different costs according to herd size



Labour expenses increased with farm size, except category 11-30 where minimal salaries were paid, as in these farms there were no external employees. It may be explained by the fact that the producer calculates his own salary as a part of the income, while on larger farms expenses of salaries of employees must also be covered by the income of the enterprise. A significant proportion of farms did not calculate any salary for the owner. Salaries and salary-like expenses made up the greatest expense, 48% of total expenses, in the 201-300 category. Average salary/goat was a bit more than 9.000 HUF/year/doe. It could not be explained from the study of animal health expenses (vet, medicine, animal hygiene) why the highest (11%) expenses for animal health was observed in the 11-30 category, and the lowest (3%) in the 201-300 category. Average animal health cost was calculated as 8% of the total expenses. These costs exceed 1.500 HUF/goat/year, and include 42% for veterinary-, 30% for medicines- and 28% for animal hygiene.

Expenses caused by changes in herd size (losses caused culls) were the highest in farms of the smallest category (5%), the total calculated average was around 1%. In the case of other (stable) expenses (water, electricity, gas, heating material, waste water etc.) a constant decrease proportionally was observed until the 101-150 category (from 12 to 2%), growing to 6% in the next category and showing a decreasing tendency again. Its relative proportion was 5% as compared to total costs.

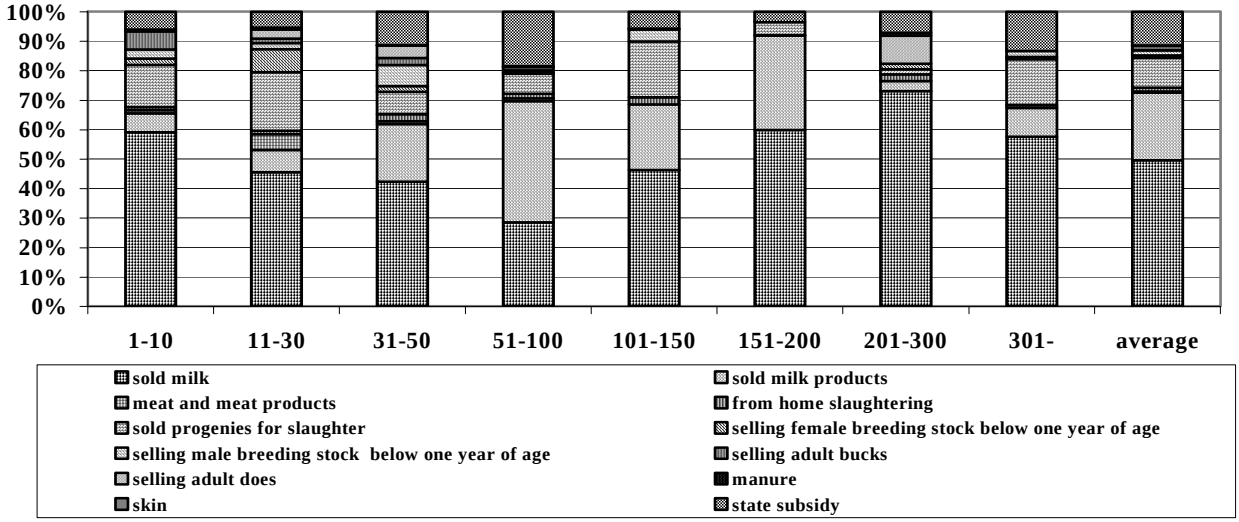
There were some differences between the incomes (Figure 2) of individual farms. But, income from selling milk was the highest in the 51-100 size category. When milk and milk products were added together their income proportion was the highest in the 151-200 category, reaching 92%.

Average milk production was 260 kg/doe, reaching 400 kg only in the smallest farm size category. The lowest milk production (158 kg) was observed in the 101-150 category.

Peer-reviewed paper: 8th International Conference on Goats

The low production level of the population is mainly caused by nutritional deficiencies and animal health problems, and it is different if we calculate the quantity of milk and sold milk to the number of all does, or only milked does. The average does milked was 61.2% over all categories. On average, more than 80% of produced milk was sold, thus a bit more than 200 kg/doe, but its ratio changed by category.

Figure 2. Distribution of different income sources according to herd size



Income from meat and meat products represented a very low proportion of the total income. Animals for slaughter were mostly sold as live animals. Selling of these products was the highest in the 11-30 category (4-5%). Proportion of milk (+milk products) and meat (goats for slaughter and meat) was 80:20 taken as ratios of total product sold.

Litter size was lower in all categories than the reproduction ability of each goat breed. The average kidding percentage was a little bit above 150%. Prolificacy decreased by farm-size (from 193 – to 114%).

Sold offspring as income source indicates the proportion of money from selling kids for slaughter. It was 20% in the 11-30, 19% in the 101-150 and 14% in the >300 category. Income from selling young breeding animals was found to be very low. It was the highest (around 10%) in the 11-30 and 31-50 categories. Selling bucks and adult does was more typical for the smaller farms; however income for sold does was the highest in the 201-300 category (10%).

The proportion of farms receiving state subsidies was very different between categories. A total average near 70% of the farms got normative (1500 HUF/does above 6 months of age) or other state subsidies. On average, state subsidies represented about 11% of the total incomes, this rate shows the low repaying and income conditions of the sector.

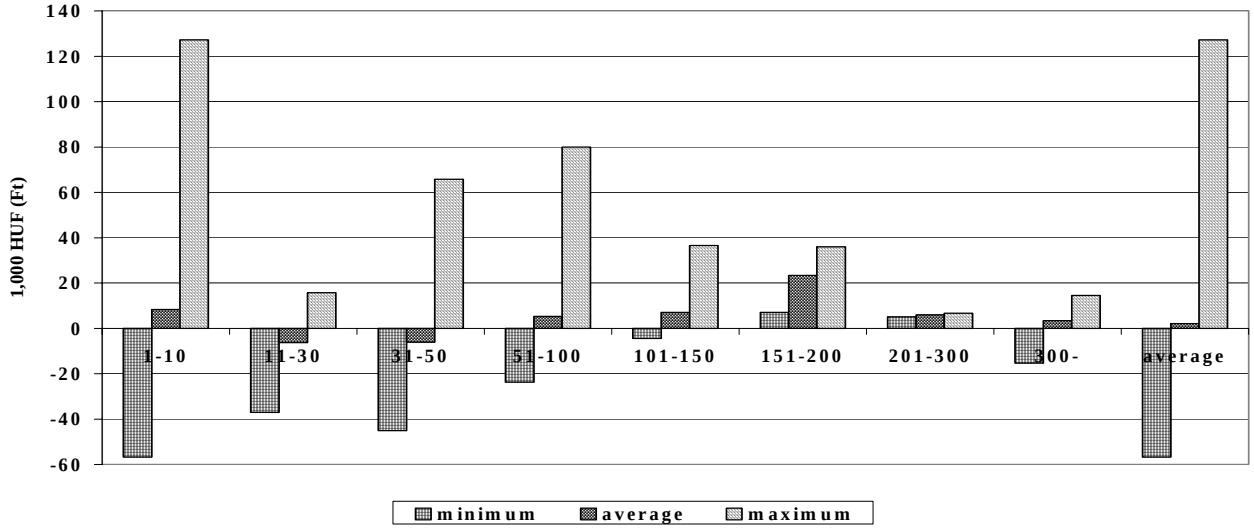
A minimum herd size is needed for covering fixed and variable expenses. Income is increased by the number of productive animals which ensures the covering of expenses, but only to a certain herd size. In the smallest category the positive balance (8 000 HUF/goat) turned to a negative balance in the next category (Fig. 3.). The average balance became positive again (6 000 HUF/goat) in the 51-100 category. The balance increased in the subsequent categories reaching the highest in the 151-200 (26 000 HUF/goat) category, then decreasing again to 2 000 HUF/goat.

Conclusions

Productivity was primarily influenced by milk production and prolificacy of does. Both of these, milk yield (264 kg) and kidding rate (152%) were considerably below the abilities of the breeds. As a consequence of this, the expenses increased significantly above incomes/goat as the herd size increased. According to the data available, goat keeping and production was a profitable activity, but increasing prolificacy and milk quantity were factors determining profitability. The calculated profitability was supported by the low level of labour costs given by the goat farmers.

Peer-reviewed paper: 8th International Conference on Goats

Figure 3. The income / cost balance according to herd size



References

Kukovics, S., Ábrahám, M.,Branduse, L., Dani, Z. & Németh, T. 2003. Economical analysis of goat farms of different sizes. In: Magyar Juhászat + Kecsketenyésztés (Hungarian Sheep-Farming +Goat Breeding), 12. (1.) 3-8. pp.

Németh, T., Branduse, L., Ábrahám, M. & Kukovics, S. 2003. Factors influencing profitability of goat Farming. In: Buletinul, Universitatii de Stiinte Agricole Si medicina Veterinara, Seria Zootechnie si Biotechnologii, ISSN 1454-2382, (Romania) Volumul 59, 77-84. pp.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Ecological use of fibrous forage with solar mobile fence grazing

D.C. Puga[1#] and M.A. Galina[2]
[1]Instituto Nacional de Ciencia Medicas y Nutrición, Salvador Zubirán,Departamento de Nutrición Animal. México, D.F
[2]Facultad de Estudios Superiores Cuautitlán, UNAM, Cuautitlán, México.

Abstract

A study was conducted on 14 ha of *Caducifolia* thorny forest (Bek 444). Average total production was 800 kg DM/ha/year. The area of study was divided two 7 ha sites. One area named free grazing (FG) and the other solar mobile grazing (SMG). Thirty-five FG goats 45 (± 3.5) kg/BW pastured continuously every day during the study. Other 35 Alpine goats 36.0 (± 4.5) BW were placed on SMG. SMG had two stoking rates, high (163 AU/ha) and low (40.8 AU/ha), with 625 m^2 and 1.250 m^2, respectively. Number of goats varied to adjust stoking rate daily. Initial markers were grass size, 24 to 30 cm (± 3) and initial leaves number 156 (±17) on selected shrubs branches (40 cm long). Animal grazed five hour/day, the botanical composition was determined by measuring transects at the beginning and end of booth observations. Chemical analyses of forage selected by goats in the FG and SMG were preformed monthly. Average grass height went from 37.1 cm to 65.2 from June to February (48.03) and leaves percentage from 18.40% to 5.90% (4.42) in SMG compared to 41.4 cm to 42.3 cm (36.3) and 16.30% to 0.91% in FG. Goats behaviour, changed from 80% in July and August, to 100% browsing, from December till March, showing the opportunistic choosing ability of goats. Economical and social status of the rural community could be improved with SMG. Reforestation of range is a key component to sustainability of a fragile ecosystem.

Keywords: Nutrition, goats, growth, rangeland, pasture.
[#]Corresponding author; E-mail: dpclau@quetzal.innsz.mx

Introduction

Previous studies showed goat's milk economically management throughout feeding agricultural products, by-products and rangeland grazing, which otherwise would be wasted. It was then proposed a seasonal utilization of rangeland, when vegetation growth permits and leaving in idle in the dormant season (Galina *et al*., 1998a). Previously Galina *et al*. (1998b) evaluated this system in term of biosustantibility. Rangeland contributed 33.0% of the DM intake, 28.2% of the energy and 39.4% of the annual protein requirements for milk production. In the northeastern of Mexico Ramirez *et al*. (1990; 1991; 1995; 1996; 2001;2003) studied goat's seasonal nutritional changes related to range forages. However, few studies have proposed vegetal markers to conduct goat's goat grazing on rangeland. Information on the intake habits of range pasture is essential to determine the competition for food or nutrition. The objective of this study was to develop a solar mobile intensive grazing system technique (SMG) in a semiarid rangeland with goats. Balancing consumption with supplementation to improve vegetation population throughout grazing.

Material and Methods

The study was conducted on the "Puma" farm in Cerro Prieto, Querétaro, Mexico, at 20º35' latitude North and 100º18' longitude west. The altitude was 1950 m above sea level. Climate is Bs 1 Kw (w) (e), described as dry semiarid with isolated rains in the winter and a total of 460 mm of average precipitation per year (García, 1973). The research was performed on 14 ha of *Caducifolia* thorny forest (Bek 444). Grasses were: *Bouteloua curtipendula, Choris virgata, Bothriochloa saccharoides, Leptochloa saccharoides, Leptochloa dubia, Rhyncheltythurum roseum, Panicum obtusum, Bouteluoa repens, Aristida adscensionis, Staria parviflora, Urochloa fasciulata;* leguminous trees: *Prosopis leavigata, Acacia farnesiana, Acacia schaffneri, Mimosa bincifera;* shrubs: *Celtis pallida, Jatropha dioica, Zalazania augusta, Verbasina serrata* and cactaceae: *Opuntiaaffasiacantha, O. amyctaea, O. cretochaeta, O. hytiacantha, O. robusta, O. streptacanta, O. tomentosa*. Average total DM/ha/year production was 800 kg (Galina *et al*., 1998). Grazing management and techniques for shrub land evaluation was published before Puga, (1998). The area of study was divided two section 7 ha each. One area was named free grazing (FG) and the other solar mobile system grazing (SMG). Thirty five FG goats 45 (± 3.5) kg/BW pastured continuously every day during the study.

The other 35 Alpine goats 36.0 (± 4.5) BW were placed on SMG. SMG had two stoking rates, high (163 AU/ha) and low (40.8 AU/ha), with 625 m^2 and 1.250 m^2, respectively. Number of goats varied to

Peer-reviewed paper: 8th International Conference on Goats

adjust stoking rate daily. Grazing area was limited with a plastic solar mobile fence 96 cm x 50 m. In the two grazing system 10 areas were established the indicated use of vegetation. Initial markers were grass size, 24 to 30 cm (± 3) and leaves 156 (±17) on selected shrubs branches (40 cm long). Grass length and leaves number were measured before and after grazing. Second use of the shrub land was allowed when re-vegetation of grasses was 10 cm long and re-foliation of branches was 49%. During grazing, animal behaviour was determined by direct observation (Gutierrez, 1991). Animal grazed five hour/day, the botanical composition was determined by transects at the beginning and end of booth observations (Palma, 1996). Chemical analyses of forage selective by goats in the FG and SMG were preformed monthly, foliage sample were collected and evaluated according to AOAC (1995).

Results and discussion

Rangeland botanical composition was resumed in Table 1. Sustainable use of vegetation was better for SMG compared to FG that augmented vegetable denudation. Lineal regression showed that the cover grasses improved with SMG (P<0.01).

Table 1. Botanical composition of rangeland by the effect two system of pasturing.

	Solar Mobile System Grazing (SMG)			Free Grazing (FG)		
Sample time Months	Grasses	Shrubs	Denudation	Grasses	Shrubs	Denudation
		Proportion %			Proportion %	
1	37.1	18.4	44.7	41.4	16.3	50.5
2	50.0	2.3	48.1	48.1	1.85	49.7
3	53.0	2.7	44.2	45.9	0.00	54.1
4	45.7	2.79	51.5	36.2	0.43	63.3
5	43.9	2.01	55.1	41.9	0.67	57.4
6	44.1	1.4	55.2	36.9	0.81	62.2
7	41.8	2.9	56.3	33.8	0.46	65.6
8	51.2	1.2	48.3	38.3	1.55	60.1
9	65.2	5.9	27.2	42.3	0.91	56.7
Average	48.03a	4.42a	47.89b	36.3b	1.44b	57.7a
	± 8.1	± 5.44	± 8.95	± 4.65	± 8.1	± 5.59

Letter a and b indicate difference between columns and treatments (P<0.05)

Goats grazing behaviour is shown in Figure 1. Initial intake preference was on grasses, changing feeding behaviour to browse, in the late months.

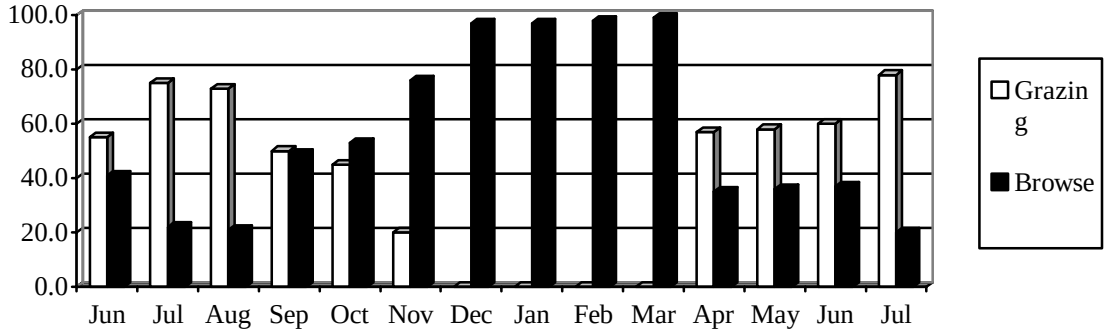


Figure 1 Grazing behaviour of goats with solar mobile SMG

Chemical composition in the rangeland forages was evaluated from July to May 2002-2003. Crude fiber (CF) in the grasses augmented from 25.5% to 30.9%. Maximum height was 36.3% in November. Level of crude protein (CP) diminished from 10.1% to 6.7% in the same period. Present results were similar to previous work in Northern Mexico (Ramirez et al., 2004), when all grasses study were low in CP to and increased most rapidly in spring and summer. These seasonal fluctuations in CP contents may have been induced by the spring (139 mm) and summer (144 mm) precipitations. On the other hand the trees and

Peer-reviewed paper: 8th International Conference on Goats

bushes, showed a low CF contain in the autumn (October) with 20.9%, provably because late re growth. Crude protein average had two peaks, one in October (21.5%) and other in April (25.3%). Late browsing could be explained due to fibre content and CP accumulation on the younger leaves.
Initial grazing was mainly on grasses; length average was 24 cm using a high (163 AU/ha) and low (40.8 AU/ha) stoking rate. After grass pasturing, high stoking grazing area needed 75 days to regain 20 cm growth on the grass mixture. In contrast low stoking recovering was only 35 days. For shrubs the initial index was 145 leaves/40cm/braches; in high and low stoking rates. Days to recover 80% were 60 and 75. A second use of the grazing area did not allow vegetation recover until the following year. After 240 d. rain precipitation stop in September stopping grass re-growth. Range SMG management allowed use of 117 different parcel and permitted two time utilization of each parcel. In FG indexes for grasses and trees were similar but continuous use of the rangeland did not allow vegetation to re obtain initial length or percentage of leaves after 240 days, demonstrating deforestation of the area. Solar mobile worked jointly with a car battery when no sun was available.

Conclusion

Use of SMG allowed two-time pasture of the rangeland in the observation, with yearly increase of the vegetation, compared to FG that did not allow re-vegetation and produced deforestation. Economical and social status of the rural community could be improved with SMG. Reforestation of semiarid scrubland is a key component to sustainability of a fragile ecosystem.

Acknowledgment

This Research was supported by project PAPIIT 211701 UNAM and Cátedra SB FES-Cuautitlan UNAM.

References

AOAC. 1995 Official Methods of Analysis. Association of Official Agricultural Chemists. 16 th Ed Washington. D.C. USA, 600 pp.

Galina, M. A., Morales, A.R., Jimenez, S. & Haenlein, G.F.W. 1998a. Performance of dairy goats pasturing shrubland in Mexico supplemented with a urea molasses mineral block. Adv. Agric. Res.7(3), 15-22.

Galina, M.A., Puga, D. C., Hernández, A. & Haenlein, G.F.W. 1998b. Biodiverse and biosustainable production system with goats in Mexico: importance of a forage bank. Small Rum. Res. 27,19-23

García, E. 1973. Modificaciones al sistema de clasificación climática de Köppen (modification of Kóppen climatic classification system). Instituto de Geografía. Universidad Nacional Autónoma de México, México D.F. pp33.

Gutierrez, A.J.L. 1991. Nutrición de los rumiantes en pastoreo (The nutrition of ruminant in grazing). University of Chihuahua, Ed. Text University, México. pp263.

Palma, J.M. 1996. Guía sobre los aspectos básicos del manejo de las praderas tropicales. Planta-suelo-animal. (Guidebook on the basic aspect to management of the tropical meadow. Plant-ground-animal). University of Colima, México.pp.56.

Puga, D. C.1998. Mejoramiento de un sistema de alimentación parcialmente biosostenible en cabras bajo un pastoreo racional tecnificado móvil (Improvement of a partial biosustainable feeding system in goats with rational technological mobile grazing). Master Thesis university of Colima, México. pp.174.

Ramirez, R.G., Haenlein, G.F.W., & Nuñez-Gonzalez. M.A. 2001. Seasonal variation of macro and trace mineral contents in 14 browse species that grow in northeastern Mexico. Small Rum. Res. 39, 153-159.

Ramirez, R.G., Haenlein, G.F.W., Trevino, A., & Reyna, J. 1996. Nutrient and mineral profile of white-tailed deer (*Odocoileus virginianus*, texanus) diets in northeastern Mexico. Small Rum. Res. 23, 7-16.

Ramirez, R.G., Loyo, A., Mora. R., Sanchez, E.M., & Chaire, A. 1991. Forage intake and nutrition of range goats in a shrubland in northeastern Mexico. J. Anim. Sci. 69, 879-885.

Ramirez, R.G., Mireles, E., Huerta, J.M., & Aranda, J. 1995. Food habits of range sheep grazing a buffelgrass pasture. Small Rum. Res. 17, 129-136.

Ramirez, R.G., Rodriguez, A., Tagle, L.A., Del Valle, A.C., & Gonzalez, J. 1990. Nutrient content and intake of forage grazed by range goats in northeastern Mexico. Small Rum. Res.3, 435-448.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Factors influencing weaning percentages of indigenous goats on communal grazing

P.J. Sebei[1], C.M.E. McCrindle[#1] and E.C. Webb[2]

[1]Department of Paraclinical Sciences, Faculty of Veterinary Science, University of Pretoria. Private Bag X04, Onderstepoort 0110 , South Africa; [2]Department of Animal and Wildlife Science, Faculty of Natural and Agricultural Sciences, University of Pretoria 0002, Pretoria

Abstract

The traditional system of goat management is mainly characterised by low survivability and high mortalities of kids, which result in low weaning percentages. High mortality among kids and slow growth among those that survive are the major constraints to production. Weaning percentage is a measure of survivability of kids from birth to weaning. By examining the variables, which affect weaning percentages in a communal goat farming system, it should be possible to develop an appropriate extension message to decrease kid mortalities and increase productivity. The aim of this study was to examine the factors that influence the survivability of kids from birth to weaning. The predisposing factors were used to develop extension messages for use by farmers in communal and small-scale systems.

The methods in this study were based on participatory rural appraisal (PRA) and farming systems research and extension (FSR/E). Initially 20 farmers were subjected to structured interview Two-stage cluster sampling (Thrusfield, 1986) was done where farmers were the primary units and goats were the secondary units. The allocation procedure was based on the purposive selection of goatherds on communal grazing within Jericho (the district falls under North West Province, South Africa). Initially 20 farmers were interviewed using a structured questionnaire. Thirteen farmers with 131 does remained in the survey over the long term and were visited once a month over the course of a full year. Body condition score, weighing of kids and collection of faecal samples for evaluation of internal parasites were done. Management was observed and informal discussions conducted during the visits. Monthly precipitation and temperature data was obtained from the Department of Soil, Climate and Water.

The parameters that were measured to study the relationship with mortality rates of the kids included: demographics and socio-economics of owners, nutrition, parasites (internal and external), infectious diseases, micro and macro environment (including housing scores), management, mortalities of goat kids (n=131) over the course of 12 months. Internal and external parasites were sampled monthly and the mass, health status and body condition score was monitored. The total mortality (n=41) was found to be 37 % of the total number of kids born (n=131) and the survival rate to weaning was thus 63 %. The majority (n=10) of farmers were pensioners of fairly advanced age (mean=68.9years) who were also performing household chores, this reflects a shortage of labour. Nutrition did not appear to be a major problem. The major problems in this case were considered to be housing and internal parasites. For the appropriate and relevant extension message it is on these factors that more emphasis should be placed. It was found that a good market for goats exists in communal areas and flock turnover was about 20%. Thus, any improvement in the survival of kids would lead to a better financial return for farmers by having more goats available for sale.

Keywords: Indigenous goats, Weaning percentage, Communal grazing
[#]Corresponding author; E-mail: mccrindle@op.up.ac.za

Introduction

The death of kids before weaning is perhaps the single biggest cause of economic loss to goat farmers. Low survivability and high mortalities of kids result in low weaning percentages. Any attempt made to ensure survival of kids is bound to increase productivity and economic returns (Ademosun, 1987; Devendra & Burns, 1970; Lebbie & Manzini, 1989).

Under extensive systems in tropical areas, a pre-weaning mortality of 16-60% has been recorded, which is higher than in intensive systems. This may be under-estimated as deaths of newborns, which occur when goats are browsing, may go unnoticed (Ademosun, 1992). The predisposing factors may be lack of colostrum, poor mothering, poor nutrition of the doe leading to low milk production, hygiene lack allowing build-up of infective agents and contaminated water (Peacock, 1996). Mortality of kids may be reduced by control of internal and external parasites, feeding of the dam, vaccination and improved housing (Boomker *et*

Peer-reviewed paper: 8th International Conference on Goats

al., 1997; Morand-Fehr *et al.*, 1984; Ndamukong *et al.*,1989; Payne & Wilson, 1999).Weaning percentage is a measure of survivability of kids from birth to weaning. Prolificacy (number of kids per doe that kidded per year) is a measure of multiple births and does that kidded more than once in a year. Kidding percentage is a measure of the kids born per doe in the flock and is a measure of the flock composition (Donkin, 1993; Mamabolo, 1999).

The aim of this study was to examine the factors that influence the survivability of kids from birth to weaning. The identified factors could be used to develop extension messages for use by farmers in communal and small-scale systems (Doll & Orazem, 1984). As the market for goats exists in communal areas, any improvement in the survival of kids will lead to a better financial return for farmers by having more goats available for sale.

Materials and Methods

The methods were based on participatory rural appraisal (PRA) and farming systems research and extension (FSR/E) (Amir & Knipscheer, 1989, McCrindle *et al.* 1996, Van Rooyen *et al.* 1990; Van Vlaenderen, 1995). Field visits and structured interviews were done over a 12-month period. Thereafter scenarios for impaired productivity were evaluated and compared.

The system being modelled was a communal low input/low output extensive goat production system. The variables that were considered were those impacting on survival of kids. Weaned kids were the measurable outputs. Scenarios were compared using data obtained from farm visits and the literature.

Feedback from the farmers was also used to obtain and record the information with regard to the births loss of the goat kids. The factors influencing the survivability of goat kids were ranked in importance so as to identify possible key factors that are likely to have a significant impact on the desired outputs (McCrindle *et al.*, 1996).Nutrition and growth rate were estimated by weighing kids and through monitoring of the body condition score (BCS) of does (Peacock,1996). Kids were weighed monthly from birth to weaning using a small pocket spring balance and a harness made out of nylon ski-rope. Rectal faecal samples for evaluations of internal parasites were collected directly from the does and kids of above three weeks of age. Nematode eggs per gram (epg) and coccidia (*Eimeria)* oocysts were counted by means of a modification of the McMaster slide technique (Reinecke, 1983).Diseases were recorded from clinical signs or necropsy. Housing was evaluated using a housing checklist (Table 3). Management was evaluated on a scale of 1 to 5 where 1 was very poor and 5 was excellent. Data was entered into Excel and transferred to the SPSS statistical program (SPSS 9.0 for Windows) for multifactor analysis of variance and covariance.

Results

All farmers interviewed about the weaning of kids mentioned that they used natural weaning at approximately five months (150 days).

Table 1 Causes of kid loss observed/recorded by farmers

Causes of loss/mortality[a]	N[b]=48
Unknown	16
Suspected fleas	2
Missed (Lost)	2
Suspected footrot	1
Diarrhoea	4
Suspected malnutrition	4
Suspected heartwater	2
Suspected predators	2
Suspected internal parasites	2
Killed by dog	5
Stillbirth	1
Fell in the toilet pit	1
Total death	42

[a] excluding necropsied kids (N=6)
[b] N= number of kids that died

Kid mortality refers to all post-natal deaths that occurred during the trial (Table 1). The proportion of kids dying is shown as a proportion of the number of kids born during the year (Mamabolo, 1999). The total

Peer-reviewed paper: 8th International Conference on Goats

mortality incurred during the survey was 48 kids. This was 37 % of the total number of kids born (n=131) and the survival rate to weaning was 63 %. From our survey it was found that prolificacy and kidding percentage per farmer ranges from 100 % to 160 % and from 44.4 % to 170 % respectively. Mortality rate and weaning rate per farmer ranged from 0 % to 75 % and 25 % to 100 % respectively

From necropsy of kids found dead (n=6) causes of kid mortality were: heartwater (n=1), acute septicaemia (probably pasteurellosis) (n=1), haemonchosis (n=2), severe verminosis (mixed infection) (n=1) and undernutrition (starvation) (n=1). Most of the farmers (65 %) were pensioners of fairly advanced age. During the structured interview five farmers said that they herded their goats and 15 farmers said that they just let their goats out to graze on their own. However, over the course of the trial it was observed that no farmers herded their goats. There was no supervision of kidding during the kidding season and this could also be the reason for the high level of mortality of kids. The farmers seldom used veterinary products or supplementary feeding .The breeding season was not controlled and the buck was always with the does. The male goats were castrated, slaughtered or sold as kids because uncastrated bucks wandered too far. Goats were housed for security after dark.

Poor housing can cause adverse effects in goats resulting in pneumonia and increased parasitic infestation (Devendra & McLeroy 1982). Goat houses in the study area were made of wire, scrap and corrugated iron, thorn bushes and wooden poles. This is in agreement with Payne & Wilson (1999). Using the housing checklist, a score of 2.5 and above was taken as acceptable. It was found that 92.3% of houses had a score below 2.5. However, only 30.8% of the houses were overcrowded. Bad roofing was common resulting in accumulation of water and muddy floors, 46 % of the houses provided no shelter from the rain. Ficarreli (1995) reported that in Malawi goat keepers lose 30 % of their young stock during the rainy season. Only 47% of the houses provided shelter from the prevailing wind. Only one house had insufficient ventilation, as the owner was worried about stock-theft. One farmer had five kids killed by dogs, when they escaped from the kraal. Mowlem (1988) recorded similar results.

In order to get an effective extension message, cost effectiveness must be considered (Bembridge, 1991). Statistical analysis, using Pearson correlations and regression (Thrusfield, 1995) was done to investigate correlations between the variables reported and kid mortality. Significant correlation of average and total mortality was found only with the presence of internal parasites.

Discussion

The findings suggested sub-optimal management factors which could be addressed by extension. The major causes of low weaning percentage were poor housing, leading to cold stress in the winter and a build up of manure which probably increased the levels of parasites. Improvement of housing and strategic deworming would be appropriate extension messages. Observation of does during partus would decrease peri-natal mortality.

Conclusion

Poor housing facilities allow the build-up of pathogens and the survival of and infection by internal parasites (Payne & Wilson, 1999). Since poor housing acts as the harbour for infection for goats by pathogens and internal parasites, the extension message should be to shift the goat house or to remove the faeces from the house shortly before the beginning of every kidding period, which will reduce the infection of newly born kids. Strategic deworming of does and kids, as well as partus observation are also recommended.

References

Ademosun A.A. 1987. Appropriate management systems for the West African dwarf goat in the humid tropics. In Smith O B & Bosman H G (Eds) *Goat production in the humid tropics. Proceedings of the workshop at the University of Ife, Ile-Ife, Nigeria,* 21-28.

Amir P. & Knipscheer H.C. 1989. *Conducting On-Farm Animal Research: Procedures & Economic Analysis.* Winrock International Institute for Agricultural Development and International Development Research Centre. pp.1-10.

Bembridge, T.J., 1991. Practice of Agricultural extension - A training manual, Development Bank of South Africa, Halfway House 1685, Gauteng, South Africa.

Peer-reviewed paper: 8th International Conference on Goats

Boomker, J., Kiwanuka, K., Bester, J., Kotze, A., Mosupi, H., Green, E., Motsabi, H. & Kyozaire, J., 1997. *Goats and Sheep*. In Stewart C G (Ed) *Resources and needs of animal owners at Jericho*.

Devendra, C. & McLeroy, G.B., 1982. *Goat and sheep production in the Tropics.* London and New York: Longman.

Donkin E.F., 1993. Goats for meat and milk production in developing areas. *Proceedings of the K Birch Veterinary Education Programme: Extensive meat and milk production in developing area,* 54-62.

Ficarelli, P.P., 1995. *Goat and Sheep keeping in Malawi*. Manual for Trainers and extension workers, Malawi German livestock programme. *Deutsche Gesellschaft Fur Techniste Zusammenarbeit* (GTZ), Malawi.pp. 3.11, 4.8.

Lebbie S H & Manzini A T 1989. The productivity of indigenous goats under traditional management in Swaziland. In Wilson R T & Melaku A (Ed), *African Small Ruminant Research and Development.*

Mamabolo M J 1999 *Dietary, seasonal and environmental influences on the semen quality and fertility status of indigenous goats in Mpumalanga Province (South Africa).* M.Inst.Agrar. Thesis University of Pretoria. Page 112

McCrindle C.M.E., Cornelius, S.T. & Krecek, R.C., (Eds) 1996. *Socio-economics of Veterinary Research and Training: A forum*. Proceedings of a forum presented by the Department of Veterinary Tropical Diseases of the Faculty of Veterinary science at Onderstepoort on September 28, 1995.

Morand-Fehr, P., Villette, Y. & Chemineau, P., 1984. *Influence des conditions de milieu sur la mortalite des chevreaux. Les maladies de la chevre goat diseases.* INRA Publishers, France. p. 28.

Mowlem, A., 1988. *Goat farming*. Farming Press Books, United Kingdom. p. 25.

Payne, W.J.A. & Wilson, T.R., 1999. *An introduction to animal husbandry in the tropics.* Fifth edition, Blackwell Science Ltd. United Kingdom. p. 447-481.

Peacock, C., 1996. *Improving Goat Production in the Tropics*. Manual for development workers: An Oxfarm/Farm-Africa Publication, UK and Ireland. pp. 46-63, 153-161, 204-205.

Thrusfield, M., 1986. *Veterinary Epidemiology.* 2nd edition. Blackwell science Ltd. Oxford, London. pp.47-75, 217.

Van Rooyen J, Stilwell T & Gouws L 1990 A review of farming systems research and extension (FSR/E). *FSR-E Newsletter No1 of September 1990.* Southern Africa: 1-4.

Van Vlaenderen H 1995 Methods in socio economic impact assessment: The use of PRA. *Workshop Socio-economic Aspects of Animal Diseases in Southern Africa. Research Priorities in Veterinary Science.* Convened by Foundation for Research Development.

Reinecke RK 1983 *Veterinary Helminthology*. Butterworths, Durban. Page 325-326.

Peer-reviewed paper: 8th International Conference on Goats

Performance characteristics and production system of the Criollo goat in the interandean valley of Mizque, Bolivia

A. Stemmer[#1], A. Valle Zarate[2] and T. Altug[2]
[1] Facultad de Ciencias Agricolas y Pecuarias, Universidad Mayor de San Simon, Casilla 4894, Cochabamba, Bolivia
[2] Institut fuer Tierproduktion in den Tropen und Subtropen, Universitaet Hohenheim, Stuttgart, Germany

Abstract

Performance traits and the production system of Criollo goats were investigated in 5 communities on 42 farms in the interandean valley of Mizque, Bolivia. Mean body weights at birth and 120 days of age were 2.22 and 9.25 kg, respectively, with a daily weight gain of 50.87 g. Mean twelve hour milk yield during the dry season estimated by the kid suckling method was 117 g and during the rainy season, as measured by hand milking, 222 ml; milk produced in 24 hours was estimated to be 235 g and 444 ml, respectively. Parturitions occurred throughout the whole year. Mean weight at parturition was 26.9 kg and mean kidding rate 79%. Mortality of kids was low for dams older than 1 year (12.8% from birth to 120 days of age). The production system is subsistence oriented and integrates animal and plant production. Main reasons for keeping goats in order of importance were given as dung, milk and meat. Women bear the main responsibility for tending the goats.

Keywords: Criollo goat, performance, production system, Bolivia
[#]Corresponding author, e-mail: caprino@albatros.cnb.net

Introduction

Goats play an important role in the smallholder economy in the interandean valleys of Bolvia. Approximately 1.5 million goats are kept in these regions (CID, 1996) and almost all of them are Criollos. The Criollo breed manages to survive in difficult environments with little care from the owner thanks to its adaptation, hardiness, and modest feed requirements. It provides the goat holder family with dung, milk, meat and other products. In spite of the importance of the Criollo goat in Bolivia, few investigations have been carried out (Altug, 2002; Stemmer & Valle Zarate, 2002; Stemmer *et al*., 2000; Campero, 1996; Aguilar, 1995; PDAR, 1992). In comparison with other Latin American countries, the Criollo goats of Bolivia have been influenced by other breeds to a much lesser extent, so that it is possible to evaluate this genetic resource in its environment and prevailing extensive production system.

Materials and Methods

The present study was conducted in 5 communities of the province of Mizque, department of Cochabamba, of which three were conducted in the valley at an altitude of 2000 m and the other two at higher altitudes (2800 to 3000 m). Data were collected from January 1999 through March 2000 on 16 farms. Body weights were taken with a weighing scale of 500 g precision; number of kids recorded at different ages was between 77 and 198. Milk performance was registered by the kid suckling method during the dry season (n=30) and by hand milking (n=139) during the rainy season using a weighing scale of 100 g precision. Reproduction data were registered at three weeks intervals at the farm visits on a total number of 270 goats. The production system was recorded using open and structured interviews, participatory observations and group discussions on 42 farms. Statistical analysis was performed using SAS version 6.12. The models used for growth performance (I) and milk yield (II) are listed below.

Model I: $y_{iklmn} = \mu + C_i + SE_j + LS_k + S_l + b1(ppDW_{ijklmn} - ppDW) + \varepsilon_{ijklmn}$

where: y_{iklmn} observed value for body weight; μ overall mean; C_i effect of community, i=1-4; SE_j effect of season, j=1-2; LS_k effect of litter size, k=1-2; S_l effect of sex, l=1-2; $b1(ppDW_{ijklmn} - ppDW)$ linear regression of kid weight on post partum dam weight; ε_{ijklmn} residual.

Model II: $y_{iklmn} = \mu + C_i + LN_j + PL_k + EP_l + \varepsilon_{ijklmn}$

where: y_{iklmn} observed value for milk yield; μ overall mean; C_i effect of community, i=1-5; LN_j effect of lactation number, j=1-3; PL_k effect of period of lactation, k=1-7; EP_l effect of evaluation period, l=1-4; ε_{ijklmn} residual.

Peer-reviewed paper: 8th International Conference on Goats

Results and Discussion

Mean body weight at birth was 2.21±0.80 kg and at 120 days of age 9.25±2.22 kg (Table 1). Significant effects on birth weight were litter size and post partum weight of dam. The influence of these effects was still significant at 60 and 120 days of age. The effect of sex was only significant at 60 days of age. The effects of community and season showed a certain influence on body weights at 60 and 120 days.

Table 1 Body weights of Criollo kids

Effect	Birth weight			Weight at 60 days			Weight at 120 days		
	N [1]	LSM [2]	SE [3]	n	LSM	SE	n	LSM	SE
Community									
Mizque Pampa	45	2.01	0.12	133	5.92 a	0.12	103	8.64 a	0.20
T'hola Pampa	20	2.59	0.23	41	5.52 a	0.23	34	8.57 a	0.39
Kuru Mayu	3	2.32	0.44	4	6.12 ab	0.62	3	10.11 ab	1.02
Molle Aguada	9	1.74	0.27	20	7.24 b	0.30	13	11.00 b	0.53
Season									
Dry	51	2.13	0.18	113	5.81 a	0.21	98	8.86 a	0.34
Rainy	26	2.20	0.17	85	6.60 b	0.20	55	10.30 b	0.34
Sex									
Female	45	2.08	0.15	106	6.02 a	0.19	83	9.38	0.31
Male	32	2.25	0.15	92	6.38 b	0.20	70	9.78	0.34
Litter size									
1	49	2.52 b	0.16	139	7.29 b	0.20	113	10.83 b	0.33
2	28	1.81 a	0.16	59	5.12 a	0.21	40	8.33 a	0.36
		b=0.05	0.01		b=0.11	0.01		b=0.15	0.03

a, b, c : Column means within effect with common superscripts do not differ (p>0.05)
[1] number of observations, [2] Least squares means, [3] standard error

Daily weight gain from birth to 120 days of age was 50.87±19,02 g. Birth weight was reported to be 2.0 kg in Criollo kids descendant from other provinces (Stemmer *et al*., 2000) and 2.4 kg in kids from Mizque valley (Campero, 1996); birth weight in the present study was just in between these values (2.2 kg).

Table 2 Twelve hour milk yield in Criollo goats

Dry season				**Rainy season**			
Effect	**Milk yield (g)**			**Effect**	**Milk yield (ml)**		
	n[1]	**LSM[2]**	**SE[3]**		**n[1]**	**LSM[2]**	**SE[3]**
Community				Community			
Mizque Pampa	43	130.41 b	10.94	Mizque Pampa	157	190.18b	8.69
T'hola Pampa	42	84.60 a	12.11	T'hola Pampa	46	103.60 a	14.23
Section of lactation				Kuru Mayu	13	144.16 ab	25.00
1. (16 - 42)	5	201.03 b	29.20	Tipa Tipa	40	218.10 b	15.23
2. (42 - 63)	13	105.38 ab	18.86	Molle Aguada	49	322.14 c	12.94
3. (63 - 84)	16	111.39 ab	16.44	Evaluation period			
4. (84 - 105)	17	113.43 ab	16.07	15th Nov.-15th Dec.	27	149.24 a	18.03
5. (105 - 126)	14	49.63 a	18.04	15th Dec.-15th Jan.	93	232.49 c	0.88
6. (126 - 147)	9	74.17 a	20.88	15th Jan.-15th Feb.	107	209.19 bc	10.45
7. (147 - 210)	11	97.48 a	19.19	15th Feb.-15th Mar.	78	191.64 ab	12.66
Lactation number				Lactation number			
1	16	80.73 a	15.87	1	41	168.77 a	15.10
$\geq$ 2	69	134.28 b	8.06	2	109	189.17 a	10.03
				≥3	155	228.97 b	8.51

a, b, c : Column means within effect with common superscripts do not differ (p>0.05)
[1] number of observations, [2] Least squares means, [3] standard error

Data collection of milk yield (Table 2) was performed in the morning only, so that milk yield is that of 12 hours, approximately. During the dry season, mean was 117,20±75.39 g between days 16 and 210 of

Peer-reviewed paper: 8th International Conference on Goats

lactation; yield in 24 hours would be app. 235 g. Yield in the community of Mizque Pampa wa 35% higher than in T'hola Pampa. During lactation, milk yield reduced to show a minimum in the 5th and 6th period at the end of the dry season and some recovery with the onset of rains in the 7th period. Goats of second or higher lactation number yielded 40% more milk than those of first lactation. Milk yield of 12 hours during the rainy season was 221.90±110.37 ml, and estimated yield in 24 hours 444 ml. In the community of Molle Aguada, yield was significantly the highest among communities. From mid November to mid December, yield was lowest and from mid December to mid January highest. Goats of third and higher lactation yielded more than those of 1st and 2nd lactation. Campero (1996) found lower milk yields than the present study; in two communities of Mizque valley, Criollo goats yielded 320 g/d and 285 g/d, respectively.

Of a total of 404 females, 270 gave birth during the study. The 270 parturitions recorded occurred during the whole year with peaks in June(23%), March (11.5%), April (10.7%), and November (10.0%) and less than 5% each in February, January, and October. Mean body weight at parturition was 26.91±5.14 kg. Mean kidding rate of females older than 1 year was 79.4%. Older goats had higher litter sizes than younger ones. Mortality was high for kids of young primiparous dams but low for dams older than 1 year (12.8%). Kidding rate reported by Campero (1996) was much higher (92%) than in the present study, whereas mean litter size was lower (1.14); the latter trait as reported by PDAR (1992) showed a large range between 1.2 and 1.7 kids/litter. Low mortality rates were also reported by PDAR (1992), Aguilar (1995) and Campero (1996) as 12.0%, 10.8% and 10.5%, respectively.

The predominant production system is subsistence oriented where animal husbandry is integrated with plant production. Several animal species were found per household, small ruminants being the most frequent. 95% of households kept goats together with sheep. Average goat flock size was 22 does and 4 bucks. Main reasons for keeping goats were given as dung (used as fertilizer in potato and maize fields), milk (consumed mainly in the form of soft cheese) and meat. Women and children bear the main responsibility for tending the goats. Problems with goat production were indicated to be lack of fodder (47%), diseases (37%) and predators (13%). The majority of households would like to expand their goat keeping. The integrated production of animals and plants was also stated by Aguilar (1995) for the subsistence oriented goat production system. The important role of women in goat keeping was noted as well in the studies of PDAR (1992), Campero (1996), CEDEAGRO (1997) and Stemmer & Valle Zarate (2000).

Conclusions

The results presented here are part of a more indepth study of the characterization of the Criollo goat in Bolivia and its production system (Altug, 2002). Research findings will help to improve management and breeding of this valuable genetic resource adapted to a difficult environment.

References

Aguilar, A., 1995. Ganaderia campesina en los Andes. Seria tecnica No. 34, AGRUCO, Cochabamba, Bolivia, 55pp.

Altug, T., 2002. Charakterisierung von Criollo-Ziegen in ihrem Produktionsumfeld in den Andentaelern Boliviens. Ph.D-tesis, University of Hohenheim, Stuttgart, Germany.

Campero, J., 1996. Programa Ganaderia y Forrajes. IBTA, Informe Anual Gestion 95/96, Cochabamba, Bolivia.

CEDEAGRO, 1997. Mizque - Diagnostico municipal consolidado de la seccion municipal de Mizque, Bolivia.

CID, 1996. Anuario estadistico del sector rural 1995-1996, La Paz, Bolivia 297 pp.

PDAR, 1992. Proyecto de desarrollo caprino en las provincias Mizque y Campero.Programa Desarrollo Alternativo Regional, C.11, Ejem. 7, Cochabamba, Bolivia.

Stemmer, A. & Valle Zarate, A., 2002. El ganado caprino en Bolivia: Estado actual, sistemas de produccione implicaciones para el mejoramiento genetico. XIV ABOPA, Cochabamba, Bolivia, 21-29.

Stemmer, A. & Valle Zarate, A. 2000. The role of women in goat keeping in Bolivia. Proc. 7th Int. Conf. on Goats, Tours, France, 707-708.

Stemmer, A., Altug, A., Valle Zarate, A. & Ergueta, R., 2000. Rendimientos productivos y caracteristicas fenotipicas de la cabra criolla en Cochabamba - Bolivia. XIII ABOPA, La Paz, Bolivia, 21-29.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Goat production in the smallholder section in the Boane district in Southern Mozambique

W.A. van Niekerk[#] and P.L. Pimentel[*]
Department of Animal and Wildlife Sciences, University of Pretoria, Pretoria 0002, South Africa

Abstract

Results are presented of a study of a smallholder goat production system in the Boane district, southern Mozambique. Goat keepers (n=65) were selected and their goats (Landim breed) (n=770) were recorded and monitored over two years (1993 – 1995). Goat numbers per household were small (9.7) and raised under a traditional management system. Females outnumbered males and most of the male kids were removed from the flock before 9 months of age. Age of first kidding was on average 390 days. Litter sizes varied between 1.44 and 1.87 and the percentage multiple births (54%) corresponded well with reported values. The mortality rate increased proportionally among twins as the number of twin births increased. This study provided a base-line survey of which the information can be used in future projects of this nature.

Keywords: goats, smallholder, productivity, reproduction, production system
[#]Corresponding author. E-mail: willem.vanniekerk@up.ac.za
*Present address: Instituto de Produçã Animal, C.P. 1410, Maputo, Moçambique

Introduction

Interest world-wide in goat production is increasing. According to Wilson (1988), tropical Africa contains one third of the world's goat population. In Mozambique the small ruminant national herd has decreased during the last two decades, due to the long-term war and drought (Tomo & Vaz, 1994). Government estimates (Dinap, 1992) indicated that small ruminants decreased in Mozambique from 466 548 in 1980 to 188 336 in 1992, of which 166 110 were goats and 22 226 sheep. The small ruminants' distribution in Mozambique is related, not only to favourable agro-climatic factors, but also to its socio-economic role in society (Tomo & Vaz, 1994). Results from this study should shed light on flock characteristics and production limitations of the population in Boane district, Mozambique.

Materials and Methods

The study area is located in the Boane district in the Maputo province, Mozambique, between the latitude 26°.02' – 26°.04' south and the longitude 32°.17' – 32°.19' west. The survey and follow up study included four villages of the district, namely: Paulo Samuel Kamkhomba; Umpala; Radio Marconi and Mahilane. These villages were considered to be representative of the social strata of the population as well as of the livestock production in the zone. All goats were of the native Landim breed.

The climate is subtropical, with a monomodal rainfall pattern. The average rainfall per annum is 678mm. January being the wettest month and August the driest month. The rainy season runs from October to April and the dry season from May to September. The annual average temperature is 22.9°C. The highest average temperature is in January (25.6°C) and the lowest during July (17.8°C). The relative humidity does not vary markedly during the year with values between 65% during August/September and 72% in March/April. The vegetation is of a savannah type, with a good potential for extensive grazing. Shrubs and trees consist mostly of *Acacia* spp., *Combretum* spp. and *Colophospermum mopane* (Timberlake, 1985). However, large areas have been cleared for cropping and other areas were affected by bush encroachment dominated by *Dichrostachys cinerea* (PNUD/FAO, 1990).

The data was recorded using D-Base and was analysed by an analysis of variance or, when comparing differences between two specific variable groups, by the chi-square test. Non-parametric techniques were used to compare differences between two specific groups with the use of the Scheffe test, the Kruskal-Wallis test and the Wilcoxon test (Snedecor & Cochran, 1980).

Results and Discussion

The average flock size in the study area was 9.7 goats, which was higher than the average flock size of 7.5 goats per flock in Nigeria (Francis, 1988), 5 goats in Cameroon (Ndamukong *et al.*, 1989) and 8 goats in Ghana (Turkson, 1992). Flock structure and composition by sex and age are presented in Table 1.

Peer-reviewed paper: 8th International Conference on Goats

Table 1 Flock structure and composition of goats (n=663) in the Boane district in Mozambique

Sex	Age 0-8 months (%)	Age 9+ months (%)	Total (%)
Females	26.66	42.02	68.68
Males	23.04	8.28	31.32
Total	49.70	50.30	100

Females clearly outnumbered males in all sections of the population. The greater number of females is in agreement with other studies in Africa (Wilson, 1988; Ndamukong *et al.*, 1989; Reynolds & Adediran, 1994). None of the flocks in this study had castrated males. The majority of male kids were removed from the flock before 9 months of age. The fastest growing males were removed from the flock first, so the remaining males tended to be the slower growing. However, when breeding males were needed, the larger males showing the highest libido were selected for this purpose. Nevertheless, there were flocks without breeding males. Generally only owners of the larger flocks kept bucks. Similar findings were reported by Reynolds & Adediran (1994) in Nigeria.

According to Wilson (1989) concern is often expressed at the poor reproductive performance of African indigenous livestock. The age at first kidding in this study (390 days ± 72) was less than the first kidding age of 693 ± 36 days reported for Landim goats in Mozambique (Wilson *et al.*, 1989). This could be rather due to the type of reproductive management system used than late sexual maturity (McKinnon, 1985). The reproductive characteristics of goats are affected by various genetic and environmental factors (Chiboka *et al.*, 1988). However, very few data exist on the effect of environmental factors on the age at first parturition (Wilson, 1989).

The number of kids per parturition (litter size) produced per female and the percentage of single and multiple births during 1993, 1994 and 1995 are presented in Tables 2 and 3, respectively.

Table 2 Mean litter size for goats in the Boane district, Mozambique from 1993 to 1995

Year	Number of observations	Litter size	SE*
1993	116	1.44	0.49
1994	243	1.87	0.87
1995	175	1.60	0.80

*SE = Standard error

Table 3 Prolificacy of does from 1993 – 1995 in the Boane district, Mozambique

Year	Number of observations	Type of birth (%)				
		Single	Twins	Triplets	Quadruplets	Quindruplets
1993	116	55	45	-	-	-
1994	243	39	41	14	6	-
1995	175	54	37	3	5	1

No significant differences were found and the litter size (between 1.44 and 1.87) in this study and compared well to the litter size of 1.57 to 1.62 kids for Landim goats at Chobela Station (McKinnon & Rocha, 1985). Other indigenous breeds of East- and West-Africa reported to have litter sizes which varied between 1.19 – 1.90, of which the highest been observed in the Boer goat in South Africa (Erasmus *et al.*, 1985; Armbruster & Peters, 1993).

The percentage of does with multiple births in this study (Table 3) (46% - 61%) corresponded well with the 56% reported by McKinnon & Rocha (1985) for Landim goats at Chobela Station. Prolificacy has been reported to be the primary reproductive trait studied that was not directly influenced by management and was rather controlled by genetic and environmental factors (Wilson *et al.*, 1989). The high prolificacy of Landim does has been well documented (Wilson *et al.*, 1989) and seem to be confirmed by the results of this

Peer-reviewed paper: 8th International Conference on Goats

study. The pattern of distribution of mortality among single and multiple births, by number of parities is presented in Figure 1.

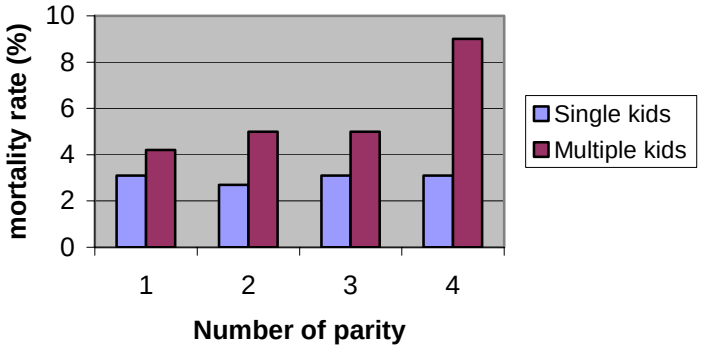


Figure 1 Distribution of the mortality rate among single and multiple kids by parity of Landim goats in the Boane district of Mozambique (1993-1995)

The mortality rate increased proportionally among twins as the number of twin births increased. However, the mortality rate among the single kids remained relatively the same between the first and fourth parity. These findings were, to a certain extent, in contrast to the findings of Chiboka *et al.* (1988) who reported that a higher mortality rate is common in the first parity.

Conclusion

The characteristics of the study area and its people were typical of towns close to urban areas of Maputo Province.There is a high reproductive efficiency in the system, thanks to an early age at first parturition and a large litter size. However, the overall productivity may be considered low, due to the high mortality rate in young animals as well as due to stock theft.

Mismanagement, poor hygiene and precarious housing conditions all contributed to the incidence of disease and high mortality. The early separation of the kids from their dams, no supplementation to lactating does with multiple births and lack of attention to the newborn could also contributed to the high mortality rate among kids.

References

Armbruster, T. & Peters, K.J., 1993. Traditional sheep and goat production in Southern Cote D'Ivoire. Small Rumin. Res. 11, 289-304.

Chiboka, O., Somade, B. & Montsma, G., 1988. Reproduction of West African Dwarf goats – A summary of research work at Ile–Ife, Nigeria. In: Proceedings of the International Workshop on Goat Production in the Humid Tropics. University of Ife. July, 20-24, 1987. Eds. Smith, O.B. & Bosman, H.G., Wageningen. Pp. 125-137.

Dinap (National Livestock Directorate, Mozambique), 1992. Annual Report. Pp. 80.

Erasmus, J.A., Fourie, A.J. & Venter, J.J., 1985. Influence of age on reproductive performance of the improved Boer goat doe. S. Afr. J. Anim. Sci. 15, 5 – 7.

Francis, P.A., 1988. Livestock and farming systems in Southeast Nigeria. In: Proceedings of the International Workshop on Goat Production in the Humid Tropics. University of Ife. July, 20-24, 1987. Eds. Smith, O.B. & Bosman, H.G., Wageningen. Pp. 125-137.

McKinnon, D., 1985. Productive capacity of small ruminants – preliminary results. In: Proceedings of the Livestock Production Seminar, 2-7 December, Maputo. Eds. Jordao, C. & Timberlake, J., Maputo, Mozambique. Pp.156-166.

McKinnon, D. & Rocha, A., 1985. Reproduction, mortality and growth of indigenous sheep and goats in Mozambique. In: "Small Ruminants in African Agriculture". Eds. Wilson, R.T. & Bourzat, D., ILCA: Ethiopia. Pp.154-162.

Ndamukong, K.J.N., Sewell, M.M.H. & Asanji, M.F., 1989. Management and productivity of small ruminants in the North west province of Cameroon. Trop. Anim. Health Prod. 21, 109-119.

Peer-reviewed paper: 8th International Conference on Goats

PNUD/FAO, 1990. Estudo Preliminar do Sistema de Produção na Região do Umbelúzi. Doc. No. 3, Projecto PNUD/FAO/MOZ., Maputo, Moçambique. Pp. 20-24.

Reynolds, L. & Adediran, S., 1994. Composition of village herds in southwest Nigeria. Small Rumin. Res. 13, 49-53.

Snedecor, G.W. & Cochran, W.G., 1980. "Statistical Methods". 7th Edition. The Iowa State University Press. Iowa, USA.

Timberlake, J., 1985. Natural pastures in Mozambique. In: Proceedings of the Livestock Production Seminar. 2 – 7 December Eds. Jordão, C. & Timberlake, J., Maputo, Mozambique. Pp. 81-106.

Tomo, P. & Vaz, Y., 1994. Development of small ruminant production in Southern Africa. Base document for the workshop on the "Orientation of small ruminant production and development in Southern Africa". Kadoma. Zimbabwe.

Turkson, P.K., 1992. The practices and problems of rural women involved in small ruminant production. In: Proceedings of the West African Commonwealth Veterinary Association / Ghana Veterinary Medical Association conference. 7-12 September. Eds. Amanfu, W. & Koney, E.B.M., Ghana. Pp. 20-29.

Wilson, R.T., 1988. Small ruminant production systems in tropical Africa. Small Rumin. Res. 1, 305-325.

Wilson, R.T., 1989. Reproductive performance of African indigenous small ruminants under various management systems: A review. Anim. Reprod. Sci. 20, 265-286.

Wilson, R.T., Murayi, T.H. & Rocha, A., 1989. Indigenous African small ruminant strains with potentially high reproductive performance. Small Rumin. Res. 2, 107-117.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

The influence of age and reproductive status on quality and quantity of cashmere produced by Boer goats under South African conditions

W.A. van Niekerk[#], S. Keva, M. Roets[1*] and R.J. Coertze
Department of Animal and Wildlife Sciences, University of Pretoria, Pretoria 0002, South Africa
[1]ARC-ANPI, Private Bag X2, Irene, 0062, South Africa

Abstract

The aim of this study was to evaluate the quality and quantity of cashmere produced by Boer goats in South Africa. No significant differences were found between reproductive status and qualitative and quantitative characteristics of cashmere produced by Boer goats. Both fibre production and fibre diameter didn't differ between two to three years old and older animals. Boer goats under typical South African conditions, produced a low quantity but good quality cashmere.

Keywords: cashmere, age, reproductive status, production, Boer goat
[#]Corresponding author. E-mail: willem.vanniekerk@up.ac.za
*Present address: P.O. Box 67822, Highveld Park Ext. 12, 0169, South Africa

Introduction

According to Braun (1998) the world demand for cashmere was 12000 ton, while only 8000 ton being produced resulting in a deficit of 4000 ton. There are world wide several goat breeds, rather than a distinct breed, which possess the ability to produce cashmere. This has led to numerous studies in various countries in search of goats that have the ability to produce high quality cashmere, and South Africa is no exception. The objective of this study was to quantify the quality and quantity of cashmere produced by Boer goats at different ages and productive stages.

Materials and Methods

Twenty-four Boer goat females were identified for combing cashmere in 1997 at Mara Research station, Limpopo Province, South Africa. The animals ranged between 3-9 years of age. The females were open or pregnant. The animals were combed every two weeks using a plastic comb during the shedding season (July to September). The total yield of each animal was collected separately in small plastic bags, weighed and analysed for cashmere and total fibre production as well as fibre diameter.

The goats in Mara were kept on natural veld, mainly *Acacia tortilis*, known as sweet veld. In summer the goats mainly selected *Commiphora africana*, forbes and a little bit of grass. In winter the animals selected mainly *Boscia albitrunca* and grass. No supplements were supplied (Du Plessis I., personal communication, 2003, Mara Research Station, Limpopo, South Africa).

The Proc GLM (General Linear Models) procedure by SAS (1994) was used to analyze the data. All main effects (age and reproductive status) and all possible first-order interactions were included in the initial model. Significance of difference between least square means was determined by the Fischer Test (Samuels, 1989).

Results and Discussion

There were no significant differences in cashmere, guard hair, total fibre and fibre diameter between open and pregnant females (See Table 1). This is in contrast to the reports by Zhou *et al*. (2003) who reported a significant effect of pregnancy on fibre production. Corbett (1979) reported that up to 10% and 12% reduction in wool production was due to pregnancy and lactation respectively. Summer & Bigham (1993) suggested that the reduction in production might be due to the higher demand of nutrients for reproduction compared to fibre growth. Kidding during the cashmere-growing season can delay the initiation of the cashmere follicles. For this reason and to prevent fibre losses, kidding should be avoided before moulting or shearing. The other possible reason for the non-significant differences could be that pregnant females tend to have higher intakes which counteract the negativeness of fibre production.

Pattie & Restall (1992) reported significant differences in down weight and diameter with increasing age. The results presented in Table 2 show non-significant effects of age on cashmere and guard hair yield and fibre diameter. Although not significant, total fibre, guard hair and guard hair diameter and cashmere

Peer-reviewed paper: 8th International Conference on Goats

production increased from younger to older animals. This may be due to the high nutrient requirements for growth by young animals or the variance between the body tissues and wool growth (Corbett, 1979). Braker (1997) reported a reduced cashmere but increased guard hair production with age, but Reis (1979) reported a reduction in wool growth with age which correlates with changing patterns of feed intake and diet selection.

Table 1 The influence of reproductive status on yield and diameter of cashmere and guard hair of Boer goats at Mara

Reproductive Status	Total fibre (g)	Cashmere (g)	Guard hair (g)	Cashmere diameter (µm)	Guard hair diameter (µm)
Open	27[a] (±4.5)	23[a] (±4.1)	3[a] (0.7)	12[a] (±0.1)	71[a] (±2.3)
Pregnant	21[a] (±4.8)	15[a] (±4.4)	4[a] (0.8)	11[a] (±0.2)	68[a] (±2.4)

[ab]Column means with common superscripts do not differ significantly (P > 0.05)
(±) = Standard error

Table 2 The influence of age on total fibre, cashmere and guard hair yields of Boer goats at Mara

Age	Total fibre (g)	Cashmere (g)	Guard hair (g)	Cashmere diameter (µm)	Guard hair diameter (µm)
2 – 3 yrs	18[a] (±4.5)	14[a] (±4.1)	3[a] (0.7)	12[a] (±0.1)	69[a] (±2.3)
4 yrs +	30[a] (±4.8)	24[a] (±4.4)	4[a] (0.8)	11[a] (±0.2)	70[a] (±2.4)

[a]Column means with common superscripts do not differ significantly (P > 0.05)
(±) = Standard error

Conclusion

Boer goats in South Africa produced good quality cashmere which is in the acceptable range as recommended by the cashmere industry, but total cashmere production is low. Scientific programs in breeding, selection and nutrition must be followed to optimize production.

References

Braker, M., 1997. Cashmere goat production for the small-holder farmer in South Africa. B.Sc. (Agric) thesis. International Agricultural College 'Larenstein' Deventer (The Netherlands).

Braun, A., 1998. The potential utilization of South African indigenous goats for cashmere production. Proc. Workshop: Research and Training Strategies for Goat Production Systems in South Africa, Hogsback, South Africa.

Corbett, J.L., 1979. Variation in wool growth with physiological state. In: Physiological and Environmental Limitations to Wool Growth. Eds. Black J.L. & Reis P.J. Proceedings of a national workshop, NSW, Australia. The University of New England Publishing Unit.

Pattie, W.A. & Restall, B.J., 1992. Genetical and environmental factors affecting cashmere production. Fifth International Conference on Goats, New Delhi, Volume 2, Part 2: 502 – 512.

Reis, P.J., 1979. Effects of amino acids on the growth and properties of wool. In Physiological and Environmental Limitations to Wool Growth. Eds. Black J.L. & Reis P.J. Proceedings of a national workshop, NSW, Australia. The University of New England Publishing Unit.

Samuels, M.L., 1989. Statistics for life sciences. Collier MacMillan Publishers, London.

SAS, 1994. Statistical Analysis Systems User's Guide. Statistics Version 6. SAS Inst., Inc. Cary, NC., USA.

Summer, R.M.W. & Bigham, M.L., 1993. Biology of fibre growth and possible genetic and non-genetic means influencing fibre growth in sheep and goats. Livest. Prod. Sci. 33, 1-29.

Zhou, H.M., Allain, D., Li, Q.J. Zhang, W.G. & Yu, X.C., 2003. Effects of non-genetic factors on production traits of Inner Mongolia cashmere goats in China. Small Rum. Res. 47(1), 85-89.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Synchronization of estrus in Toggenburg goats during the breeding season

J.F. Fonseca [1#], J.H. Bruschi [2], A.F.A. Santos[3], V.V. Maffili [3], E.A. Moraes [3], R.A. Pontes [3] and C.P. Prosperi [3]

[1]Embrapa Goats, Estrada Sobral/Groaíras, Km 4, CP D10, Cep 62.011-000, Sobral-CE, Brasil.
[2]Embrapa Dairy Cattle Research, Rodovia MG 133, Km 42, 36.155-000, Cel Pacheco-MG, Brasil.
[3]Departamento de Zootecnia, Universidade Federal de Viçosa, Av. P.H. Rolfs, s/n, Brasil, 36.571-000.

Abstract

The objective of this study was to investigate the efficiency of two protocols in synchronizing estrus and fertility in dairy Toggenburg goats during the breeding season. Thirty lactating does were randomly assigned to two treatments (T1 and T2). In T1 (n=15), CIDR was inserted and removed after 6 days and a dose of 22.5 mg cloprostenol was administered via subvulva. In T2 (n=15), CIDR was inserted and removed after 6 days, but 22.5 mg cloprostenol was administered 24h before CIDR removal. After detection of estrus, animals were bred with the aid of a fertile buck (T1=6 and T2=7) or artificially inseminated (T1=8 and T2=7). The percentage of does in estrus was similar for groups T1 and T2 (93.3%). The interval from CIDR removal to the induced onset of estrus did not differ between T1 (40.3±12.0h) and T2 (41.1±9.3h). The duration of estrus was not affected by T1 (43.6±13.4h) or T2 (37.9±13.2h) and the duration of the induced estrus was not influenced by natural breeding (36.5±10.4h) or artificial insemination (44.3±14.9h). The pregnancy rate did not differ between T1 (64.3%) and T2 (64.3%) or natural breeding (64.3%) and artificial insemination (64.3%). During the breeding season, estrus can be efficiently synchronized in lactating does using CIDR plus cloprostenol, independent of the time of cloprostenol administration and acceptable fertility can be achieved with both natural mating and artificial insemination.

Keywords: dairy goats, estrus, prostaglandin, synchronization.
[#]Corresponding author. E-mail: jeferson@cnpc.embrapa.br

Introduction

During the last decade, goats experienced exceptional growth in numbers among farm animals worldwide. This growth was particularly evident in the developing countries (Morand-Fehr & Boyazoglu, 1999). Brazilian researchers have focused in studies on assisted reproduction techniques to increase goat production. In this regard the induction and synchronization of estrus can be very useful.

The synchronization of estrus is important in artificial insemination. There are many techniques to induce and/or synchronize estrus in goats. Induction of estrus can be obtained by the use of natural or synthetic progesterone, with gonadotrophins and prostaglandins. Induction of estrus is generally restricted to the non-breeding season. Synchronization of estrus can be obtained by the use of the same previous associations but during the breeding season it is not necessary to use gonadotrophins, as only progesterone or progestagens associated with prostaglandin, or prostaglandin alone can effectively synchronize estrus. On the other hand, synchronization protocols require a relatively long time of exposure to progestagen or between prostaglandin administrations. In progestagen protocols, prostaglandin is commonly administered 24 to 48 hours before progestagen/progesterone removal wich implies more than one management intervention (Gordon, 1997).

The objective of this study was to investigate the efficiency of short periods of progesterone exposure and time of prostaglandin administration in inducing estrus and the corresponding fertility achieved after natural breeding or artificial insemination in lactating Toggenburg goats.

Material and Methods

This study was carried out in May to July (final third of the local breeding season) in Coronel Pacheco, Minas Gerais - in the southeast region of Brazil. The research unit is located at an altitude of 435 m and 21º35''S and 43º15''W latitude and longitude, respectively, while area receives an average annual precipitation of 1581 mm[3]. The average annual temperature experienced on site is 21ºC.

Thirty lactating Toggenburg does, in their second to fifth lactations, were used in this study. Animals were maintained on intensive pastures, receiving Triturated Napier grass and a protein concentrate according to their nutritional needs. Mineral salt and water were offered *ad libitum*. After reproductive and clinical

Peer-reviewed paper: 8th International Conference on Goats

examinations, does were randomly assigned to two treatments (T1 and T2) groups. The average body weight and body condition score (1 to 5 variation) were 42.3±10.1 and 40.2±8.6 kg and 2.8±0.8 and 2.8±0.8 for T1 and T2, respectively. In T1 (n=15), controlled internal drug release (CIDR-G; Eazi Breed, InterAg, Hamilton, New Zealand) devices containing 0.33 g of progesterone were inserted into the vagina and removed after 6 days followed by a dose of 22.5 μg of a synthetic prostaglandin analogue (cloprostenol; Prolise®, ARSA S.R.L., Buenos Aires, Argentina) administered subvulvarly at the same time of CIDR insertion. In T2 (n=15), CIDR was inserted and removed after 6 days but cloprostenol was administered 24h before CIDR removal. After CIDR removal, does were monitored for estrus three times daily (0600, 1200, and 1800 h).

The does were considered to be in estrus when they allowed to be mounted by bucks. After detection of estrus, animals were bred with fertile bucks or artificially inseminated with frozen-thawed semen (0.25 straw, 100 millions spermatozoa) 12 h after detection of estrus and 12 later if the female was still in estrus.

The following parameters were calculated: (i) percentage of animals in estrus: determined as the number of females in estrus / number of females treated X 100; (ii) interval to estrus - interval (hours) from device removal to time of first estrous identification (onset of estrus); (iii) duration of estrus: induced interval (hours) from time of the first to the last estrous identification; (iv) the pregnancy rate.

Statistical analysis was performed using all tests for statistical significance at the 95% confidence interval. Using the chi-square test compared the percentages of animals in estrus and pregnancy rates. The average interval from device removal and onset of estrus and duration of estrus were submitted to one-way analysis of variance and compared by the SNK-test, using a SAEG program (System for Statistical Analysis; Ribeiro Júnior, 2001).

Results and Discussion

The percentage of does in estrus was the same for T1 and T2 (93.3%). Previous research reported similar results in protocols using gonatrophins and relatively longer times (10 to 18 days) of progestagen exposure. In this study a shorter exposure time to progestagen was used without a loss of estrous response. Additionally, the administration of prostaglandin concomitant to device insertion (T1) reduced the animal stress and management practices.

Estrus was detected from 27 to 57 h after device removal in both treatments. The average interval from device removal to the onset of estrus did not differ (P>0.05) between the T1 (40.3±12.0h) and T2 (41.1±9.3h) groups. Regueiro et al. (1999) reported similar results in dairy goats during the breeding season, using vaginal sponges containing 60 mg medroxyprogesterone acetate (MAP) for a period of 14 days with or without gonatdotrophin (500 IU of equine chorionic gonadotrophin; eCG) at the time of sponge removal. These authors reported that eCG shorten the interval to estrus, but the more animals returned to estrus following eCG treatment than in the control group (62.6% versus 15%). So, during the breeding season the use of eCG not only can be dispensable, but deleterious to fertility too. Nevertheless, the dose of eCG used by referred authors was so long, because efficient protocols with MAP for 6 or 9 days were reported with 200 IU eCG (Fonseca et al., 2002).

The duration of estrus was not significantly different (P>0.05) in the T1 (43.6±13.4h) and T2 (37.9±13.2h) groups. After detection of estrus, animals were naturally bred (T1=6 and T2=7) or artificially inseminated (T1=8 and T2=7), yet the duration of estrus was not significantly (P>0.05) influenced by natural breeding (36.5±10.4h) or artificial insemination (44.3±14.9h) and there was no interaction (P>0.05) between treatments and type of service. The recognized effect of penile introduction and mechanisms displayed by this phenomenon (Romano, 1994a,b) were not able to significantly shorten the duration of estrus.

The pregnancy rate did not differ between the T1 (64.3%) and T2 (64.3%) groups or natural breeding (64.3%) and artificial insemination (64.3%). It attests that both protocols use were equally efficient for both natural breeding and artificial insemination in dairy goats.

Conclusions

During the breeding season, estrus can be efficiently synchronized in lactating does by CIDR plus cloprostenol treatment, irrespective of the time of cloprostenol administration. Acceptable fertility can be obtained following both natural breeding and artificial insemination.

Acknowledgements

Peer-reviewed paper: 8th International Conference on Goats

Authors want to thank Dr Marlene Bruschi from Agropecuária Água Limpa and Tecnopec Ltd. Also the National Council for Scientific and Technological Development (CNPq, Ministry of Science and Technology, Brazil) and Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG) for financial support and Pfizer do Brasil for CIDR® donation.

References

Fonseca, J.F., 2002. Controle e perfil hormonal do ciclo estro e performance reprodutiva de cabras Alpinas e Saanen. Ph.D Thesis, Departamento de Zootecnia, Universidade federal de Viçosa, Laboratório de Reprodução Animal, Viçosa, Brasil.

Gordon, I., 1997. Controlled reproduction in sheep and goats. Cambridge, UK: University Press.

Morand-Fehr, P. & Boyazoglu, J., 1999. Present state and future outlook of the small ruminant sector. Small Rumin. Res. 34, 175-188.

Regueiro, M., Pérez Clariget, R., Ganzábal, A., Aba, M. & Fosberg, M., 1999. Effect of medroxyprogesterone acetate and eCG treatment on the reproductive performance of dairy goats. Small Rumin. Res. 33, 223-230.

Romano, J.E., 1994a. Effects of service number on estrus duration in dairy goats. Theriogenology 41, 1273-1277.

Romano, J.E., 1994b. Effects of different stimuli of service on estrus duration in dairy goats. Theriogenology 42, 875-879.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Physiological responses to preslaughter transportation stress in Tasco-supplemented Boer goats

S. Galipalli, K.M. Gadiyaram, B. Kouakou, T.H. Terrill and G. Kannan#
Agricultural Research Station, Fort Valley State University, Fort Valley, Georgia 31030, USA

Abstract

Tasco seaweed (*Ascophyllum nodosum*) supplementation is known to increase antioxidant activity and immune response in farm animals, but its effects have not been adequately studied in goats. This study was conducted to determine the effects of Tasco feed supplementation on stress responses in transported goats. Mature uncastrated Boer goats were fed an alfalfa pellet diet and a Tasco supplement either with (Treatment) or without (Control) seaweed extract (2% of daily intake) for 8 weeks (n = 16/treatment group). The animals were transported 6 h to impose stress, held in pens overnight without feed, and slaughtered on two different days. Blood samples were collected via jugular venipuncture, before (0 h) and after transportation (6 h), and after overnight holding (24 h) to assess stress responses. Dietary treatment did not influence plasma cortisol, glucose concentrations and creatine kinase (CK) activity. Plasma cortisol and glucose increased due to transportation, but decreased after holding ($P < 0.01$). Plasma CK activities increased during transportation and holding, and peaked at 24-h sampling ($P < 0.01$). Transportation increased neutrophil counts and decreased lymphocyte counts ($P < 0.01$), but did not affect eosinophil and monocyte counts. Tasco feed supplementation did not have any effect on the physiological responses to transportation stress in goats. Transportation stress may have negative effects on immune function in goats.

Keywords: Goats, Stress, Transportation
#Corresponding author. E-mail: govindak@fvsu.edu.

Introduction

Tasco feed supplement, which contains an extract from brown seaweed (*Ascophyllum nodosum*), is known to positively influence antioxidant activity and immune response in farm animals, particularly during stressful situations. Saker et al. (2001) reported that the antioxidant activity of Tasco lowers oxidative stress in cattle.

Meat goats are frequently transported long distances to slaughter facilities before being harvested (Kannan *et al*., 2000). Overnight feed withdrawal prior to harvesting is a common commercial practice, primarily to reduce carcass contamination with gut contents during slaughter. However, transportation and prolonged feed deprivation may increase stress responses and live weight losses (Kannan *et al*., 2000; 2002). The antioxidant nature of Tasco could increase stress tolerance by reducing the effect of toxic oxygen radicals produced during stress.

The effect of Tasco feed supplement on meat goats has not been adequately documented. The objective of this experiment was to determine the effects of Tasco feed supplementation on certain physiological indicators of stress in goats subjected to preslaughter transportation.

Materials and Methods

A feeding trial was conducted using 32 uncastrated Boer goats. Goats were housed in pens (4 bucks/pen) and fed an alfalfa pellet diet supplemented with Tasco either with (Treatment, 4 pens) or without (Control, 4 pens) seaweed extract for 8 weeks. Daily ration contained 40% Tasco supplement and 60% of alfalfa pellets. For the treated group, 2% of daily intake was seaweed extract.

At the end of the feeding trial, goats were subjected to transportation stress on two different days (one week apart) and then slaughtered. Each day, goats from 2 control pens and 2 treatment pens (16 goats) were subjected to a 6 h transportation to impose stress. Goats were held in pens overnight without feed, but with *ad libitum* access to water. Blood samples were collected by jugular venipuncture before (0 h) and after transportation (6 h), and after overnight holding (24 h) to assess stress responses (Time). Blood tubes were placed on ice immediately after collection until plasma was separated. Blood smears were prepared and counted for differential leukocyte profiles as described by Kannan *et al*. (2000). Plasma cortisol concentrations were determined as described by Kannan et al. (2000). Blood glucose and creatine kinase (CK) were analyzed using commercially available kits as described by Kannan *et al*. (2002). The data were

Peer-reviewed paper: 8th International Conference on Goats

analyzed as a Randomized Complete Block Design (RCBD) using GLM procedures (Repeated Measures Analysis) in SAS (SAS, 1995).

Results and Discussion

Treatment or Treatment × Time interaction effects were not significant for any of the blood hormone and metabolite responses (Table 1). Cortisol concentrations peaked after the 6-h transportation and decreased after overnight holding (24 h sampling). The concentrations at 24 h sampling were greater than those at 0 h. This suggests that stress increased due to transport and decreased during holding. However, it is not known whether cortisol concentrations at 6 h were declining after being elevated during transportation, since blood sampling was not done during this 6 h non-stop journey. Cortisol concentrations in cattle decrease as a result of habituation during prolonged or repeated exposure to transportation (Lay *et al*., 1996).

Table 1 Plasma cortisol (ng/mL), glucose (mg/dL) levels and creatine kinase (CK) activities (IU) as influenced by Tasco feed supplementation and transportation stress in Boer bucks

		Blood sampling time			P-value	
Variable	Treatment	0 h	6 h	24 h	Treatment	Time
Cortisol	Tasco	7.6 ± 1.18	31.9 ± 4.30	11.3 ± 2.52	0.98	0.01
	Control	9.5 ± 1.62	27.1 ± 5.93	14.1 ± 3.48		
Glucose	Tasco	60.1 ± 1.89	163.5 ± 17.27	48.2 ± 8.37	0.57	0.01
	Control	58.3 ± 2.60	168.9 ± 23.79	63.2 ± 11.53		
CK	Tasco	138.9 ± 20.08	392.1 ± 91.18	582.7 ± 93.51	0.54	0.01
	Control	129.5 ± 27.67	306.9 ± 125.62	533.9 ± 128.83		

Plasma glucose concentrations increased when measured 6 h after transportation and decreased thereafter. Catecholamines secreted from the sympathetic nerve endings and adrenal medulla induce glycogenolysis in liver and muscle (Nwe *et al*., 1996). Plasma CK activity increased at 6 h, and further increased after overnight holding. Elevation of CK levels at 6 h may be due muscular activities and injuries during loading and transportation, and that at 24 h may be due to agonistic activities during feed deprivation. Feed deprivation tends to increase agonistic encounters, resulting in bruises and muscle damage in goats (Kannan *et al*., 2002).

Table 2 Neutrophil (N) and lymphocyte (L) percentages as influenced by Tasco feed supplementation and transportation stress in Boer bucks

		Blood sampling time			P-value	
Variable	Treatment	0 h	6 h	24 h	Treatment	Time
N (%)	Tasco	56.1 ± 0.60	41.5 ± 0.65	45.1 ± 0.59	0.79	0.01
	Control	56.3 ± 0.83	43.1 ± 0.89	43.9 ± 0.82		
L (%)	Tasco	41.7 ± 0.76	57.4 ± 0.59	53.3 ± 0.61	0.69	0.01
	Control	41.4 ± 1.05	55.9 ± 0.82	53.9 ± 0.83		

Stress affects the immune system of farm animals since both cortisol and catecholamines reduce immunity in animals. Tasco feed supplementation in this study, but transportation for 6 h decreased lymphocyte counts and increased neutrophil counts did not influence the differential leukocyte counts. The same trends continued during overnight holding (Table 2). However, transportation did not affect eosinophil and monocyte counts (not shown).

Peer-reviewed paper: 8th International Conference on Goats

These results are in agreement with our previous observations (Kannan *et al*. 2000) that transportation and feed deprivation for 18 h decreased the lymphocyte counts and increased neutrophil counts and N:L ratio in goats. Tasco feed supplementation has been reported to increase immune function in cattle (Saker *et al*., 2001). In this study, the effect of Tasco was not significant enough to cause changes in the leukocyte profiles of uncastrated Boer goats.

Conclusions

Transportation increased physiological stress responses in goats. Overnight holding without feed decreased stress, but increased muscle damage and/or activity as indicated by elevated CK activity. Tasco supplementation did not influence any of the stress responses, including leukocyte profiles. However, transportation stress may have negative effects on immune function as shown by decreased lymphocyte counts. Goats may become susceptible to infections after experiencing an intense transportation stress.

Acknowledgements

This research was supported by the Agricultural Research Station at FVSU. The authors would like to thank Nealie Moye and Shirley Wang for technical assistance.

References

Kannan, G., Terrill, T. H., Kouakou, B., Gazal, O. S., Gelaye, S., Amoah, E. A. & Samake, S., 2000. Transportation of goats: Effect on physiological stress responses and live weight loss. J. Anim. Sci. 78, 1450-1457.

Kannan, G., Terrill, T. H., Kouakou, B., Gelaye, S. & Amoah, E. A., 2002. Simulated preslaughter holding and isolation effects on stress responses and live weight shrinkage in meat goats. J. Anim. Sci. 80, 1771-1780.

Lay, D. C., Friend, T. H., Randel, R. D., Jenkins, O. C., Neuendorff, D. A., Kapp, G. M. & Bushong, D. M., 1996. Adrenocorticotropic hormone does response and some physiological effects of transportation on pregnant Brahman cattle. J. Anim. Sci. 74:1806-1811.

Nwe, T. Hori, M. E., Manda, M. & Watanabe, S., 1996. Significance of catecholamines and cortisol levels in blood during transportation stress in goats. Small Ruminant Res. 20, 129-135.

SAS, 1995. SAS Institute Inc, SAS/STAT User's Guide. , SAS Institute Inc, Cary, NC.

Saker, K. E. , Allen, V. G., Fontenot, J. P., Bagley, C. P., Ivy, R. L., Evans, R. R. & Wester, D. B., 2001. Tasco forage: II. Monocyte immune cell response and performance of beef steers grazing tall fescue treated with a seaweed extract. J. Anim. Sci. 79, 1022-1031.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Preliminary results on the role of the vomeronasal organ in modulating the response to the buck effect in does

H.J. Jansen van Vuuren[1], K.K. Booth[2] and E.C. Webb[1#]
[1]Department of Animal & Wildlife Sciences, University of Pretoria, Pretoria 0002, South Africa
[2]Department of Anatomy, Faculty of Veterinary Science, University of Pretoria, Pretoria 0002, South Africa

Abstract

The vomeronasal organ (VNO) consists of paired, blind ending tubes, on either side of the nasal septum. The VNO lumen connects to the nasopalatine canal and also to the oral and nasal cavities. The vomeronasal sensory epithelium is connected to the accessory olfactory bulb (AOB). The AOB in turn has a direct link to the hypothalamus. If the VNO and the accessory olfactory system do play a role in the detection of pheromones, females with a non-functional VNO would not be able to detect male pheromones. Therefore, theoretically, no or a very poor endocrine response should be detected in does after the introduction of males during the non-breeding season, while does with a functional VNO are expected to show an endocrine response. The aim of this study was evaluate the role of the VNO in the reproductive responses of does in terms of oestrus behaviour and conception rates subsequent to the introduction of bucks.

The preliminary results, although not statistically significant, supports this hypothesis. Only 20% of does with a non-functional VNO was pregnant while 56% of does with a functional VNO were pregnant after the introduction of bucks during the non-breeding season. Lower concentrations of oestradiol and LH were also observed in treated does compared to the controls.

Keywords: Vomeronasal organ, buck effect, pherhormones, goats
[#]Corresponding author; E-mail: edward.webb@up.ac.za

Introduction

The vomeronasal organ (VNO) consists of a pair of blind ending tubes, situated on either side of the nasal septum (Kratzing, 1971). A neuro-anatomical pathway linking the VNO, accessory olfactory bulb and the hypothalamus has been described (Scalia & Winans, 1975; Raisman, 1972; Kevetter & Winans, 1981). This pathway is distinct from the neural pathway of the main olfactory system, which does not connect to the hypothalamus. The receptors of the sensory epithelium of the VNO seem to be more sensitive to non-volatile substances. This is in contrast with olfactory receptors that show more sensitivity to volatile substances (Wysocki, 1980, Keverne *et al*, 1986). Vomeronasal and olfactory receptors also differ in certain biochemical and functional aspects, which indicates a fundamental difference between odour and pheromone reception (Liman, 1996a; Tirindelli, 1998). Pheromone receptors have only been identified in the VNO, and not in the nasal cavity (Dulac and Axel, 1995, Tirindelli, 1998).

When a ram or buck is introduced to a group of females, the reproductive cycles of these females tend to synchronize. During the non-breeding season, some females may even be stimulated to ovulate and express oestrus. This effect is known as the "buck effect", and is mediated by male pheromones. The physiological effects of the "buck effect" has been extensively investigated and described by various authors but the exact mechanism by which the male stimulus is delivered to the female neuro-endocrine system remains to be accurately described (Rosa & Bryant, 2002; Over *et al.*, 1990).

Flehman has been indicated as a possible mechanism by which stimuli can be delivered to the VNO. It is postulated that during Flehman, airflow over the nasal opening of the nasopalatine canal is manipulated to draw fluids from the nasopalatine canal and the vomeronasal lumen, into the nasal cavity, through a venturi-effect. This is supported by a pumping mechanism within the VNO lumen, which expels vomeronasal fluids into the nasopalatine canal. These fluids are then sucked into the nasal cavity, and replaced by fluids from the oral cavity (Bailey, 1977).

Evidently the accessory olfactory system (AOS), with the VNO as its primary sensory apparatus, seems to be well equipped to receive and transfer male sensory cues to the female endocrine system. The introduction of bucks to a group of does is known to synchronize their oestrus cycles during the breeding season. This is known as the "buck effect" and is mediated through male pheromones and does in the non-breeding season can also be stimulated to ovulate and exhibit oestrus subsequent to the introduction of males.

Peer-reviewed paper: 8th International Conference on Goats

LH is responsible for inducing ovulation. The hypothalamus controls the secretion of LH through the pulsatile release of GnRH, which mediates the secretion of LH from the adenohypophysis. Since the "buck effect" modulates the oestrous cycle in does and stimulates ovulation, it appears that the "buck effect" facilitates the secretion of LH. The "buck effect" is probably mediated through sensory stimuli via the VNO's neural link to the hypothalamus in the doe. If the VNO and the accessory olfactory system do play a role in the detection of pheromones, females with a non-functional VNO would not be able to detect male pheromones. Therefore, theoretically, no endocrine response should be detected in the female after male introduction during the non-breeding season. In contrast, females with a functional VNO would be expected to show an endocrine response to male introduction. An endocrine response can be characterised in the blood levels of LH, FSH and estradiol, and in the conception rate.

Materials and Methods

Nineteen, indigenous does were randomly assigned to a treatment (n=10) and a control group (n=9). The vomeronasal organ of treated does was rendered non-functional by means of cauterisation of the nasopalatine canal. The treated and control or normal does were not separated, but housed away from the bucks. The does were synchronized with two injections of Estrumate (Scherring-Plough Animal Health), 10 days apart. The bucks were introduced on day 32 of the experiment, for 5 days. Blood sampling was done by jugular venipuncture and commenced on day 27 of the experimental period, and continued for ten days. Blood samples were collected twice daily, while samples were collected at 2 hourly intervals for 48 hours around the expected time of oestrus. Blood samples were analysed for estradiol and LH.

Conception rates were used as a preliminary, indirect parameter to assess the response of the does subsequent to the introduction of bucks during the non-breeding season. The does were scanned for pregnancy ten weeks after the bucks were introduced. The data was analysed by means of the ANOVA procedure on SAS (SAS®, 2001). Categorical data was analysed by means of log- linear analysis and multiple comparisons tested by means of the Bonferroni technique for unbalanced data.

Results and Discussion

In the treatment group 20% of the does conceived, while 55.6% of the does in the control group conceived. Although the difference in conception rates only tended towards significance ($P<0.07$), these preliminary results support the hypothesis that the VNO plays an important role in modulating the buck effect, which stimulates oestrus behaviour and ovulation in does. Estradiol concentrations in blood samples from does in the control group (78.515 pmol/L) were numerically higher compared to those in the treated does (75.318 pmol/L), while LH concentrations were higher ($P=0.1$) in the control (0.372 IU/L) compared to the treated does (0.289 IU/L).

These results agree with the initial observations just after the introduction of the rams, suggesting a difference in reproductive behaviour between normal does and does with a non-functional VNO. Most of the control does expressed interest in the males immediately after being introduced, while the vomero-ectomised does did not express any interest in the males. So, signs of overt oestrus activity were more pronounced for does in the control group compared to the treated does, which coincides with the hormone profiles obtained. Similarly the results of the pregnancy diagnosis at 60 days suggest that animals with a non-functional VNO showed less of a response to the buck effect compared to those with a functional VNO in terms of conception rates.

Although rare, spontaneous ovulation in some individuals will occur in seasonal breeders during the non-breeding season, particularly in South African indigenous goats that tend to breed all year round (Webb *et al*., 1998). Also, the animals used were sexually experienced and it is possible that odour (stimuli perceived by the main olfactory system) of the males provided adequate stimulus to induce oestrus in certain experienced individuals. However, if this affected the does in the present study, a higher conception rate was to be expected in the does with a non-functional VNO. The only difference between these does was the functionality of the VNO, so it follows that this organ probably contains receptors that mediate the buck effect.

Conclusions

The preliminary results suggest that the VNO plays a role in modulating oestrus in does, in response to the introduction of bucks or the so-called "buck effect".

Peer-reviewed paper: 8th International Conference on Goats

Acknowledgements and References

Bailey, K., Flehman in the ring tailed lemur (Lemur catta). Behaviour LXV, 309-319.

Dulac, C. & Axel, R., 1995. A novel family of genes encoding putative pheromone receptors in mammals. Cell 83, 195-206.

Kratzing, J., 1971. The structure of the vomeronasal organ in the sheep. Journal of Anatomy 108,247-260.

Kevetter, G.A. & Winans, S.S., 1981. Connections of the corticomedial amygdala in the golden hamster. I. Efferents of the "Vomeronasal Amygdala". J. Comp. Neur. 197, 81-98.

Kevetter, G.A. & Winans, S.S., 1981. Connections of the corticomedial amygdala in the golden hamster. II. Efferents of the "Olfactory Amygdala". J. Comp. Neur. 197,99-111.

Over, R., Cohen-Tannoudji, J., Denhard, M., Claus, R. and Signoret, J.P., 1990. Effect of pheromones from male goats on LH-secretion in Anoestrus ewes. Physiology & Behaviour 48, 665-668.

Liman, E.R., 1996. Pheromone transduction in the vomeronasal organ. Current Opinion in Neurobiology 6, 487-493.

Raisman, G., 1972. An experimental study of the projection of the amygdala to the accessory olfactory bulb and its relationship to the concept of a dual olfactory system. Exp. Brain Res. 14, 395-408.

Rosa, H.J.D. & Bryant, M.J., 2002. The "ram-effect" as a way of modifying the reproductive activity in the ewe. Small Ruminant Research 45, 1-16.

SAS, 2001. SAS Institute, Carey.

Scalia, F & Winans, S.S., 1975. The differential projections of the olfactory bulb and accessory olfactory bulb in mammals. J. Comp. Neur. 161, 31-56.

Tirindelli, R., Mucignat-Caretta, C. & Ryba, N.J.P., 1998. Molecular aspects of pheromonal communication via the vomeronasal organ of mammals. Trends in Neurosciences 21(11), 482-486.

Webb, E.C., Mamabolo, M.J., Du Preez, E.R., and Morris, S.D., 1998. Research and training strategies for goat production systems in South Africa. Proceedings of a workshop held on 22-26. November, 1998. E.C. Webb & P.B. Cronje. pp. 81-87.

Peer-reviewed paper: 8th International Conference on Goats

The use and macro-mineral content of saline water for goat production

B.A. McGregor
PIRVic (Primary Industries Research Victoria), Department of Primary Industries, Attwood, Victoria, 3049, Australia

Abstract

To overcome a lack of data on the use and acceptability of saline water for goats, a survey of saline water use by drought affected goat producers in Australia was completed. The responses (n=31) from all but one contributor indicated that the goats survived on saline water sources without any noticeable problems. The range in the acceptable total dissolved salts (TDS) was (median; minimum; maximum): 2,300; 200; 11,000 mg/l; electrical conductivity (EC) 4,200, 400, 16,000 μS/cm; total alkalinity 240; 0; 550 mg $CaCO_3$/l; pH 7.5; 3.7; 8.5; total P 0.03; 0.01; 0.17 mg/l; total N 1.1; 0.09; 14.0 mg/l; Mg 110; 0; 470 mg/l; Na 560; 50; 3,200 mg/l; Cl 970; 25; 4,600 mg/l. Two producers noted that goats walk past fresh ground water to drink bore water with 11000 mg/l of TDS and survived. One case of saline poisoning was related to water with a TDS of 33,000 mg/l and a Mg concentration of 1,300 mg/l. The application of the results is discussed. Goats can tolerate water with high salinity levels, but they need to be adapted to saline water. Long-term effects of increased saline water intake and elevated trace element exposure in adapted goats should be investigated.

Keywords: water quality, conductivity, total dissolved salts, Mg, mortality
#Corresponding author; E-mail: bruce.mcgregor@dpi.vic.gov.au

Introduction

Provision and quality of water is a constant management issue for goat producers in Africa, Australia, the Middle East and other parts of Asia. Water maybe supplied to livestock from oasis, lakes, rivers, canals, bores, natural soaks, dams or troughs. Water use by animals is related to the liveweight of animals to the power 0.82, as water is used for intermediary metabolism and for evaporative cooling (Wilson 1989). All natural waters contain some dissolved salts, referred to as salinity. Salinity levels are measured directly as total dissolved salts (TDS) and indirectly by EC (electrical conductivity). Over large areas of Australia, the water supply for livestock comes from saline surface or ground water. The provision and quality of saline water is critical for livestock production, especially during periods of drought. For example, during the recent drought in southern Australia, a goat producer experienced the sudden death of three Angora does caused by drinking water with a TDS of 33,000 mg/l and a Mg concentration of 1,300 mg/l. The water originated from a waterhole in a river that had stopped flowing.

As there is little published information on the likely saline and mineral exposure to goats via drinking water (McGregor 2004), a survey of saline water provided to goats in Australia was conducted in 2003.

Materials and methods

Farmers (n=45) were contacted in the area of interest and 31 participated in the survey. They were provided with a water sampling kit with instruction and a brief questionaire. Water samples were returned by post and stored under refrigeration at 4°C. Water testing was conducted at the Ellinbank Water Laboratory, Department of Primary Industries, Ellinbank, Victoria, a NATA Accredited Laboratory. The Test methods follow the standard tests of the American Public Heath Association (Anon 1998). TDS and EC were directly measured as some farmers have equipment to measure EC on their farms. Test results were analysed to determine the mean, median, maximum, minimum and standard deviation in the measurement data. One sample was not included in this analysis as it was associated with the premature deaths described in the introduction.

Results

Samples were received from New South Wales, South Australia, Victoria and Western Australia. The analysed results for the samples are given in Table 1. The responses from all but one contributor indicated that the goats survived on the water sources without any noticeable problems. For example, the contributor of a sample of bore water with 11000 mg/l of TDS and 470 mg/l Mg, stated that "goats walk past fresh groundwater to drink this". Similarly for another sample of bore water (11000 mg/l of TDS, 400 mg/l Mg) the contributor stated that sheep and goats did well. Despite prompting, none of the following symptoms

Peer-reviewed paper: 8th International Conference on Goats

of salt poisoning were reported: watery scour; discharge from nostrils; uncoordinated walking; swellings under the jaw and belly.

Table 1 Mean, median, SD and range in the water test data. TDS: total dissolved solids (180°C); EC: electrical conductivity

	TDS mg/l	EC µS/cm	Hardness mg $CaCO_3$/l	Total Alkalinity mg $CaCO_3$/l	pH	Total P mg/l	Total N mg/l	NO_3-NO_2 mg N/l
Mean	3600	5900	900	250	7.4	0.05	2.20	1.60
Median	2300	4200	540	240	7.5	0.03	1.1	0.25
Minimum	200	400	6	0	3.7	0.01	0.09	0.01
Maximum	11000	16000	3100	550	8.5	0.17	14.0	13.0
SD	3300	4900	860	190	0.9	0.04	3.10	3.00

	Al mg/l	B mg/l	Ca mg/l	Cl mg/l	Cu mg/l	Fe mg/l	K mg/l	Mg mg/l	Mn mg/l	Na mg/l	S mg/l	SAR	Zn mg/l
Mean	2.7	0.75	130	1600	0.10	2.10	32	150	0.19	950	150	14.0	0.12
Median	0.3	0.22	68	970	0.03	0.12	11	110	0.01	560	48	10.0	0.03
Min.	0.1	0.03	2.2	25	0.03	0.01	0.2	0	0.01	51	0.3	2.1	0.03
Max.	62	3.4	520	4600	1.8	19	160	470	2.60	3200	850	42	0.69
SD	11.0	0.96	140	1400	0.31	4.50	49	140	0.54	900	220	10.0	0.20

Hardness is caused mainly by the presence of calcium and magnesium salts and is often observed as a build up of scale on surfaces and in pipes. If water has a hardness of < 100 mg/l (expressed as Ca-carbonate) it is regarded as soft water. Of the submitted samples most were hard as only 4 had < 100 mg/l of hardness. Two bore samples were very acid and five bore samples were alkaline. In these cases corrosion of metal pipes and fittings may occur. Many samples had total N levels (n = 22) and total P levels (n = 11) greater than recommended and 11 samples had high levels of both N and P. This indicates that under typical drought conditions these waters may experience algal blooms. The level of minerals in all but one of these submitted waters must have been within tolerance ranges as no stock mortality and other signs of ill health were reported (although intake was not measured, nor trace element exposure). The exception is that associated with mortality of Angora goats (see introduction). The level of 1300 mg/l of magnesium may have been the cause of death as it is recommended that Mg levels be kept below 600 mg/l (Cummings 2002).

Discussion

Limited evidence suggests that goats have slightly greater tolerances to salt in water compared with sheep. Bell (1959) reported on the thresholds for taste discrimination using British dairy goats. Bell defined the acceptance threshold at the concentration point when the goats showed no discrimination between fresh water and the test solution, ie 40 to 60% of the total fluid intake was the test solution. For salty tastes, at dilutions below the acceptance threshold (1.25 g/100 ml), goats preferred salty water over fresh water. Dunson (1974), Burke (1994) and Abou Hussien et al. (1994) provide useful data on saline water intake by goats. Dunson (1974) and Burke (1990) reported seawater consumption of feral goats on isolated oceanic islands. Burke reported that the conductivity and thus the salinity of water used was identical to that of water from the ocean (EC 51,000 µS/cm). Burke calculated that these goats could produce urine more than twice the osmolarity of seawater, probably enough to allow them to realise a net gain of free water from drinking seawater. It is possible that by drinking seawater it allowed the goats to increase urine volume to enable them to excrete larger amounts of other solutes such as urea. These goats had access to a good supply of browse vegetation with a moisture percentage of 17 to 48. The goats drank from temporary rainwater puddles when available. The goats remained relatively inactive during the day and fed primarily at dusk and dawn.

Abou Hussien et al. (1994) examined the response of bucks (38 kg body weight) and rams (55 kg) to drinking water salinity by increasing the TDS of tap water (260 mg/l) to either 9,500 or 17,000 mg/l. Increasing salinity to 17,000 mg/l increased total water intake of goats by 59% to 376 ml/$kg^{0.82}$ and that of sheep by 99% to 500 ml/$kg^{0.82}$. Increase in water intake was associated with greater urinary water loss and little change in faecal and insensible water loss (sweating, breathing). Intake of water with 9,500 mg/l TDS reduced the dietary intake of sheep but not of goats. Increasing the salt content from 9,500 to 17,000 mg/l TDS reduced the dietary intake of both sheep and goats.

Peer-reviewed paper: 8th International Conference on Goats

Macfarlane (1982) concluded that since most Merino sheep become partly intoxicated by salt at 1.3% (220 m mol/l) in water (Peirce, 1968) and Turkana goats tolerate 1.5% (257 m mol/l) of salt in drinking water that these goats must be more adapted to higher salt loads by having slightly better sodium pumps than sheep. Macfarlane noted that within 4 days of being exposed to saline water there is an induction of NaK ATPase enzymes in the ilium, liver and kidney, which is a powerful adaptive mechanism.

There may be differences between goat breeds in their tolerance to salinity but this survey is not able to provide objective evidence to clarify breed tolerance or palatability differences to salinity. (Table 1 illustrates a range of salinity and mineral content in water supplied to different goat breeds that may provide useful information to breeders during subsequent drought. Cummings (2002) provided guidelines for farmers to use when providing water to livestock. He suggested that water with an EC of < 5800 μS/cm is suitable for all livestock. In the present surveyed, 13 samples had EC of > 5800 but < 16500 μS/cm. These samples are suitable for non-lactating small ruminants and are unsuitable for weaned sheep. Caution is required when providing such water to lactating small ruminants. EC levels > 16500 up to 25000 μS/cm are suitable for non-lactating stock and EC levels > 25000 μS/cm are not recommended for livestock.

The evidence from the literature (McGregor 2004) suggests that goats adapted to water of high EC can grow and lactate when water as concentrated as seawater (EC about 50,000 μS/cm) is used provided adequate green herbage and shade is available. However, non-adapted goats do not perform well when high EC water is provided and in drought situations adequate green herbage will not be available. For goats adapted to saline water it appears that in all but one situation, it would have been possible for contributors to the survey to provide water of higher salinity level up to a maximum of 25000 μS/cm to adult dry goats during drought feeding. During drought, goat producers should monitor the salinity of their water supply, particularly farm dams. Test results should be checked against the tables of recommended water quality guidelines and with the data in this report. When water is purchased or goats are transferred to an unknown water source, the water quality should be checked. As goats grazing unshaded dry pastures in Australia consume 50% more water than Merino sheep (104 ± 4 ml/$kg^{0.82}$/day compared with Merino sheep: 70 ± 3 ml/$kg^{0.82}$/day, McGregor, 1986) drought affected goat farmers need to frequently monitor water quality, water use and water supplies.

Conclusions

All but one of the water samples tested was suitable for goats when livestock production is expected to be low or zero. Goats safely used saline water with up to 11,000 mg/l TDS and 470 mg/l Mg. It appears goats can tolerate water with high salinity levels and prefer water with up to 12,500 mg/l over fresh water but they need to be adapted to saline water. Evidence of the ability of goats to survive on seawater was found and in all circumstances the goats were adapted and had access to shade and moist herbage. During drought, goat producers should monitor the salinity of their water supply, particularly new sources of water. Long-term effects of increased saline water intake and elevated trace element exposure in adapted goats should be investigated.

Acknowledgments

The Rural Industries Research and Development Corporation, colleagues and participants are thanked.

References

Abou Hussien, E.R.M., Gihad, E.A., El-Dedawy, T.M. and Abdel Gawad, M.H., 1994. Response of camels, sheep and goats to saline water. 2. Water and mineral metabolism. Egyptian Journal of Animal Production 31: Supplement Issue November 387-401.

Anonymous, 1998. Standard Methods for the Examination of Water and Wastewater. 20th Edition. Ed. Lenore S. Clesceri; Arnold E. Greenberg & Andrew D. Eaton. Published by 'American Public Health Association', 'American Water Works Association' and 'Water Environment Federation': Washington DC.

Bell, F.R., 1959. Preference thresholds for taste discrimination in goats. J. Agric. Sci., 52, 125-128.

Burke, M., 1990. Seawater consumption & water economy of tropical feral goats. Biotropica, 22, 416-419.

Cummings, D., 2002. Water quality for farm water supplies. Landcare Note LC 0089, 3pp. Department of Natural Resources and Environment, Melbourne.

Peer-reviewed paper: 8th International Conference on Goats

Dunson, W.A., 1974. Some aspects of salt and water balance of feral goats from arid islands. American J. Phys., 226, 662-669.

Macfarlane, W.V., 1982. Concepts in animal adaptation. Proceedings of the 3rd International Conference on Goat Production and Disease: 375-385. Dairy Goat Publishing Co., Scottsdale, USA.

McGregor, B.A., 1986. Water intake of grazing Angora wether goats and Merino wethers. Australian Journal of Experimental Agriculture, 26, 639-642.

McGregor, B.A., 2004. Water quality and provision for goats. Research Report No 04/036. Rural Industries Research and Development Corporation, Barton, ACT, Australia.

Peirce, A.W., 1968. Studies on salt tolerance of sheep. VIII The tolerance of grazing ewes and their lambs for drinking waters of the types obtained from underground sources in Australia. Aust. J. Agric. Res., 19, 589-595.

Wilson, R.T., 1989. Ecophsiology of the Camelidae and desert ruminants. Springer-Verlag: Berlin, 120 pp.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Exposure assessment of potentially toxic trace elements in indigenous goats in the rural communal production systems of the Northern Region of South Africa

J A Meyer[1*] and NH Casey[1]
[1]Department of Animal and Wildlife Sciences, University of Pretoria, Pretoria 0002, South Africa

Abstract

Recent advances in analytical techniques have allowed hydro-geochemical databases to form an essential component of animal and human epidemiological studies. Geographically localised communities and livestock production systems have a higher incidence of risk factors, and therefore baseline concentrations of key health elements are required to assess the quality of the water. Risk assessments conducted for drinking water for indigenous goats in rural communal livestock production systems for three separate communities found several trace elements (As, Br, Cd, F, Pb, Hg, Mo and Se) occurring as localised anomalies in the aquatic environment at concentrations exceeding local and international guidelines (at times by several orders of magnitude). The watering points assessed are capable of contributing significantly to the mineral requirements of the indigenous goats thus exposed. Potential hazards were identified that impact on the norms of health, palatability and product quality for human consumption. Hydro-geochemical correlations were noted that increase both the risk associated with exposure and the likelihood of incomplete diagnosis of mineral related disorders. Recommendations are also made with regard to a programme monitoring water quality and the need to include water chemistry when formulating rations, mineral supplements and diagnosing disorders or diseases, across different production environments.

Keywords: water quality, geochemistry, indigenous goats, toxicology
*Corresponding author; E-mail: jmeyerc@mweb.co.za.

Introduction

Groundwater is a major water source in rural communities in South Africa, with over 280 towns relying on subterranean water. Research conducted for the Water Research Commission of South Africa (WRC) regarding livestock production systems for rural communities observed the presence of potentially hazardous chemical constituents (PHCC) in groundwater used for livestock and human consumption (Casey *et al*., 1998; Casey & Meyer, 2001). Investigations into PHCC in rural groundwater supplies occurred concurrently with the development of software-driven, risk assessment models for water quality guidelines applicable to multiple livestock species and shared domestic exposures typical within the rural context (Casey & Meyer 2001). This paper presents concerns raised by tier 1 generic risk assessments applicable to the norms affecting indigenous goat production in rural communities.

Materials and Methods

Point-of-use samples were collected from groundwater utilized by indigenous goats and domestic users in three separate communities in the Northern Region of South Africa, namely the Immerpan Resettlement District, Jericho District, and the Rietgat and Hartebeeslaagte District, situated on the eastern periphery, central, and western periphery of the Bushveld Igneous Complex, respectively. Following chemical analyses by ICP-AES techniques using full quantitative and semi-quantitative procedures (ISCW, 2001), generic level risk assessments were conducted using constituent ingestion rate risk assessment software (CIRRA Version 1.03 developed for the WRC) (Casey *et al*., 1998; Casey & Meyer, 2001). Results are presented according to recognized stochastic water quality constituents (WQC) variables where:

PHCC (Potentially hazardous chemical constituent): Indicates that exposure to the (WQC) in question is likely to result in adverse effects. Exceeds the Department of Water Affairs and Forestry (DWAF, 1996) guideline, or the internationally recommended upper guideline limit (WHO, 1996; USEPA, 1998).

COC (Constituent of Concern): Observed within 10% of the PHCC guideline, and indicates that the WQC in question could conceivably become a PHCC due to concentration variations, such as seasonal fluctuation in the water source or evaporative effects, and should therefore be monitored.

Results and discussion

Table 1 presents the point prevalence observations for the generic risk assessments for the three districts. Some of the associations of PHCC recorded within a district may be explained to some extent by

Peer-reviewed paper: 8th International Conference on Goats

known geochemical correlations, whilst others are probably influenced to a greater extent by agricultural practices and Eh and pH conditions in the water delivery system. Apart from the Immerpan District where high TDS values resulted in high sodium and chloride concentrations, the majority of the PHCC recorded are associated with trace element geochemistry. This accords with findings of other workers in the field of geochemistry and epidemiology (Mills, 1996). From Table 1, the elements with well-documented toxico-dynamics and toxico-kinetics that are of concern include arsenic, cadmium, fluoride, lead, mercury and selenium. Uncertainty regarding either the toxicity, or physiological significance, from drinking water exposure exists for antimony, beryllium, bromide, strontium, tellurium, thallium and titanium.

Table 1 Point prevalence of potentially hazardous chemical constituents (PHCC) and constituents of concern (COC) in the drinking water of indigenous goats in three rural communities in the Northern Region of South Africa.

Water Quality Constituent	Potentially Hazardous Chemical Constituents*			Constituents of Concern*		
	Immerpan District (n = 16)	Jericho District (n = 41)	Rietgat & Hartebeeslaagte District (n = 16)	Immerpan District (n = 16)	Jericho District (n = 41)	Rietgat & Hartebeeslaagte District (n = 16)
Antimony	-	M	-	-	-	-
Arsenic	H	I	-	-	-	-
Beryllium	-	H	-	-	-	-
Bromide	H	H	H	-	-	-
Cadmium	-	H	-	-	I	-
Chloride	H	-	-	-	-	-
Chromium	-	I	-	-	I	-
Fluoride	H	I	-		I	-
Lead	-	M	-	-	I	-
Manganese	-	H	-	-	-	-
Mercury	-	M	M	-	-	-
Molybdenum	-	M		H	I	-
Nickel	-	-	I	-	-	I
Nitrate	-	-	-	-	-	I
Selenium	H	H	I			I
Sodium	H	-	-	-	-	-
Strontium	-	-	-	H	H	H
Tellurium	M	M	-	-	-	-
Thallium	H	H	-	-	-	-
Titanium	H	I	-	-	-	-
TDS**	H	I	-	-	I	-
Uranium	-	I	I	-	I	-
Vanadium	-	-	I	-	-	-
Zinc	-	-	-	-	-	H

*Where, n = number of watering points observed, and H = high (PHCC or COC > 66% of n), M = medium (PHCC or COC >33% but <66% of n), I = isolated (PHCC or COC < 33% of n), - = no observed PHCC or COC.
** TDS = total dissolved solids (electrical conductivity)

The observations of anomalously high concentrations of essentially toxic elements may be considered to be congruous with associated geology, and furthermore, may result in adverse effects in indigenous goats for the recognized norms of health, palatability and product quality. Implications of water chemistry for environmental exposure and clinical applications have been demonstrated in beef cattle with regard to selenium and lead in an area to the south of the Immerpan District (Elsenbroek *et al*., 2003). The high maximum values observed for many of the constituents are depicted in Table 2, and highlight the requirement to progress from PHCC assessments to dose-based estimates of risk. Site-specific risk factors may ameliorate or exacerbate toxicity in indigenous goats following exposure. Concurrent exposure to multiple PHCC in the drinking water may cause additive to infra-additive biological effects that can include potentiation. These influence animal health directly through drinking water, and may also impact human health indirectly via adverse livestock product quality. Water for domestic use (drinking, food preparation and bathing) and agricultural use (animal watering, and irrigation of household crops) constitutes a multiple-exposure pathway with limited dietary dilution. High doses (concentration and environmentally based) coupled with repeated exposure typical of the rural communities studied increase the risk of cellular injury. Many PHCC identified in the communities are stored by binding to fat and negatively charged, sulphur-containing groups of proteins, thereby altering receptor structure and function and causing cellular or tissue dysfunction. Many PHCC are also class A, B, or C carcinogens (IARC, 1987).

Peer-reviewed paper: 8th International Conference on Goats

Table 2 Main potentially hazardous chemical constituents (PHCC) and constituents of concern (COC) identified from 41 water samples in villages in the Jericho District – Northern Region of South Africa.

WQC	PHCC	COC	Average (mg/L)	SD (mg/L)	Median (mg/L)	Guideline (mg/L)	Range (mg/L)	
							Min	Max
As	8	0	0.039	0.074	0	0.01	0	0.288
Br	35	0	0.261	0.176	0.275	0.01	0	2.292
Cd	30	1	0.046	0.045	0.038	0.005	0	0.186
Cr	4	15	0.039	0.072	0.019	0.05	0.003	0.329
F	11	1	1.087	0.747	0.53	1	0.01	7.77
Hg	28	0	0.118	0.116	0.082	0.001	0	0.444
Pb	24	1	0.026	0.024	0.021	0.01	0	0.090
Mn	35	0	0.35	0.61	0.15	0.4	0.01	2.76
Mo	20	5	0.055	0.052	0.049	0.02	0	0.204
Se	30	0	0.752	0.685	0.711	0.02	0	2.292
Ti	12	0	0.433	1.025	0.1	0.1	0.033	4.531
TDS	8	4	294.3	200.5	251	500	63	805
Sr	0	32	0.254	0.268	0.149	0.1	0.034	1.137
U	12	4	0.016	0.016	0.011	0.02	0	0.068

Although PHCC toxicities are described by quantitative structure-activity relationships, allowing for predictable responses from chemical exposure, many expressions of toxicity are generic, with low-dose, long-term exposure characteristic of the rural communities. These are also more relevant, causing subclinical responses to exposure, with adverse effects primarily attributed to chronic, secondary induced deficiencies. A major challenge is to adequately define the criteria for identifying these disturbances and detecting the primary toxicity. Although effects tend to be non-specific, they have significant impacts on health and productivity. An additional concern is that some PHCC have the ability to produce adverse, long-term effects through mobilization after exposure has ceased (e.g. Lead). The localised nature of the causative geochemical anomalies poses a challenge to community epidemiologists, animal scientists and veterinarians because of the difficulty in establishing a clinical reference point. The cumulative nature of the observed PHCC highlights the need for water quality monitoring, linked to clinical biochemistry and pathological investigations, as a vital means for using retrospective identification of causative factors in proactive risk management. The use of animals to monitor biochemical trends is of great value in this regard. It follows that the indigenous goat, due to the shared exposure, economical importance, and as a food source for humans, may serve as an ideal animal model that can be used to obtain rapid evidence critical to community epidemiology, thereby constituting an integral part of rural public health.

Acknowledgements
The authors thank the Water Research Commission of South Africa for financial assistance.

References

Casey, N.H., Meyer, J.A. & Coetzee, C.B., 1998. An investigation into the quality of water for animal production livestock production with the emphasis on subterranean water and the development of a water quality guideline index system. Volume 2: Research results. Report to the Water Research Commission. WRC Report No: 644/2/98. ISBN No: 1 86845 380 4.

Casey, N.H. & Meyer, J.A., 2001**.** An extension to and further refinement of a water quality guideline index system for livestock watering Volume 1. Rural Communal Livestock Production Systems and Wildlife Production. Report to the Water Research Commission. WRC Report No: K5/857/1/00.

Elsenbroek, JH, Meyer, JA & Myburgh J. 2003. Haemorrhagic diarrhoea and reproductive failure in Bonsmara cattle resulting from anomalous heavy metal concentrations in soils, forages and drinking water associated with geochemical anomalies of toxic elements on the farm Puntlyf, South Africa. *J. Phys. IV France* 107 409-413.

IARC, 1987. Overall Evaluations of Carcinogenicity. IARC Monographs on the Evaluation of Carcinogenic Risks, An Updating of International Agency on Research of Cancer Monographs, Vols 1 to 42, Suppl. 7, International Agency of Research on Cancer.

Mills, C.F., 1996. Geochemical aspects of the aetiology of trace element related diseases. In: Appleton, J D, Fuge, R and McCall, G J H (eds) 1996. *Environmental Geochemistry and Health.* Geological Society Special Publication No. 113, 2-6.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Protein supplementation, body condition and ovarian activity in goats - Preovulatory serum profile of insulin

C. A. Meza-Herrera[1,3,#], J. M. Sánchez S.[1], J. G. Chávez-Perches [2], H. Salinas [3], M. Mellado [4]

[1] Unidad Regional Universitaria de Zonas Aridas. Universidad Autonoma Chapingo. Mexico.
[2] Radiodiagnóstico y Ultrasonografía. Mexico.
[3] Instituto Nacional de Investigaciones Forestales, Agricolas y Pecuarias. Mexico.
[4] Universidad Autonoma Agraria Antonio Narro. Mexico.

Abstract

This study evaluated the effect of by-pass protein supplementation level (PSL) and body condition (BC) upon ovarian activity and serum insulin (INS) concentrations in goats. Goats (n=32, 19 mo.), with a BC either low (LBC, n=16, 28.81±0.72 kg BW, BC= 2.1±0.3), or high (HBC, n=16, 35.12±0.72 kg, BC=3.2±0.3) received one of two PSL's: Without protein (NPROT, 0 g goat d^{-1}) or Protein (PROT, 120 g goat d^{-1}) during a 40-d preovulation period. Once estrually synchronized, blood samples were collected during the middle follicular phase at 60 min intervals during a 6-h period to quantify serum INS. During the late luteal phase (post-ovulation), total ovarian activity (TOA) was evaluated by transrectal ultrasonographic scanning, considering the total number of follicles (FT) and corpus luteum (CLT). While BC affected ($P<0.05$) CLT, favoring to the HBC group (2.81±0.20 *vs* 1.87±0.20), no differences occurred between BC with respect to FT (2.43±0.25 *vs* 2.18±0.25). While PSL affected CL and FT, favoring to the PROT-goats (2.62±0.21 *vs* 2.06±0.21, and 2.68±0.25 *vs* 1.92±0.17, respectively), the HBC goats had the largest serum INS levels (1.92±0.17 *vs* 0.81±0.17 ng mL^{-1}), and the supplemented goats also depicted an increased serum INS level with respect to the non supplemented goats. There was observed a positive correlation between serum INS levels and CLT (r=0.46; P=0.06) and FT (r=0.38, P=0.1). Both the static effect (live weight-body condition) and the dynamic effect (by-pass protein supplementation) of nutrition, promoted a metabolic status characterized by high insulin levels, and an increased ovarian activity.

Keywords: Goats, by-pass protein, body condition, ovarian activity, insulin**.**
[#]Corresponding author. E-mail: cmeza2000@hotmail.com

Introduction

While there is a paucity of data regarding the effect of protein supplementation in goats with different metabolic statuses, knowledge on nutritional and reproductive strategies can help to maximize overall production efficiency. Changes in metabolic fuel availability and associated endocrine status are important determinants in the signaling the metabolic status to the reproductive axis. In fact, some metabolic hormones such as insulin could act as the signaling link between the metabolic status and reproductive function. Nutritional deficiencies or shortcoming on dietary protein are related in humans to low serum insulin levels and, consequently, hypoglycemia (Picarel–Blanchot *et al.,* 1995). In fact, animals in negative energy balance are characterized by hypoinsulinemia (Whitaker *et al.,* 1993). In rats, insulin stimulates GnRH release, keeps normoglycemia and provokes FSH secretion, the pulsatility of LH, as well as luteal progesterone secretion (Arias *et al*., 1992). Nutritionally induced changes in the serum insulin level are strongly related to the IGF-1 and IGF-2 plasma concentrations, with increases in IGF-1, as well as to a concurrent increase in the steroidogenic ability of ovarian follicles (Spicer & Echternkamp, 1993). The aim of this study was to evaluate the effect of by-pass protein supplementation and body condition (BC) on ovarian activity and on serum insulin (INS) concentrations as well as to determine their possible relationship in goats.

Material and Methods

The study was carried out at the Southern Goat Research Unit of the Regional Universitary Unit for Arid Lands-Chapingo Autonomous University, Bermejillo, Durango, Mexico. The Unit is located at 103° 36' WL, 25° 53' NL, at 1, 117 meters above sea level. Annual averages for temperature and precipitation were 20°C, and 242.2 mm, respectively. After a 40-d adaptation period, crossbreed goats (Saanen-Alpine x Criollo, n=32, 19 mo) were weighed at weekly intervals (BW, kg) and body condition scored (BCS, 1=very

Peer-reviewed paper: 8th International Conference on Goats

thin, 5=very fat (Russel *et al*., 1969). The 16-heaviest goats received 1 kg of alfalfa hay per goat (14.6% PC) while the lighter 16 goats, besides 1.0 alfalfa hay per goat received 100 g of crushed corn with weekly increases up to 200 g in six weeks. Thereafter, the goats in the low condition (LC, n=16, 28.4 ± 0.78 kg) and high condition (HC, n=16, 35.6 ± 0.78) groups received a basal diet alfalfa hay to cover 70 and 100 % of the nutritional requirements, respectively. Both BW and BCS between groups differed (P<0.01) at the end of the adaptation period.

Thereafter, goats were randomly assigned, within body condition to one of the two by-protein supplementation levels (PSL): Without protein (NPROT, 0 g goat d^{-1}) or With protein (PROT, 120 g blood meal, goat d^{-1}) during 40-d pre-ovulation. The experimental design considered a 2 x 2 factorial arrangement of treatments, with two body condition levels (LC & HC) and two by-pass protein supplementation levels (NPROT & PROT). Goats received a basal diet of alfalfa hay (2.0% BW, 14.6% CP), mineral salts, water and shades, during the whole experimental period (40d) under natural photoperiod conditions prevailing in August and September at this latitude.

Goats were estrually synchronized with two $PGF_{2\alpha}$ injections, two days apart. A total of 16 goats, were randomly selected to perform an intensive blood sampling. Blood was collected via jugular venipuncture into 10 mL sterile vacutainer tubes (Corvac, Sherwood Medical St. Louis, MO) at 60 min intervals during a 6 h period. A total of 7 samples per goat, 28 samples per treatment and 112 blood samples accross the experiment were collected. Blood was allowed to clot for 30 min at room temperature and then centrifuged at 1500 x *g* for 20 min. Serum was then decanted into polypropylene vials and stored at -20°C. Concentrations of INS were determined by RIA in all the samples collected during the experiment having a intra-assay CV of 6.2 % (Hoefler & Halford, 1987). During the late luteal postovulation phase, total ovarian activity (TOA) was evaluated by transrectal ultrasonographic scanning, using a 7.5 Mhz linear transducer for veterinary use (Toshiba Medical System, Ltd, Crawley, UK). The considered ovarian variables included the total follicle number (TF), the total corpus luteum number (CL) as well as total ovarian activity (TOA=TF + CL).

The variables BW, BC, and TOA, were evaluated by ANOVA having a completely random design with a 2 x 2 factorial arrangement of treatments (Snedecor & Cochran, 1967). Serum insulin profile was analyzed by split-plot ANOVA for repeated measures on animals across time (Gill & Hafs, 1971). In the event of significant treatment differences, comparisons among least square means were performed using the PDIFF option of the PROC GLM-SAS. Correlation analyses were conducted by the Pearson´s Product Moment Test, when appropriate. All the analyses considered the procedures of SAS (Littlel *et al*., 1991).

Results and Discussion

While BC affected (P<0.05) CLT, favoring to the HBC group, (2.81±0.20 *vs* 1.87±0.20), there were no differences between BC with respect to FT (2.43±0.25 *vs* 2.18±0.25). Protein supplementation level affected the expression of both CL and FT, favoring the PROT-goats (2.62±0.21 *vs* 2.06±0.21, and 2.68±0.25 *vs* 1.93±0.25, respectively). While the HBC goats had the largest serum INS levels (1.9±0.2 *vs* 0.8±0.2 ng mL^{-1}) the supplemented goats recorded the highest serum INS levels compared to the non supplemented goats (Table 1). A positive correlation between serum INS levels and CLT (r=0.46; P=0.06) and FT (r=0.38; P=0.10) was observed.

In this study, serum INS levels were affected by both BCS and the PSL. According to Petters & Mayer (1993), protein supplementation acts as a potent stimulator on INS secretion. Muturi *et al.* (2002) evaluated the effect of low and high levels of by-pass protein upon plasma glucose, IGF-1 and INS. While no differences were observed on plasma IGF-1 levels, glucose concentrations differed (P<0.05) at the 60, 90 and 120 min post-feeding, and high protein supplementation affected (P<0.05) the plasma insulin concentrations. Animals in negative energetic balance display high blood levels of GH and NEFA´s and low concentrations of IGF-1, insulin, and glucose (Whitaker *et al.,* 1993). Serum insulin concentration during middle lactation in animals in a positive energy balance was close to 2.5 ng mL^{-1}, while in negative energy balance during early lactation it was found to be around 0.5 ng mL^{-1}. Therefore, glucose has shown to positively affect ovarian function highlighting the role that insulin could play in that process as the main regulator of glucose levels and, in turn, in the process of ovarian follicular growth (Williams *et al*., 1997).

Peer-reviewed paper: 8th International Conference on Goats

Table 1 Least square means for body weight (BW), body condition score (BCS), total ovarian activity (TOA), and serum insulin cocnetrations (INS) during the late follicular phase in goats in northern Mexico (25 ° LN) [1]

	Body Condition			Protein Level [2]			
Variables	Low	High	OSL [3]	Wihout	With	OSL	SE [4]
BW, kg	28.7	38.4	0.01	32.5	34.6	0.15	1.02
BCS, number	2.1	3.2	0.01	2.5	2.6	0.55	0.31
TOA, number	3.9	5.2	0.01	4.0	5.1	0.01	0.32
INS (ng mL^{-1})	0.81	1.93	0.01	1.04	1.69	0.01	0.18

[1] Since no simple effects interaction occurred, least square main effects are reported.
[2] Protein Level: Without (0 g goat d^{-1}), With (120 g goat d^{-1}).
[3] Observed significance level.
[4] SE, standard error of lsmeans.

Almeida *et al.* (2001) reported increased ovulation rate in nutritionally restricted females who received exogenous insulin promoting increases in the pulsatility of E2 and LH, diminishing follicular atresia, increasing the number of follicles of the preovulatory pool and augmenting ovualtion rate. In the long term, nutrition level determines both body weight and body condition, while in the short-term it is related to an increased level of nutrients at intracellular level, stimulating the release of gonadotropic hormones or acting directly in the ovary by increasing its metabolism and function (Cox *et al.,* 1987).

Conclusions

Both the static (body weight, body condition) as well as the dynamic (by-pass protein supplementation) effect of nutrition in 19-mo goats generated a metabolic status characterized by high levels of serum insulin which in turn was positively correlated with an increased ovarian activity. Results suggest that high serum insulin levels may have prevented follicular atresia and enhanced ovarian activity in both the high body conditioned and the by-pass protein supplemented goats, possibly in a route independent of increases in GnRH-gonadotropins. The better understanding of the interactions between nutrition and reproduction will contribute to enhanced reproductive efficiency of breeding goat herds through the development of optimal nutritional management strategies.

References

Almeida, F.R.C.L., Mao, J., Novack, S., Cosgrove, J.R. & Foxcroft, G.R. 2001. Effects of different patterns of feed restriction and insulin treatment during the luteal phase on reproductive, metabolic, and endocrine parameters in cyclic gilts. J. Anim. Sci., 79, 200-212.

Arias, P., Jarry, H., Leonhardt, S., Moguilevsky, J. & Wuttke, W. 1993. Estradiol modulates the LH release response to N-methyl-d-aspartate in adult female rats: studies on hypothalamic luteinizing hormone-releasing hormone and neurotransmitter release. Neuroendocrinology 57, 710–715.

Cox, N.M., Stuart, M.J., Althen, T.G., Bennet, W.A. & Miller, H.W. 1987. Enhancement of ovulation rate in gilts by increasing dietary energy and administering insulin during follicular growth. J. Anim. Sci., 64, 507-516.

Gill, J.L. and Hafs, H.D. 1971. Analysis of repeated measurements of animals. J. Anim. Sci. 33, 331.

Littel, R. C., Freund, R.J. & Spector, P. 1991. SAS System for Linear Models, Third Edition, Cary, NC., SAS Institute INC.

Muturi, K.N., Birnie, L.M., Struthers, J., Wheelhouse, N.M. and Lomax, M.A. 2002. The effect of rumen protected protein on plasma insulin, IGF-1 and glucose in sheep. University of Aberdeen. UK. http://www.bsas.org.uk/meetings/annlproc/PDF99/163.pdf

Peters, A.L. & Mayer, B.D. 1993. Protein and fat effects on glucose responses and insulin requirements in subjects with insulin-dependent diabetes mellitus. Am. J. Clin. Nutr., 58, 555-560.

Peer-reviewed paper: 8th International Conference on Goats

Picarel-Blanchot, F., Alvarez, C., Bailbe, D., Pascual-Leone, A.M. & Portha, B. 1995. Changes in insulin action and insulin secretion in the rat after dietary restriction early in life: influence of food restriction *vs* low-protein restriction. Metabolism. 44, 1519–1526.

Snedecor G.W. & Cochran, W.G. 1967. Statistical Methods. (6th Ed.). The Iowa State Univ. Press, Ames.

Spicer, L.J., Alpizar, E. & Echternkamp, S.E. (1993). Effects of insulin, IGF-1 and gonadotrophins on bovine granulose cell proliferation, progesterone production *in vitro*. J. Anim. Sci. 71, 1232-12421.

Whitaker, D.A., Smith, E.J., Rosa, G.O.D. & Kelly, J.M. 1993. Some effects of nutrition and management on the fertility of dairy cattle. Vet. Rec. 133, 61-64.

Williams, S.A., Yaakub, H., O'callaghan, D., Boland, M.P. and Scaramuzzi, R.J. 1997. Ovulation rate in ewes infused with glucose. J. Reprod. Fert., 109, 57-63.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Thermoregulation and reproductive performance of British Anglo Nubian and Saanen goats reared in an intensive system in Trinidad

I. Paul[1], G. Bourne[2] and C. H. O. Lallo[3#]
[1]Ministry of Agriculture, Land and Marine Resources, Republic of Trinidad and Tobago.
[2]School of Veterinary Medicine, Faculty of Medical Sciences
Mount Hope. The University of the West Indies, Trinidad and Tobago.
[3]Open Tropical Forages - Animal Production Laboratory (OTF-APL), Department of Food Production,
Faculty of Science and Agriculture, The University of the West Indies, St. Augustine. Trinidad and Tobago

Abstract

Thermoregulation, heat tolerance, and reproductive parameters were evaluated for imported Anglo Nubian and British Saanen goats kept in an intensive management system. Their rectal temperatures were recorded twice daily at 6.00 a.m. and 6.00 p.m. during the dry and wet season. Rectal temperature and respiration rates were evaluated for animals staked outdoor with out shade for two consecutive hours (08:00 to 10:00) each day for three consecutive days during the dry season. Am rectal temperature irrespective of breed or season ranged from 38.5 to 38.7 ^{0}C and pm ranged from 38.8 to 39.0 ^{0}C. After 2 hours of exposure outdoors without shade Saanen parent stock (SAPS) respiration rate (105 br/min) was significantly higher than Saanen F1 (SAF1, 76 br/min), Anglo Nubian parent stock (ANSP, 65 br/min), and Anglo Nubian F1 (ANF1, 51 br/min). Age at first kidding showed no significant difference between breeds or between parent stock and the F1 generations. These ranged from 638 to 686 days. The ANPS were the most prolific of all groups, the mean for this group was 1.86±0.07 kids/kidding. Saanen F1 was least prolific among the groups. The mean number of kids/kidding was 1.23 (±0.11). Kidding interval showed no significant differences between the groups and ranged from 319 to 521 days. It was concluded that, the Anglo Nubian appears to be more suitable for the tropical humid environment in Trinidad.

Keywords: Anglo Nubian, Saanen, Adaptability, Performance, Humid Tropics
#Corresponding author. E-mail massalal@hotmail.com

Introduction

In Trinidad and Tobago the goat population is estimated at 70,000 heads, most of which are reared in low input backyard and semi-intensive systems. However, demand for goat meat and milk far outstrip supply, with domestic goat meat production being only 10% of total demand. Further, annual goat population growth rate has been rather low averaging around 3.72% (Jacque *et. al*., 1999). In an attempt to improve the level of production and productivity in goats, the government of the Republic of Trinidad and Tobago embarked on a goat multiplication project designed to produce stock of superior genetic quality, for the farming community. Thus, exotic stock was imported to form the nucleus of this goat expansion programme. The objectives of this study were to evaluate whether the animals were thermo-regulating normally under housing conditions provided, and to evaluate and compare the degree of heat tolerance of Anglo Nubian and Saanen purebreds and their F1. The reproductive performances of the imported Anglo Nubian and Saanen purebreds and their offsprings were compared.

Materials and Methods

Trinidad has two distinct seasons a dry season lasting from January to May, and a wet season from June to December. The mean (± SEM) daily temperature measured at Centeno during the dry-season was 28.93 ±0.59 ^{0}C indoor and 29.15 ±0.70 ^{0}C outdoors. The mean daily temperatures within and outside the housing for the wet season was 27.93 ±0.04 ^{0}C and 28.18 ±0.04 ^{0}C, respectively. One hundred and sixty registered animals (110 Anglo Nubian females and 12 males; 42 British Saanen females and 4 males) averaging seven months of age were imported from the United Kingdom into the facilities at Centeno Livestock Station. The housing complex consisted of three rectangular structures each of 280 m^2 of floor space (28m x 10m). The concrete floor of all individual and community pens was partially covered (50% approximately) by slatted wooden floor. Tanner grass (*Brachiaria arrecta*) was the major forage utilized along with a commercial concentrate for feeding. Twenty Saanen and Anglo Nubian does were randomly selected, and their rectal temperatures recorded twice daily at 6.00 a.m. and 6.00 p.m. during the dry and wet

Peer-reviewed paper: 8th International Conference on Goats

season. Hourly, ambient temperature and relative humidity (RH) indoors and outdoors during the dry and wet seasons were measured. Rectal temperatures and respiration rates of twenty randomly selected female goats were used to assess heat tolerance. There were four groups each consisted of five animals, Anglo Nubian Parent Stock (ANPS), Anglo Nubian F1 generation (ANF1), Saanen Parent Stock (SAPS), and Saanen F1 generation (SAF1). Animals were staked outdoor with out shade for two consecutive hours (08:00 to 10:00) each day for three consecutive days in the dry season. Data on rectal temperature and on reproductive performances (age at first kidding, prolificacy and kidding intervals) over three parities were collected and analyzed. The rectal temperature and respiration rate data were analysed by ANOVA and mean separation using Fisher's pair wise comparison. Reproductive performance data was analysed by GLIM using Minitab Release 12 (Minitab Inc, 1998).

Results

The mean rectal temperatures for the parent stock in the dry season at 6.00am and 6.00pm were 38.7 $\pm 0.05^0$C and 39.0 $\pm$ 0.06^{0}C and 38.7 $\pm$ 0.05^{0}C and 38.9 $\pm$ 0.02^{0}C for the Anglo Nubian and Saanen, respectively. Similarly, values were recorded during the wet season at the same periods of the day (38.6 ± 0.04 ^{0}C and 38.8 ± 0.04 ^{0}C and, 38.5 ± 0.03 ^{0}C and 39.0 ± 0.05 ^{0}C) in the same breeds. There were no significant differences in am rectal temperature between breeds and seasons. However, pm rectal temperature for Saanen was higher ($p<0.01$) than the Anglo Nubian in the wet season, these differences were not significant during the dry season ($p<0.06$). After 2 hours exposure outdoors with-out shade Saanen parent stock (SAPS) respiration rate was significantly higher ($p<0.001$) (105 br/min) than that of Saanen F1 (SAF1) (76 br/min), Anglo Nubian parent stock (ANSP) (65 br/min), and Anglo Nubian F1 (ANF1) (51 br/min). However, rectal temperature after the 2 hours exposure outdoors without shade showed significant differences ($p<0.04$) between ANPS (39.7^{o}C), SAF1 (39.8^{o}C) and SAPS (39.4^{o}C), and ANF1 (39.4^{o}C). A summary of the reproductive performance for goats is given in Table 1.

Table 1 Age at first kidding, prolificacy and kidding interval (Mean (±SEM) for Anglo Nubian and Saanen goats reared intensively in a humid tropical environment

	ANGLO NUBIAN		SAANEN		
Performance Indicators	Parent Stock (ANPS)	F1 Generation (ANF1)	Parent Stock (SAPS)	F1 Generation (SAF1)	p-value
Age at first kidding (days)	n=89 674 (±23)	n=48 686 (±35)	n=17 638 (±52)	n=17 657 (±50)	p>0.05
Prolificacy (kids/kidding)	n=200 1.86^a (±0.07)	n=89 1.65^a (±0.10)	n=64 1.46^b (±0.12)	n=38 1.23^b (±0.11)	P<0.05
Kidding Interval (days)	n=141 479 (±34)	n=47 319 (±35)	n=37 521 (±94)	n=24 474 (±66)	p>0.05

^{a,b} Means with common superscript do not differ ($p>0.05$)

Discussion

Normal rectal temperature range for goat is 38.5 to 39.7 ^{0}C (Cunningham, 1992). In this case am rectal temperature irrespective of breed ranged from 38.5 to 38.7 ^{0}C and pm ranged from 38.8 to 39.0 ^{0}C. These results of diurnal variation in rectal temperature are similar to those observed in Alpine goats kept under thermoneutral conditions (Baccari *et al*., 1997). Respiration rates for goats after two hrs exposure to the ambient conditions without shade (temperature 30.4 (± 0.1) ^{o}C, RH 79.7 (± 1.2) %, THI 83.4 (± 0.3)) peaked at 76 to 105 br /min, for Saanen and 51 to 65 br /min for Anglo Nubian. Gall (1991) observed that the respiration rate at ambient temperature of 30 ^{0}C generally stayed below a 100 br/min for goats. Average respiration rate showed a four fold increase (from 26 to 105 br/min) for SAPS and a 2.2 fold increase (from 34 to 76 br/min) for SAF1, which are much lower than the ten fold increase (26 to 261 br/min), observed for Saanen goats exposed to high environmental temperature (Bianca & Kunz, 1978). Shoklink & Choshniak (1985) noted that the sweat glands of the British Saanen breed were sparse and rapidly fatigued. Cutaneous moisture loss represents only a small proportion of total evaporative heat loss (Robertshaw, 1982). However, the poorer evaporative heat loss mechanism through sweating displayed by the Saanen breed would have

given rise to higher respiration rates observed (Joshi *et al*., 1977). This may also explain differences in pm rectal temperature observed.

Figures of 365 to 396 days for the age at first kidding of the Anglo Nubian and Saanen, respectively was recorded in the US by Majid *et al*. (1993). Both Saanen groups kidded earlier than the Anglo Nubian although the differences were not significant. The values obtained ranging from 638 to 686 days are much higher than that obtained by Majid *et al.* (1993). Wilson & Murayi (1988) reported 766, 557 and 598 days for Anglo Nubian crosses, Alpine crosses and Small East African goats, respectively. The mean litter size for Anglo Nubian in this study ANPS was 1.86 (± 0.07) and ANF1 was 1.65 (± 0.10) compares favorably with 1.63 reported by Harricharan *et al.* (1987) in Trinidad. The values recorded for Saanen were lower in the SAPS (1.46 ±0.12) and SAF1 (1.23 ±0.11). Majid *et al*. (1993) reported litter sizes of 1.96 and 1.72 for Nubians and Saanen does, respectively. Local nondescript goats crossed with Anglo Nubian raised intensively in Trinidad had 2.4 (±0.1) kid /kidding (Lallo & Neckles, 1988). According to Macfarlane (1992) because of lowered steriodgenesis caused by hot environments, unadapted animals living in these environments commonly have fewer offsprings. Kidding interval recorded appears to be too long with the exception of ANF1 (Table 1), which appears to be closer to other values reported. Oppong & Yebuah (1981) reported a value of 365 days; and Betancourt (1983) observed a kidding interval of 305 days in native goats in Venezuela. It was concluded that, the Anglo Nubians (ANSP and ANF1) appeared to be more suitable for the tropical humid environment in Trinidad.

References

Baccari, Jr., F., Brasil, L. H. A., Teodoro, S. M., Goncalves, H. C., Wechsler, F. S. & Aguir, I. S., 1997. Thermoregulatory responses of Alpine goats during thermal stress. In Livestock Environment. Eds Bottcher, R. W. & Hoff, S. J. American Society of Agricultural Engineers. Michigan, USA. Vol. 2. pp. 789-794.

Betancourt, O. J. G., 1983. Genetic Analysis of a Crossbreeding Experiment Using Improved Dairy Goat Breeds and Native Goats in a Dry Tropical Environment. Ph. D Thesis, University of California Davis.

Bianca, W & Kunz, P., 1978. Physiological reaction of three breeds of goats to cold, heat and high altitude. Livestock Prod. Sci. 5, 57-69.

Cunningham, J.G., 1992. Textbook of Veterinary Physiology. W. B. Saunders Company. Philadelphia, 656pp.

Gall, C.F., 1991. Breed Differences in Adaptation of Goats. World Animal Science. Genetic Resources of Pig, Sheep and Goat. Elsevier Publ. Amsterdam. 1991, pp. 419-426.

Harricharan, H.; Ramlal, H. & Lauckner, F.B., 1984 Some Production Parameters of Pure Breeds of Goats Reared in Trinidad and Tobago. Paper presented at the 17th West Indian Agricultural Economics Conference, St Augustine Trinidad, January, 1984.

Jacque, A., Douglas, V., Davis, F., Bute, R., Harry, E. & Kalloo, M., 1999. Development plan for the small ruminant sub-sector in Trinidad and Tobago. Publ. Government of The Republic of Trinidad and Tobago. Ministry of Agriculture, Land and Marine Resources. Pp 63.

Joshi, B. C., Arivindam, M., Singh, K. & Bhattacharya, N. K., 1977. Effect of high environmental stress in the physiological responses of bucks. Indian J. Anim. Sci. 47, 200-203.

Lallo, C. H. O. & Neckles, F. A., 1988. The performance of crossbred goats under zero-grazing conditions. In Proc. of the second annual seminar on agricultural research in Trinidad & Tobago. Publ. NIHERST, POS. Vol. 2. 125-133.

Macfarlane, W.V., 1982. Concepts of Adaptation. In Proceedings of the Third International Conference on Goat Production and Disease, 10-15 January, 1982. Tucson, USA. Dairy Goat publishing Co. pp375-385.

Majid, A.M.; Cartwright, T.C.; Yazman, J.A. & Fitzhugh H.A., 1993. Performance of Five Breeds of Dairy Goats in Southern United States: Reproductive Traits and Maturing Patterns. World Review of Animal Production. 28, 15-23.

Minitab Inc., 1998. Statistical software release 12 for Windows . Publ. Minitab Inc.USA.

Oppong, E.N.W. & Yebuah N.M.N., 1981. Some Production Traits of the West African Dwarf Goat. Tropical Animal Health and Production. 13, 208-212.

Peer-reviewed paper: 8th International Conference on Goats

Robertshaw, D., 1982. Concepts of Animal Adaptation: Thermoregulation of the Goat. In Proceedings of the 3rd International Conference on Goat Production and Disease1982. 10-15 January. Tucson: Arizona. The Dairy Goat Journal Publishing Company. pp. 162-174.

Shoklnik, A. & Choshniak, I., 1985. Physiological Responses and Productivity of Goats. In Stress Physiology in Livestock. Eds Yousef, M. K. Publ. CRC Press, Inc. Boca Raton, Florida. USA. Vol. 2. pp 39-57.

Wilson, R. T. & Murayi, T., 1988. Productivity of the small East African goat and its crosses with the Anglo Nubian and the Alpine in Rwanda. Tropical Animal Health and Production. 20, 219-228.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

The influence of rearing systems on gut development of kids: preliminary results

T. Songabe[1,3 #], E.F. Donkin[2], E.D. Green[3] and E. Gruys[4]

[1]Department of Production Animal Studies, Faculty of Veterinary Science, University of Pretoria, Private Bag X04, Onderstepoort 0110, South Africa; [2]Department of Animal and Wildlife Sciences, University of Pretoria, 0002 Pretoria; [3]Department of Anatomy, Faculty of Medicine, Box 54, Medunsa 0204, South Africa; [4]Department of Pathology, Faculty of Veterinary Medicine P.O. Box 80.163, 3508 TD Utrecht, The Netherlands

Abstract

Field observations in some communal areas of South Africa have shown that, kids are kept in closed kraals with no exposure to roughage until they are five months old. This study evaluated differences in surface morphology of the rumen, reticulum and omasum in two groups of Crosses of Saanen and South African Indigenous Goat (SAIG) kids. Kids were assigned to two rearing groups, MRCC fed (milk, roughage and concentrates were fed) and M fed (milk only was fed). Kids were sacrificed at two, four and six months of age. Ultrastructural differences of the rumen, reticulum and omasum were investigated. The fore-stomachs were less developed for the goats in the M fed group when compared to those in the MRCC fed group. Differences in the rumen/body weight ratios and the reticulum/bodyweight ratios were not statistically significant between the two groups in all slaughter ages. Differences in the omasum/body weight ratios were statistically significant.

Keywords: Goats, gut development, rearing systems, roughage, rumen
[#]Corresponding author; E-mail: tembile.songabe@up.ac.z

Introduction

Kid mortality is one of the main factors adversely affecting goat production in tropical and subtropical regions (Hussain *et al.*, 1995). Managemental factors such as poor housing contribute to these high mortalities (McCrindle *et al.* 2001;). Ruminants begin to graze in the first week of life when given access to pasture ((Church, 1988; Santra & Karim, 2002). The consumption of solid food stimulates the anatomical and functional development of the rumen, favoring transition from non-ruminant to ruminant status ((Church, 1988). Creep feeding is thus therefore generally provided a few days after birth to stimulate early rumen development (Santra & Karim , 2002). Field observations in communal areas of North-west Province of South Africa (Sebei, 2002) have shown that kids are kept in closed kraals to reduces the risk of predation of young kids but there is no exposure to the roughage until they are about five months old.

Materials and Methods

Twenty-three crosses of Saanen and South African Indigenous goat kids, 4 to 7 days old, were assigned to two rearing groups according to diets. One group was fed milk only (M group) until four months of age and thereafter was given poor roughage (kikuyu) *ad libitum*. The other group was fed milk, lucerne and concentrates (MRCC group). Kids were sacrificed at different ages, at two months, four months and six months. Tissue samples were collected. Ultrastructural differences of the fore-stomachs were investigated using scanning electron microscopy (SEM) and Computer AnalySIS (SIS Extended Pro) Software Image Processing System®.

Results and Discussion

Differences in slaughter weight are presented in Figure 1 and Figure 2 indicates that MRCC kids were bigger at slaughter. Differences in the rumen/body weight ratios and the reticulum/bodyweight ratios were not statistically significant between the two groups in all slaughter ages. Differences in the omasum/body weight ratios were statistically significant. The fore-stomach compartments of the MRCC group were bigger than the M group. The papillae were less developed and papillae were less numerous for the goats in the M fed group when compared to those in the MRCC fed group (Fig 3). Poor growth that was noted in the group fed with milk only was consistent with earlier reports in calf (Church, 1988) and in sheep (Swan & Groenewald, 2000). The findings showed

Peer-reviewed paper: 8th International Conference on Goats

differences between the groups emphasizing the key role of adequate roughage in gut development when rearing goat kids.

Figure 1 Average slaughter weights in months

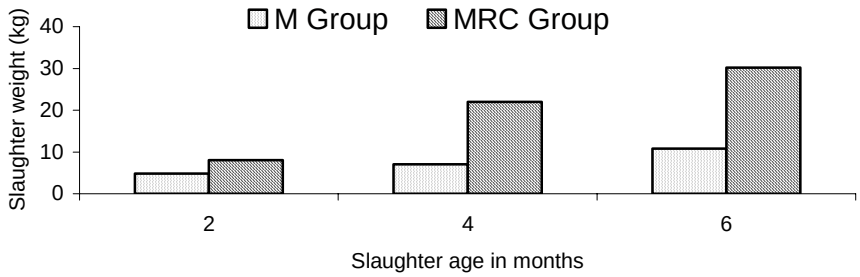
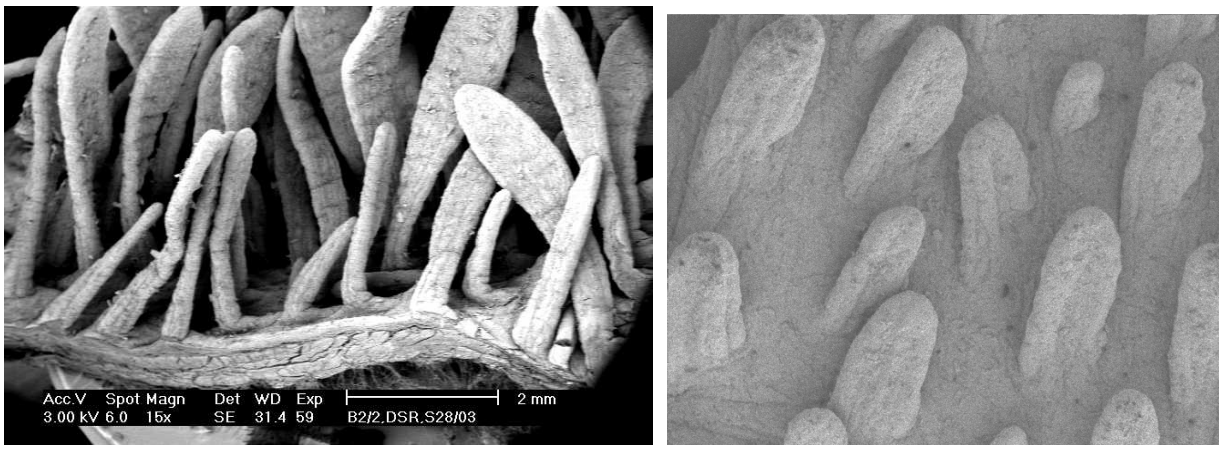


Fig 2 MRCC kid (right) and M kid (left) at 6 months



(a) (b)

Fig 2 Rumen, slaughtered at six months (a) long leaf-shaped rumen papillae of the MRCC-group when compared to (b) shorter tongue-shaped rumen papillae of the M-group.

Peer-reviewed paper: 8th International Conference on Goats

Conclusions

This study concluded that of proper rearing techniques are critical for gut development. High priority must be given to the development of small-scale farming husbandry skills to improve the production.

Acknowledgements

The authors wish to thank staff members of the University of Pretoria and Utrecht University who contributed with funds and services.

References

Church, D.C. 1988. The ruminant animal: Digestive physiology and nutrition. Ed Church D.C Prentice Hall London, Prentice-Hall International

Hussain, S. S., Horst, P. & Islam, A. B. M. M. 1995. Effect of different factors on pre-weaning survivability of Black Bengal kids. Small Ruminant Research 18, 1-5

McCrindle, C. M. E. & Sebei J. P. 2001. A systems approach to small scale sheep and goat farming in South Africa. Proceedings of the Vth International Sheep Congress, Stellenbosch, South Africa

Santra, A. & Karim, A.A. 2002. Nutrient utilization and growth performance of defaunated and faunated lambs maintained on complete diets containing varying proportion of roughage and concetrates. Animal Feed Science and Technology, 101, 87-99

Sebei, J.P. 2002**.** The assessment of some factors influencing the survival of kids in a small-scale communal goat production system. MSc(Vet) Thesis, University of Pretoria, South Africa

Swan, G.E. & Groenewald, H.B. 2000. Morphological changes associated with the development of the rumeno-reticulum in growing lambs fed different rations. Onderstepoort J. Vet. Res. 67, 105-114

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Effects of cryopreservation on sperm motility in Blanca Serrana Andaluza goat

Vallecillo A[1#], Trigo. PI[2], Delgado JV[1], Cabello A[3], Santos E[4], Tenorio T[4]
[1]Departamento de Genética. Universidad de Córdoba, Campus Rabanales, 14071- Córdoba. Spain
[2]Departamento de Biología Celular, Fisiología e Inmunología. Universidad de Córdoba. Spain
[3]Delegación de Investigación y Desarrollo Agrícola y ganadero. Diputación de Cordoba. Spain.
[4]Universidad Federal Rural de Pernambuco. Pernambuco. Brazil

Abstract

The Blanca Serrana Andaluza goat has been used as a source of food and it has helped to maintain the ecosystem, but is currently threatened by extinction. This breed's most important reproductive characteristics were studied in order to generate information to improve the use of assisted reproduction technologies in this breed as part of a breed preservation program. Sperm motility was evaluated before and after a simple freezing method. It is concluded that the semen of the Blanca Serrana Andaluza goat can be frozen and thawed successfully, in terms of mass motility and individual motility.

Key words: sperm, motility, fresh, thaw, goat, conservation
[#]Corresponding author. E-mail: ge2vahea@uco.es

Introduction

The Blanca Serrana Andaluza Goat is one of the oldest breed in the Iberian Peninsula, and is one of the few with marked influences of the African trunk, for its origin. Its meat aptitude, wildness, and capacity of adaptation to the adverse local conditions, allowed this breed to be used in marginal areas where cropping and cattle raising don't have productive perspectives. This breed was strongly disseminated in the Andalusian region up to the eighties. (Rodero *et al*., 1994). Its importance as a zoogenetic resource exploited in extensive production in Mediterranean ecosystems. Where it contributed with other species to maintain the ecological balance, contributing to the cleaning of the forest (avoiding fires), disseminating seeds and fertilizing the lands, among other interactions with the environment. At the moment, it is one of the genetic goat resources most threatened by extinction in Spain, because their numbers have fallen considerably.

Spain, as other developed countries, has a great interest in to conserve and to preserve its own native genetic patrimony, as future alternative linked to its own development. A technology that provides an appropriate method to conserve species in danger of extinction is the establishment of germplasm banks, which bears gathering of resources in form of semen, oocytes, embryos or live tissues. In order to begin with this line of work, we evaluate in this breed the efficiency of semen cryopreservation techniques commonly used in other goat breeds.

Material and Methods

This work was carried out in the Investigation Centre of the Provincial Delegation of Cordoba-Spain (CIDPC), during December and January 04. Semen was collected from four Blanca Serrana Andaluza bucks, 19- 24 months of age. All bucks were known to be fertile and were actively being used for natural service breeding. Four ejaculates from each animal were obtained from one semen collection per buck, twice a week, over two consecutive weeks in December 2003. Buck number 3, does not present the minimum values to freeze one of its ejaculates, then we extracted a new one in that same day, to replace it. So, a total of 17 ejaculated were obtained but only 16 were frozen.

Semen was collected with the aid of an artificial vagina (40 – 42º C). A non estrogenized female goat was used as a dummy. Each ejaculate was kept in the collector tube at 35º during initial evaluation of semen quality. The volume was determined (using a collector tube graduated in millilitres as were mass motility (warming sage at 37º C, 40x; scale 0 – 5), individual sperm motility (warming stage at 37º, x400), and sperm concentration by spectrophotometer method (Spermacue, Minitube). Only ejaculates of good quality were frozen immediately (volume > 0.5 ml; mass motility > 3.5; individual sperm motility > 60%; sperm concentration > 3000 x 10^6 cells/ml). Semen was diluted 2:1 in Triladyl medium (Minitube) and centrifuged for 6 minutes at 500g. The supernatant was removed and spermatozoa resuspended to 200 x 10^3/ml in Triladyl medium with 20% egg yolk. Semen was loaded into 0.5 ml straws and equilibrated at 4ºC for 4

Peer-reviewed paper: 8th International Conference on Goats

hours. Semen freezing was carried out in automated liquid nitrogen based programmable freezer (Biotronik Products Ltd.) using the protocol described in Table 1.

Table 1 Rate of temperature reduction used for semen cryopreservation

Start temperature	4ºC
Cooling rates	
From 4 to –10ºC	-5º C per min
From -10 to –11ºC	-1º C per min
From -11 to –80ºC	-5º C per min

Finally the straws were plugged and stored in liquid nitrogen for 30 days before being thawed in a water bath at 37ºC for 60 seconds. The pos thaw evaluation was similar to initial evaluation of semen quality. Between Buck differences were compared by Fisher's least significant difference test. The effects between individuals were compared by Student's t-test.

Results

All the bucks mounted the dummy in less than five minutes from exposure and the semen was collected in 100% of the attempts. Data showing the semen characteristics of the Blanca Serrana Andaluza bucks and the response to freeze and thaw protocol are summarized in Table 2. Significant differences among fresh and post thaw semen in sperm motility were recorded. Similar efficiency rates of individual sperm motility and mass motility were obtained.

Table 2 Semen characteristics and motility response to freeze and thaw in the Serrana Blanca Andaluza bucks.

	Fresh semen		Thaw semen		
	Mean	Standard des.	Mean	Standard des.	Recovery rate
Volume (ml)	0.73	0.25			
Concentration (cell x10^6/ml)	4721.38	1109.87			
Individual Sperm Motility (%)	74.38*	8.73	60.50*	14.74	0.81
Mass Motility (0-5)	3.38	0.50	2.69	0.51	0.80

*Indicates differences among values ($p < 0.05$)
Recovery rate is calculated as: thaw/fresh

Data showing the semen the response to freeze and thaw, from each male are summarized in Table 3. Significant differences between animal 1 with 2 and 4 in individual sperm motility recovery rate.

Table 3 Motility response in each animal

	Individual Sperm Motility (%)			Mass Motility (0-5)		
Animal	Fresh	Thaw	Recovery rate	Fresh	Thaw	Recovery rate
1	81.25	75	0.92[a]	3.5	2.62	0.74
2	71.25	45	0.63[b]	3.25	2.5	0.76
3	70	59.5	0.85[b]	3.25	2.37	0.73
4	75	62.5	0.82[b]	3.5	2.75	0.78

Different superscripts represent differences among buck ($p < 0.05$)

Discussion

The differences of motility among fresh and freeze-thawed semen confirm that the frozen and defrosted technique is a stress procedure that hinder different aspects of cell physiology. All the post thawed samples had a individual sperm motility value higher than 40%, these values are similar to those observed by Ritar *et al*. (1982), in Angora goats; and by Grabance *et al.* working with Saanen. This indicates that the freezing method was successful. After carrying out the evaluation only 6% of the samples were not able to be

Peer-reviewed paper: 8th International Conference on Goats

frozen because they had a progressive motility below 60%. These results coincide with those from Roca *et al*. (1994), working with Murciano-Granadina goats.

The concentration and individual motility results were higher than those reported by Karagiannidis *et al.* (1999). While the mass motility and the volume were lower. Finally, the total number of sperm cells per ejaculate was slightly lower than those recommended by Lebouf *et al*. (2000)

The fact that mass motility is more affected by the freezing process than individual sperm motility implies that these parameters measure different aspects of cell physiology and in particular, that the physiological basis for the mass motility parameter is more sensitive to cryobiological damage (Anel *et al*., 2003).

England *et al*. (1992) have shown that the freezability of the spermatozoa, based on post thaw motility, of different ejaculates can be highly variable between individuals, this study showed similar results, with a reduced number of animals. So it is suspected that in this breed the differences among individuals are very high. Nevertheless, the post-thaw of motility only indicates viability, but not fertilising ability of the sperm cells. For this reason further research are needed to warrantee the post-thaw fertilization ability of cryopreserved sperm on the Blanca Serrana Andaluza breed.

Conclusion

The semen of the Blanca Serrana Andaluza buck can be frozen and thaw successfully, using TRis - egg yolk extender and standard freezing protocols used for buck semen.

References

Anel, L., De Paz, P., Álvarez, M., Chamorro, C.A., Boixo, J.C., Manso, A., González, N., Kaabi, N. & Anel, E. (2003). Field and *in vitro* assay of three methods for freezing ram semen. Theriogenogoly; 60, 1293-1308.

England, C.G.W. & Allen, W.E. (1992). Factors affecting the viability of canine spermatozoa: II Effects of seminal plasma and blood. Theriogenology 37, 373-381.

Gravance, C.G., White, C., Robertson, K.R., Champion, Z.J., Casey, P.J. (1997). The effects of cryopreservation on the morphometric dimensions of caprine sperm heads. Anim Reprod Sci.;49(1):37-43.

Karagiannidis, A., Varsakeli, S. & Karatzas, G. (2000). Characteristics and Seasonal Variations in the Semen of Alpine, Saanen and Damascus Goat Bucks Born and Raised in Greece , Theriogenology, 53, 6, 1285-1293.

Leboeuf, B., Restall, B. & Salamon, S. (2000). Production and storage of goat semen for artificial insemination. Animal Reproduction Science: 62, 113–141.

Ritar, A.J. & Salomón, S. (1982). Effect of seminal plasma and of its removal and egg yolk in the diluyent on the survival of fresh and frozen.- thawed spermatozoa of the Angora goat. Aust.J. Biol. sci. 35, 305-12.

Roca, J., Carrizosa, J.A., Campos, I., Lafuente, A., Vázquez, J.M. & Martínez, E. (1994). Inseminación artificial con semen refrigerado en la raza caprina murciano-granadina: adecuación del diluyente. Proceedings of the VII Jorn. Int. Reprod. Anim. Murcia. 329 332.

Rodero, A., Rodero, E., Camacho, M.E. & Delgado, J.V. (1994). Conservación de Razas Autóctonas Andaluzas en Peligro de Extinción. Ed Junta de Andalucía. 167-181

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Production and reproduction characteristics of South African indigenous goats in communal farming systems

E.C. Webb# and M.J. Mamabolo
Department of Animal and Wildlife Sciences, Faculty of Natural and Agricultural Sciences, University of Pretoria, Pretoria 0002, South Africa

Abstract
South African indigenous does in rural communal farming systems kid for the first time at approximately 17 to 18 months of age. Does conceive at a relatively low body condition score (BCS ≈ 2.5 to 3) and their average litter size is 1.7 kids per doe. The average kidding interval was approximately 238 days and the highest kidding rates were attained in autumn (96 %), followed by spring (93%), winter (63 %) and summer (0 %). The mortality rates in goats in communal systems were extremely high (40.62 %) compared to systems with better management (<5%). The mortality rates result from theft, poor hygiene, and predation. Breeding is not controlled and occurs all year round, which creates managerial problems.

Keywords: Indigenous goats, communal farming systems, productivity
#Corresponding author; E-mail: edward.webb@up.ac.za

Introduction

Livestock production is the most important agricultural activity in most of the countries in southern Africa. The breeding strategies followed in southern Africa generally depend on the environment and level of management. As far as the environment is concerned, livestock production is often practiced under unstable and hazardous production conditions, and further threatened by bush encroachment or desertification. Producers vary from sophisticated commercial to communal subsistence producers (Braker *et al.,* 2002).

The role of goats in the traditional areas has been recognised (Devendra *et al.,* 1970; Devendra *et al.,* 1980; Wilson, 1988 & 1989). Goats, like cattle, play an important role in the livelihood of rural people in communal farming systems. Indigenous goats are more common in the communal areas, while Boer goats are mostly found on commercially owned farms. Indigenous goats constitute a valuable genetic resource because of their ability to adapt to harsh climatic conditions, to better utilize the limited and often poor quality feed resources and their natural resistance to a range of diseases such as pulpy kidney, gall sickness and internal parasites. Goats thus play an important socio – economic role in rural areas, which include some of the most resource poor farmers in Africa. These animals are prolific and require low inputs for a moderate level of production, reach maturity early and are profitable to keep (Devendra & Burns, 1970).

Although there is now a considerable body of published research on indigenous types of small ruminants in tropical areas of Africa, much of the work published has the disadvantage of having been carried out under controlled conditions at research stations - so results are often not applicable to communal production systems in rural areas. The aim of this research was to study the fertility status and performance of goats indigenous to South Africa in communal production systems, in order to recommend strategies for improved production.

Materials and Methods

This study was conducted in the Moutsi district of Mpumalanga, 25°27` S and 30°58` E . This is a rural area and the agricultural pressure on the land is very high. Small ruminants are enclosed and tethered in a wooden hut during the night and are only allowed to graze and browse during the day under the supervision of a herdsman, particularly young men or women. The seasonal characteristics of the area are summer (October – January) winter (May – July), autumn (February – April) and spring (August – September). Forty goat farmers were randomly selected from 7 villages, and farms with between 4 to 156 goats were monitored (297 goats in total) from February 1997 to November 1997. Each herd was visited monthly and the reproductive characteristics, growth performance and mortality rates were recorded. At the onset of the study all animals were weighed and aged by dentition. Growth performance and estimates of age at first kidding were only recorded for animals with a known birth date. Weaning was assumed to occur at 150 days

Peer-reviewed paper: 8th International Conference on Goats

(Wilson, 1983; Devendra *et al.,* 1980). The effects of season and production system on production and reproduction data were analysed using the Proc GLM procedure of SAS (SAS, 1991).

Results and Discussion

Prestige and status were terms used in derogatory manner, to describe the behaviour of traditional ownership in relation to their animals. The reasons for keeping livestock are rational and are related to their particular needs in the long or short term. This is supported by the age and sex structure of the flocks. In rural areas, goats are generally more important than sheep for sacrificial purposes. Nevertheless, goats and sheep do not arouse the same emotions in rural people as apposed to cattle (Hunter, 1936). Despite the major objectives of keeping goats, there is always a predominance of does in the flock, while minor differences in sex and age structure are maintained. All animals in the flock are productive, whether production consist of giving birth to young, producing milk, or simply the process of growth to a size at which another product becomes the principal one.

The major management practice used to obtain stability of structure is the selling or slaughtering of bucks for home consumption and/ or performance of rituals, for goats not required for other production functions. Usually one or two bucks are retained in the flock for reproduction. Animal production systems in Mpumalanga are traditional and the households are generally dependent on livestock production for an income or food supply and crop production is often associated with livestock production. Daily movement of livestock from home to the grazing fields is recognised as an important aspect of management within the system. The enclosing of livestock in huts or kraals is done mainly to protect them from theft and predation.

In many African countries, culture dictates that women are subordinates to men and hence are socially marginalized (Braker *et al*., 2002). Women own goats but they are often not allowed to sell goats in the absence of their husbands, who generally work as migrant labourers. The various decision-making levels related to goat's ownership in Mpumalanga depict a conspicuous gender imbalance, which is a product of strong cultural background biased against women. Nevertheless, goats are generally more prolific and easier to manage than sheep for people with little animal experience. Goats forage more widely and on a greater variety of foods, they survive the seasonal droughts due to their ability to browse and are quite prolific under these extensive conditions. Although not reflected by official statistics, it is probable that the number of goats kept by the rural people has increased markedly in the last few years. The ownership of goats bestow prestige and they have a place in local custom and religion.

The annual reproductive rate is a composite parameter that does not appear to be utilised as much as it should be (Wilson, 1989). The total number of young per breeding female per year has been calculated as the size of the litter and the number of days in a year divided by the kidding interval – i.e. litter size x 365/ kidding interval. The annual reproductive rate of indigenous does increase with age and peaks at 3 to 4 years of age, remain stable and then starts to decrease (Table 1).

Goats are the most prolific of all domesticated ruminants under tropical and subtropical conditions and certain goats are able to breed throughout the year (Devendra *et al.,* 1970, Casey et al 1988, Hofmeyr *et al.,* 1965, and Greyling, 1988). Indigenous goats in Mpumalanga breed throughout the year with the highest kidding rate recorded in autumn, which indicates a summer breeding season that coincides with optimum feed availability. The length of the breeding season is primarily the result of genetic and environmental interactions (Casey *et al.,* 1988) with the environment playing a major role. Tropical goats reportedly exhibit polyestrous all year round (Amoah *et al.,*1996), but it is known that environmental factors other than photoperiod (e.g., availability of feed and variations in rainfall, temperature and humidity) may affect the breeding season of goats (Prasad *et al.,* 1979).

The gestation length for indigenous goats in Mpumalanga varied between 145 to 148 days, which agrees with that reported for Boer goat does (Greyling, 1988). A gestation period of 149 days is normal in does (Shelton, 1978), with variations between 144 and 151 days. It was not possible to quantify the effect of the weight of the kids, type of birth (single or twins) or type of diet on the gestation length in the present study.

Similar to Boer goat does (Casey *et al.,* 1988; Greyling, 1988), the indigenous goats in Mpumalanga are early breeders, reaching puberty at 6 to 7 months of age. The age at first kidding varied between 16 to 18 months of age, which is similar to West African Dwarf goats in Chad, but longer compared to the Togo (15 months), Sahel (13 months) and Maradi goats (14 months)(Wilson et al., 1989) and West African Dwarf goats in Nigeria (Ikwaegbu, *et al.,* 1995). Age at first kidding of South African indigenous goats is shorter than that reported for Rwandan goats (21 Months, Wilson et al., 1989). Average litter size was 1.7, and 76%

Peer-reviewed paper: 8th International Conference on Goats

of the births that occurred in autumn and spring were twins, while only 24% of the births in winter were twins (Table 1).

Table 1 Effect of season and age on the prolificacy of indigenous South African goats (n=297)

Season	Single birth	Twin birth	Proportion of total
Autumn	4%	96%	54%
Winter	68%	32%	24%
Spring	7%	93%	22%
Summer	0%	0%	0%

Age (years)	Prolificacy
2.5	56.1 - 77.3%
3.5	7.3 - 98.2 %
4.5	133.4- 183.7%
5.5	106.2-146.3%

The average kidding interval of indigenous goats in Mpumalanga was 258 days (n=297), which is slightly shorter compared to that of West African Dwarf goats or goats from other parts of Africa (Wilson, 1989; Odubute et al., 1992). Ikwuegbu *et al*. (1995) also reported a kidding interval of 250 days for West African Dwarf goats in Southern Nigeria. Apparently these shorter kidding intervals are more common in traditional systems where uncontrolled breeding is practiced. So does in Mpumalanga often kid three times in two years which agrees with the findings of Mack (1983). The-kidding pattern of indigenous goats also suggest that they are most prolific at about four years of age (Table 1).

Mortality rates of goats in Mpumalanga ranged between 3.8 and 40.1 %. Similar mortality rates were reported for goats in other parts of Africa (Bembridge, 1989, Manjeli *et al.,* 1996, Wilson, 1989, Ikwuegbu et al., 1995, Gall, 1981, and Devendra *et al.,* 1970). Unlike the West African Dwarf goats where stillbirths or abortions constituted the major cause of mortalities, mortalities of indigenous goats were mainly due to theft, predation and coccidiosis due to poor hygiene. These causes of mortality can be controlled if proper management practices are implemented.

It appears that the potential productivity of goat is constrained by a poor understanding of the value of goats and of strategies for improved natural resource management in target environments. False perceptions about environmental degradation, biases, inadequate official support and resources are probably the major constraints that detract from sustainable goat production. Until recently, in Southern Africa there has been an official bias against the goat as destroyer of vegetation. Because of this prejudice, efforts to exploit the full potential of this animal have been generally minimal, compared to efforts in sheep and cattle (Bembridge, 1988).

Indigenous goats have a considerable potential provided that proper management is employed and that their potential in terms of valuable and productive small stock is recognised.

Conclusion

The current reproduction status of communal goat does is low, mainly due to high kid mortalities and inbreeding. In traditional livestock management, does and bucks run together all year round. Usually one or two bucks are left in the herd for up to five years resulting in inbreeding. The genetic resource of indigenous goats is therefore at risk if no effort is made to improve the management of goats in communal farming systems. Research and development efforts can significantly improve production from goats and simultaneously enhance the livelihood of the poor. In the search for efficiency and the maximum use of available animal genetic resources, more enlightened thinking is necessary about the role that the goat can play .

Peer-reviewed paper: 8th International Conference on Goats

Acknowledgements

The authors wish to thank the National Research Foundation (NRF) for their financial support and STATOMET at the University of Pretoria for the statistical analysis of the data.

References

Bembridge, T.J., 1989. Aspects of small stock production in Ciskei. South African Journal of Animal Science, 19, 1-3.

Braker, M.J.E., Udo, H.M.J. & Webb, E.C., 2002. Impact of intervention objectives in goat production within subsistence farming systems in South Africa, *SA J Anim. Sci*. 32(3),185-191.

Casey, N.H. & Van Niekerk, W.A., 1988.The Boer goat.1. Origin, adaptability, performance testing, reproduction and milk production. Small Ruminant Research, 1,291-302.

Devendra, C. & Burns, M., 1970. Goat production in the tropics. Common wealth agricultural bureaux, Farnham royal bucks. England.

Devendra, C. & McLeroy, G.B., 1982. Goat and sheep production in the tropics. Longman Scientific and Technical.

Greyling, J.P.C., 1988. Certain aspects of reproductive physiology in the Boer goat doe. D.Sc. Thesis, University of Stellenbosch, South Africa.

Hunter, M.,1936.Reaction to conquest. Oxford University press, London.

Hofmeyr, H.S., Joubert, D.M., Badenhorst, F.J.G. & Van De Steyn, G.J., 1965. Adaptability of sheep and goat to a Southern African tropical environment. Proceeding of South African Society of Animal Production.4, 191-194.

Ikwuegbu, O.A, Njwe, R.M. & Tarawali, G., 1995. On -farm reproductive performance of the West African Dwarf goat at Ganawari in the sub-humid zone of Nigeria.Tropical Agriculture.73, 49-55.

Mack, S.D., 1983. Evaluation of the productivity of West African Dwarf sheep and goat in southwest Nigeria. Humid zone program document 7, International livestock centre for Africa.Ibadan, Nigeria, pp.55.

Manjeli, Y., Tchoumbue, J. &Tequia, A. and Zango, P., 1996.Productivity of West African Dwarf goats under traditional management in the western highlands of Cameroon. World Review of Animal Production,13,88-92.

Odubute, I.K., Akinokun, J.O. & Ademosun, A.A., 1992.Production characteristics of West African dwarf goats under improved management system in the humid tropics of Nigeria.Proc.Intl. Workshop,Ile-Ife,Nigeria,pp.202-207.

SAS, 1991. SAS Users Guide, SAS Institute, Carey.

Wilson, R.T., 1988. Small ruminant production systems in tropical Africa. Small Ruminant Research, 1,305-325.

Wilson, R.T., 1989. Reproductive performance of African indigenous small ruminants under various management systems review. Animal Reproduction science, 20,256-286.

Wilson, R.T., Murayi, T.H. & Rocha, A., 1989. Indigenous African small ruminants strain with potentially high reproductive performance. Small Ruminant Research, 2,107-117.

Wilson, R.T., Peacock, C. & Sayers, A.R., 1984. Aspects of reproduction in goats and sheep in south central Kenya. Animal Production.38, 363-368.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Seasonal variation in semen quality of Gorno Altai and South African indigenous goats

E.C. Webb[1#], M.H. Dombo[2] and M. Roets[3]
[1]Department of Animal and Wildlife Sciences, University of Pretoria, 0002 Pretoria, South Africa
[2] ARC-Animal Nutrition and Animal Products Institute, Private Bag X 2 Irene 0062, South Africa
[3]Scientific Roets CC., P.O. Box 461, Kokstad, 4700, South Africa

Abstract

Seasonal effects on semen quality of Gorno Altai cashmere goats and South African indigenous goats were studied in this experiment. A definite breeding season for the two breeds was determined. Semen quality parameters that were quantified include semen volume, sperm concentration, sperm motility, percentage live sperm, dead sperm and scrotal circumference. Scrotal circumference, semen volume, concentration and sperm concentration of the two breeds followed a seasonal pattern. These seasonal variations were significantly affected by changes in photoperiod, with subsequent effects on sperm production. The results suggest that environmental temperature plays a secondary role in terms of semen production compared to seasonal differences in photoperiod.

Keywords: Indigenous goats; Gorno Altai, Semen quality, seasonal effects.
[#]Corresponding author; E-mail: edward.webb@up.ac.za

Introduction

In South Africa, goats comprise a large portion of the livestock in possession of small-scale farmers. Over the decades the use of goats as a means to generate an income has been limited mainly because of being utilized for traditional purposes. Another drawback is that the reproduction potential of goats was never realized and not well researched to date. Some studies have indicated that in temperate environments, semen production is influenced by seasonal changes (Loubser & Van Niekerk, 1983). In addition, South African indigenous goats produce a small amount of cashmere, but crossbreeding with the Gorno Altai could improve cashmere production and contribute substantially to the income of small-scale goat farmers. Gorno Altai goats are typical short day breeders, while previous studies suggest that South African indigenous goats tend to breed all year round (Greyling, 1988; Webb *et al*., 1998). The aim of the present study was evaluate the effect of season on the semen quality of Gorno Altai cashmere bucks and South African indigenous bucks, to facilitate crossbreeding programs.

Materials and Methods

The experiment was conducted at the ARC-Irene (25º55` S; 28º12' E), South Africa. The location is in the high veld climate, at an altitude of 1525 m above sea level. The climatic conditions ranged from hot days and cool nights in summer to moderate winter days with cool nights. Two goat breeds were studied in this experiment namely 6 Gorno Altai buck (an imported cashmere breed) and 6 indigenous bucks that were donated to the ARC. The Gorno Altai and indigenous goats varied in age between 4 and 5 years and the two breeds weighed between 45 to 65 kg respectively. All animals were housed in enclosed pens with roofing and an open –air area. Every morning the bucks were fed lucerne and hay, while water and a mineral lick were provided *ad libitum*. During the day bucks were allowed free access to open paddocks.

Monthly ambient temperatures were obtained from the South African Weather Services and the average daily ambient temperatures were calculated according to the method of Loubser *et al.* (1983). Semen was collected on a monthly basis during 2002 by means of an electro-ejaculator, consisting of a bipolar electrode and variable source of alternating electrical current. Prior to the rectal insertion of the probe, the electrode was lubricated with KY-jelly to ease insertion and improve contact. Before semen collection commenced, preputial hair was clipped and the preputial orifice was thoroughly cleansed.

Semen quality parameters that were quantified monthly from January to December 2002 were semen volume, sperm concentration, sperm motility, percentage live sperm, dead sperm as well as scrotal circumference. Immediately after collection, semen samples were placed in a water bath at 35ºC and each ejaculate was examined for volume, % motility and sperm concentration. Semen volume was estimated in a

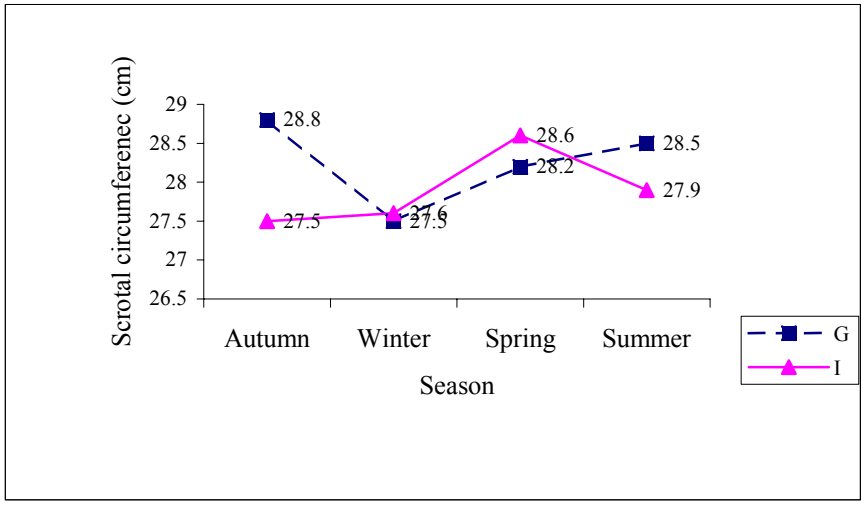
Peer-reviewed paper: 8th International Conference on Goats

calibrated semen collection tube. Sperm concentration and motility were determined on a warm stage (35ºC) under a light microscope. Motility rate was determined under a light microscope and a scale ranging from 0 to 5 was applied with 5 showing very turbulent movement. Semen concentration was determined by means of a Neubauer haemocytometer under a 400 X magnification. Percentages live and dead sperm were determined by eosine-negrosin staining on a glass slide (Vilakazi & Webb, 2004).

Results and Discussions

Scrotal circumference data are presented in Figure 1. Seasonal changes in scrotal circumference occurred in the Gorno Altai breed with the most significant ($P<0.05$) increase occurring during March, which is similar to the findings of Folch (1984). During the natural breeding season, Gorno Altai goats recorded a larger scrotal circumference (29.3±1.4 cm) compared to indigenous bucks (27.8±0.8 cm). The mean values and seasonal variations in scrotal circumference obtained for indigenous bucks in this study agree with that reported by Webb *et al.* (1998). The increase in scrotal circumference in the Gorno Altai was associated with a marked decrease in photoperiod, which triggered sexual activeness towards the end of autumn (Figure 1). In the other seasons, scrotal circumference did not differ between these breeds and tended to decrease during the non-breeding season in both breeds. Body weight did not affect the scrotal circumference of indigenous (55.95±6.4 kg) or Gorno Altai (56.83±6.3 kg) bucks which is in agreement with the results of Tegegne *et al.*, (1994). Although the scrotal circumference of the Gorno Altai was higher, indigenous bucks recorded higher semen volumes in the hot summer months of December (1.9±0.4 ml) and January (1.57±0.35 ml) and higher semen motility, compared to the Gorno Altai.

Figure 1 Seasonal effects on the scrotum circumference of South African indigenous and Gorno Altai goats.



G=Gorno Altai; I=South African indigenous goats

Although the semen volume (1.77±0.3 ml) of indigenous bucks was marginally higher compared to the Gorno Altai, sperm concentration was higher ($P<0.05$; Figure 2) in Gorno Altai (161.3±83.6 x 10^6 sperm / ml) than in indigenous bucks (126.5±73.2 x 10^6 sperm / ml) particularly during winter and early spring.

It was also evident that the sperm concentration in the Gorno Altai bucks recorded highest values in the breeding season, which agrees with the findings of Roca *et al.* (1992), while less variation was noted for indigenous goats. Semen concentrations tended to increase in both breeds at the end of winter and onset of spring and decreased again in summer (Figure 2).

Semen volume in May (mid autumn) and August (end of winter) differed significant ($P<0.05$) between the Gorno Altai (2±0.52 ml and 1.55±0.24 ml) and indigenous bucks (1.43±0.4 ml and 1.32±0.15 ml) (Figure 3). In September (spring), when the environmental temperature started to increase, the semen volume of indigenous bucks was higher (1.77±0.3 ml; $P<0.05$) compared to the Gorno Altai (1.28±0.25 ml).

Other researchers (Tegegne *et al.*, 1984; Roca *et al.*, 1992) reported a strong correlation between body weight and scrotal circumference, but no significant correlation was obtained between body weight and scrotal circumference in this study, probably since all goats were well fed and in a good condition (Table 1) and because the number of animals was rather small. Negative correlations were recorded between body

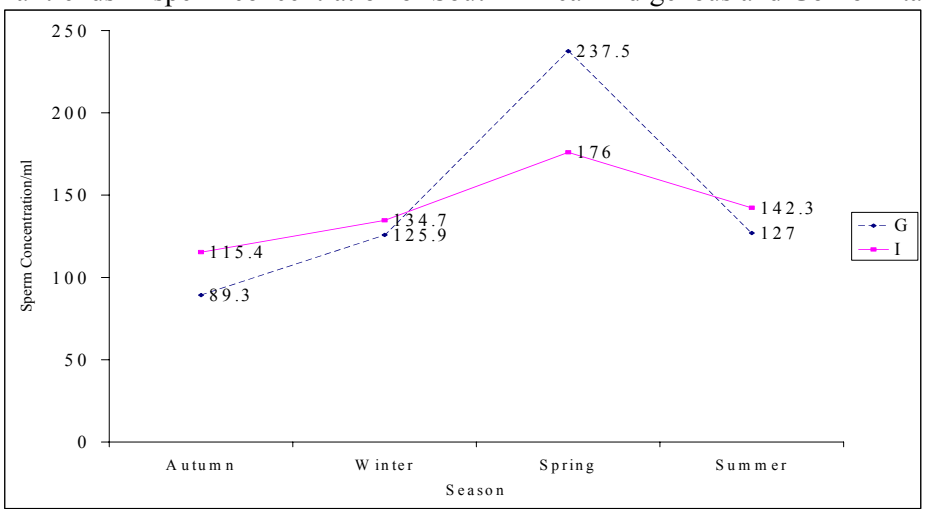
Peer-reviewed paper: 8th International Conference on Goats

weight and the % live sperm and semen colour. Positive correlations were found between semen volume and semen concentration (r=0.27) and % live sperm (r=0.22).

Table 1 Correlations between body weight, semen volume, sperm concentration, % live sperm, semen colour and scrotal circumference (SC).

		Weight	Volume	Concentration	% Live sperm
Weight	Person Correlation	1			
(kg)	Significance (P<F)	0.0			
	N	152			
Volume	Person Correlation	0.067	1		
(ml)	Significance (P<F)	0.413	0.0		
	N	152	152		
Concentration	Person Correlation	0.089	0.274	1	
(x 10^6 sperm/ml)	Significance (P<F)	0.278	0.001	0.0	
	N	152	152	152	
% Live sperm	Person Correlation	-0.242	0.220	0.323	1
	Significance (P<F)	0.003	0.006	0.000	0.0
	N	152	152	152	152
Semen colour	Person Correlation	-0.327	0.139	0.323	0.411
	Significance (P<F)	0.000	0.088	0.000	0.000
	N	152	152	152	152
SC	Person Correlation	0.098	-0.020	-0.107	-0.101
(cm)	Significance (P<F)	0.230	0.810	0.188	0.216
	N	152	152	152	152

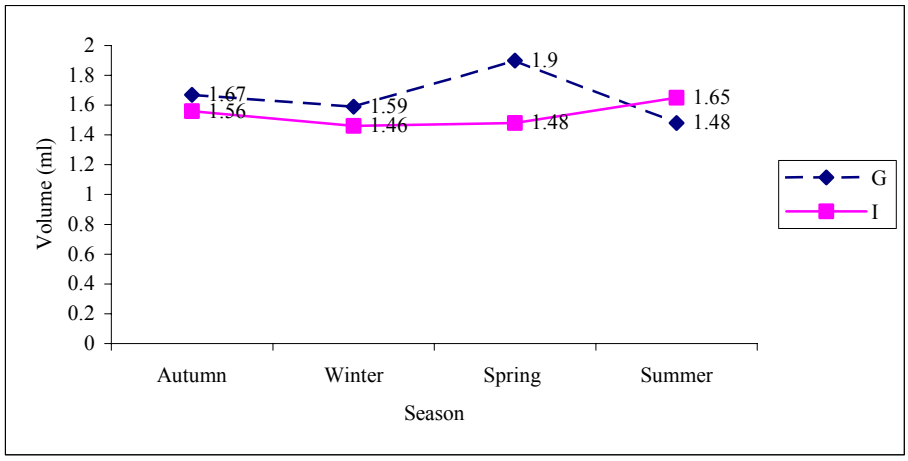
Figure 2 Seasonal trends in sperm concentration of South African indigenous and Gorno Altai goats.



G=Gorno Altai; R=South African indigenous goats

Peer-reviewed paper: 8th International Conference on Goats

Figure 3 Seasonal effects on the semen volume of South African indigenous and Gorno Altai goats.



G=Gorno Altai; I=South African indigenous goats

Conclusions

It is concluded that seasonal variations in semen quality of goats are evident in temperate environments. Season significantly affected the semen quality of both Gorno Altai and South African indigenous goats. Gorno Altai bucks exhibited significant seasonal variation in semen production, with the best quality semen being produced during the breeding season. Semen quality was less affected by seasonal changes in the environmental temperature in indigenous bucks, which suggests a higher level of adaptability in subtropical environments. The semen characteristics of the Gorno Altai bucks were more favourable than those of indigenous bucks during the natural breeding season. This information could be of importance in an artificial insemination programme. It appears that the extent of these seasonal effects on the semen quality of the Gorno Altai are not so severe that it cannot be used for breeding purposes throughout the year, compared to indigenous goats.

Acknowledgements

The authors wish to thank the National Research Foundation (NRF) for their financial support and STATOMET at the University of Pretoria for the statistical analysis of the data.

References

Folch, J., 1984. The influence of age, photoperiodism and temperature on semen production of rams. In:M. Courot (Editor), The male in farm animal reproduction. Martinus Nijhoff, Amsterdam, pp.141-160

Greyling, J.P.C., 1988. Certain aspects of reproductive physiology in the Boer goat doe. D.Sc. Thesis, University of Stellenbosch, South Africa.

Loubser, P.G., Van Niekerk, C.H. & Botha, L.J.J., 1983. Seasonal changes in activity and semen quality in the Angora ram.1. Libido and male hormone concentrations. SA J. Anim. Sci. 13, 131-133.

Loubser, P.G., & Van Niekerk, C.H., 1983. Seasonal changes in sexual activity and semen quality in the Angora ram. 2. Semen volume, quality and freezability. SA J. Anim. Sci.13, 161-163

Roca, J., Martinez, E., Vazquez, J.M. & Coy, P., 1992. Characteristics and seasonal variations in the semen of Murciano-Granadina goats in the Mediterranean area. Anim. Reprod. Sci. 29, 255-265

Tegegne, A., Dembarga, Y., Kassa, T., Franceschini, R., 1994. Effect of plane of nutrition and season on body and testicular growth and on semen characteristics in Boran X Friesian bulls in Ethiopia. Anim. Reprod. Sci. 36, 197-209

Vilakazi, D.M. & Webb, E.C., 2004. Effect of age and season on sperm morphology of Friesland bulls at an artificial insemination centre in South Africa. SA J. Anim. Sci. 34(1), 62-69.

Webb, E.C., Mamabolo, M.J., Du Preez, E.R. & Morris, S.D., 1998. Research and training strategies for goat production systems in South Africa. Proceedings of a workshop held on 22-26 November, 1998. E.C. Webb & P.B. Cronje. p 81-87

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Content and fatty acid composition of plasma lipids of goat kids receiving a fish oil supplemented diet

V. Banskalieva[a#], V. Tzvetkova[b], P. Marinova[a] and R. Puchala[c]
[a] Institute of Animal Science, Kostinbrod, Bulgaria
[b] Institute of Cryobiology and Food Technologies, Sofia, Bulgaria
[c] E (Kika) de la Garza American Institute for Goat research, Langston, OK, USA

Abstract

Two groups of five male kids (3 months of age) each were fed for 33 days on iso-nitrogenous diets, containing either no added fat (control), or experimental, fish oil added (2.5% of wet weight of concentrate). It was found that feeding fish oil decreased significantly ($p<0.05$) the contents of plasma free fatty acids (FFA) and triacylglycerols (TG), whereas the concentrations of phospholipids (PL) and cholesterol remained the same. Fish oil treatment did not change the proportion of C16:0 in FFA, TG and PL, but increased ($p<0.01$) the C16:0 content in cholesterol esters (ChE). The proportions of C18:0 was depressed in all lipid classes studied, whereas oleic acid was enhanced in FFA, TG and PL. The percentage of linoleic acid was increased both in ChE and FFA, decreased in TG, but was not changed in PL. Fish oil supplementation elevated the contents of C20n-3 and C22n-3 in PL and ChE. The increase of n-3PUFA lowered the n-6/n-3 ratio. The results of this study show that fish oil supplementation markedly affects the fatty acid composition of plasma lipids in kids. The observed changes in plasma lipid classes may have important implications in the structure and function of various cell membranes.

Keywords: kids, fish oil, plasma lipids, fatty acids.
[#] Corresponding author; E-mail: vbanskalieva@hotmail.com

Introduction

Increasing n-3 C_{20} and C_{22} long chain PUFA in the diet of ruminants is considered a desirable strategy to increase the content of these nutritionally important fatty acids in meat and milk in relation to human health. Investigations with lambs and calves, but not with goats, showed that diets supplemented with fish meal or fish oil influenced the fatty acid composition of meat lipids, by increasing the levels of n-3 polyunsatureted fatty acids (Jenkins & Kramer, 1990; Ponnampalan *et al.,* 2001)**.** In our previous study with kids it was found that a fish oil supplemented diet had a noticeable effect on the deposition and distribution of body fat (Marinova *et al*., 2003), suggesting that diets rich in long-chain PUFA could be a repartitioning factor for carcass fat in goats. In this study we were particularly interested in the effect of a fish oil supplemented diet on the content and fatty acid composition of plasma lipid classes of kids.

Material and Methods

Two groups of five male kids (age 3 months) were fed iso-nitrogenous diets for 33 days, as described in a previous paper (Marinova *et al.,* 2001), which contain either no added fat (control), or experimental, fish oil added (2.5% of wet weight of concentrate). Kids from both groups were offered their total ration of concentrate and hay (600g and 960g, respectively for each animal) in half, two times a day. Daily dry matter intake (kg/per animal), daily fat intake (g/per animal) and daily energy intake (MJ/per animal) for the control and experimental group, were 1.463; 31.03 and 46.03; 12.7 and 13.2, respectively. Blood samples were taken in the morning, 4 hours after the last feeding. Plasma was extracted according to the method of Bligh and Dyer (1959). Aliquots of the lipid extracts were submitted for cholesterol and phospholipids assay, using the methods of Sperry and Webb (1950) and Bartlet *et al*., (1959), respectively. Methyl esters of phospholipids (PL), free fatty acids (FFA), triacylglycerols (TG) and cholesterol esters (ChE), isolated by preparative TLC, were obtained using a 0.01% solution of sulfuric acid in dry methanol at 47^{o}C for 14h for FFA, TG and PL, and 57^{o} C for 16h for cholesterol esters, as described by Christie (1973). The fatty acid compositions of the lipid fractions, as well as the contents of FFA and TG, using internal standards (heptadecanoic acid and triheptadecain) were analyzed by gas chromatography. For statistical evaluation of the results *t*-criterion of Student was used.

Peer-reviewed paper: 8th International Conference on Goats

Results and Discussion

A fish supplemented diet significantly reduced plasma TG ($p<0.05$) and FFA ($p<0.05$) by 21.45% and 35.8%, respectively (Table 1). The observed changes for the TG were similar to results reported by Ikeda *et al*. (2001), Kitessa *et al*., (2001), Ponnampalan *et al*.,(2001). The constancy of the plasma PL and cholesterol concentrations (Table 2), however, differed from the results of Jenkins and Kramer, (1990); Ponnampalan *et al.,* (2001) showed a decrease in these two lipid classes in calves and sheep, which were fed fish oil diets.

In experimental animals the relative proportion of C16:0 (Tables 1, 2) in FFA, TG and PL remained the same, whereas in ChE it was significantly increased ($p<0.01$). The proportion of C18:0 was significantly depressed in all studied lipid classes studied, and a decrease in the percentage of C18:1 in ChE was also noticed. Similar changes were reported by Kitessa *et al*. (2001). The increased relative proportion of oleic acid in FFA ($p<0.01$), TG ($p<0.001$) and PL ($p<0.001$), however differs from the results of Jenkins and Kramer, (1990) and Kitessa *et al*. (2001). Different effects of fish oil supplementation on the n-6 fatty acids in the fourth lipid classes were observed. The linoleic acid content did not change in PL, tended to increase in ChE (which agrees with the data of Jenkins and Kramer, 1990), was significantly higher ($p<0.05$) in FFA, and decreased ($p<0.05$) in TG (contrary to data of Kitessa *et al*., 2001). Arachidonic acid tended to decrease in both ChE and PL, whereas an opposite tendency for the proportions of C22:5 n-6 was noticed.

Table 1 Fatty acid composition (Molar %) of plasma free fatty acids and triacylglycerols in kids fed a fish oil supplemented diet

Fatty acids	Free fatty acids				Triacylglycerols			
	Groups[a]							
	Control		Experimental		Control		Experimental	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
14:0	3.57	0.25	4.10	0.42	1.79	0.15	1.69	0.24
15:0	2.65	0.78	1.99	0.30	1.41	0.22	1.63	0.18
16:0	30.79	1.78	33.01	0.51	25.42	1.11	26.00	0.35
16:1	3.37	0.39	3.66	0.29	1.90	0.06	3.73***	0.37
17:0	3.09	0.89	2.16	0.20	1.67	0.17	2.33	0.94
18:0	35.54	1.35	26.66***	1.15	36.95	1.53	18.10***	2.45
18:1	15.36	0.79	20.11**	1.26	24.71	1.02	41.64***	2.10
18:2 n-6	4.22	0.92	6.63*	0.61	5.24	0.41	4.01*	0.23
18:3 n-3	1.41	0.19	1.68	0.10	0.91	0.09	0.87	0.21
USFA[b]	24.36		32.08		32.76		50.25	
n-6/n-3	2.99		3.95		5.75		4.61	
Free fatty acids[c]	15.18	2.09	9.74*	0.62				
Triacylglycerols[c]					30.44	2.02	23.91*	1.65

[a] Control: no added fish oil; experimental : fish oil supplemented diet (2.5% of concentrate wet weight);
[b] USFA – unsaturated fatty acids; [c] (μM/100 ml); * $p < 0.05$; ** $p < 0.01$; *** $p< 0.001$.

Fish oil treatment elevated the sum of n-3 PUFA fatty acids, and as a result the ratio n-6/n-3 was reduced by 19% and 27% for PL and ChE, respectively (Tables 1 & 2). The content of C20:5n-3 was increased significantly in PL ($p<0.05$) and ChE ($p<0.05$).These results are in agreement with those reported by Jenkins and Kramer, (1990); and Kitessa *et al*. (2001). In both lipid classes the percentage of C22:6n-3 tended to increase, while C22:5 decreased ($p<0.01$). According to Bauer *et al*., (1997) C20:5 n-3 is preferentially incorporated into lipids.

The variations of the proportions of the individual fatty acids influenced the sum of unsaturated fatty acids, being increased in FFA, TG and PL, but not in ChE. The lower content of FFA probably reflects an increased consumption from the different tissues. Triacylglycerol synthesis and secretion as hepatic output of VLDL (the primary source of lipids for extrahepatic tissues) is directly related to FFA uptake (and therefore to the plasma concentration and composition of FFA) as was shown by Heimberg *et al*. (1974). The results of this study support the suggestion of Ikeda *et al*. (2001) that the lowering of plasma TG after fish oil supplementation, is a result of a depression of liver TG secretion, rather than changes in intestinal synthesis or absorption (Ponnampalan *et al*.,2001). Despite of the fact that the content of plasma PL was not changed in the treated animals, the changed PL fatty acid profiles, however, suggest that the dietary long-chain n-3

Peer-reviewed paper: 8th International Conference on Goats

PUFA influence the liver reactions of deacilation-acylation, where new-formed PL molecular species are secreted into blood plasma. The enriched PL molecules in long-chain PUFA may encourage the formation of ChE with long-chain n-3 PUFA via the plasma lecithin-cholesterol acyltransferase reaction. However, this process occurs much more slowly than esterification with n-9 and n-6 fatty acids (Parks *et al*., 1989). Most likely, the considerable accumulation of long–chain n-3 PUFA in PL results in a relative deficiency of C18:2 (n-6) and C18:3 (n-3) fatty acids, and in order to supply a substrate for cholesterol esterification, the synthesis of endogenous C18:1 n-9 increases. The higher content of oleic acid, and concomitant decrease in stearic acid (Table 2), suggests that the PUFA flow to the liver affected the activity of stearoyl-CoA desaturase.

Table 2 Fatty acid composition (Molar %) of plasma phospholipids and cholesterol esters of kids fed a fish oil supplemented diet

Fatty acids	Phospholipids				Cholesterol esters			
	Groups[a]							
	Control		Experimental		Control		Experimental	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
14:0	0.47	0.10	0.37	0.12	1.46	0.47	1.06	0.16
15:0	0.54	0.03	0.67	0.17	0.65	0.04	1.00***	0.05
16:0	18.23	0.69	17.94	1.16	13.84	0.43	18.14**	0.92
16:1	0.83	0.05	0.70***	0.11	3.48	0.38	5.92**	0.39
17:0	1.11	0.08	1.32	0.06	0.60	0.07	1.08	0.29
17:1	0.58	0.05	0.74	0.06	1.48	0.30	1.72	0.14
18:0	30.30	1.32	9.87**	2.00	4.69	0.40	2.28*	0.55
18:1	19.35	1.07	27.91***	1.27	31.87	1.68	22.88**	1.51
18:2 n-6	19.35	0.74	20.68	1.24	34.57	2.94	37.34	1.81
18:3 n-3	0.62	0.09	0.91	0.18	0.88	0.11	1.27	0.18
20:2 n-6	0.50	0.08	0.53	0.14	0.53	0.11	0.53	0.10
20:3 n-6	0.49	0.11	0.74	0.15	0.47	0.07	0.40	0.08
20:4 n-6	4.35	0.81	3.71	0.64	1.65	0.19	1.53	0.23
20:5 n-3	0.26	0.07	0.76*	0.16	0.12	0.02	0.49**	0.06
22:5 n-6	1.20	0.09	1.36	0.18	1.82	0.13	1.91	0.2
22:5 n-3	0.39	0.02	0.22***	0.03	0.25	0.02	0.23	0.04
22:6 n-3	1.43	0.26	1.57	0.14	1.64	0.29	2.22	0.40
USFA[b]	49.35		59.83		78.76		76.54	
n-6/n-3	9.59		7.81		13.51		9.91	
Phospholipids[c]	65.03	5.93	67.24	5.29				
Cholesterol[c]					60.88	3.16	63.12	4.8

[a] Control: no added fish oil; experimental : fish oil supplemented diet (2.5% of concentrate wet weight);
[b] USFA – unsaturated fatty acids; [c] (mg/100 ml); * $p < 0.05$; ** $p < 0.01$; ***$p< 0.001$

Conclusion

The results of this study show that fish oil supplementation significantly affects the fatty acid composition of and function of various cell membranes.

References

Bartlett, G., 1959. Phosphorus assay in column chromatography. J. Biol. Chem., 234, 466-468.

Bayer, J.E., McAlister, K.G., Rawlings, J.M., & Markwell, P., 1997. Molecular species cholesterol esters formed via plasme lecithin:cholesterol acyltransferase in fish oil supplemented dogs. Nutr. Res., 17, 861-872.

Bligh, E. & Dyer, W. 1959. A rapid method of total lipid extraction and purification. Can. J. Biochem. Physiol., 37, 911-917.

Cristie, W.W**.** 1973. Lipid analysis, Pegamon Press, Oxford.

Jenkins, K.J. & Kramer, J.K.L., 1990. Effects of dietary corn oil and fish oil concentrate on lipid composition of calf tissues. J. Dairy Sci., 73, 2940-2951.

Heimberg, M., Wilcox, H. G., Woodside, G. D., Breen, K. J. & Soler-Agilaga, C. 1974. Studies on the regulation of secretion of the very low density lipoprotein, and on ketogenesis by the liver, in

Peer-reviewed paper: 8th International Conference on Goats

Regulation of Hepatic Metabolism, Lindquist., F. and Tygstrup, N., eds, Munksgaard, Copenhagen, pp. 119-143.

Ikeda, I., J. Kumamaru, N. Nakatani, M. Sakono, I. Murota, K. & Imaaizumi, K.,2001. Reduced hapatic triglyderide secretion in rats fed docosahexaenoic acid-rich fish oil suppresses postprandial hypertriiglyceridemia, J. Nutr., 131, 1159-1164.

Kitessa, D.M., Gulati, S.K.,.Ashes, J.R., Fleck,E., . Scott T.W. & Nickols, P.D., 2001. Utilisation of fish oil in ruminants. I.Fish oil metabolism in sheep, Anim. F.Sci. Tech., 89 (3-4), 189-199.

Marinova, P., Banskalieva, V., Alexandrov, S., Tzvetkova, V. & Stanchev, H. (2001). Carcass composition and meat quality of kids fed sunflower oil supplemented diet. Small Rum. Res., 42, 219-227.

Marinova, P., Banskalieva, V. & Tzvetkova, V., 2003., Body and carcass composition, and meat quality of kids fed fish oil supplemented diet. Options Mediterraneennes (In press).

Parks,J.S., Bullock, B.C. & Rudel, L.L., 1989. The reactivity of plasma phospholipids with cholesterol acyltransferase is decreased in fish oil-fed monkeys. J. Biol. Chem., 5, 2545-2551.

Ponnampalam, E.N., Sinclair, A.J.,.Egan, A.R, Blackley, S.J., Li, D. & Leury, B.J., 2001. Effect of dietary modification of muscle long chain n-3 fatty acid on plasma insulin and lipid metabolites, carcass traits, and fat deposition in lambs, J. Anim. Sci., 79, 895-903.

Sperry, W.W. & Webb, M., 1950. A revision of the Schoenheimer-Sperry method for cholesterol determination. J. Biol. Chem., 187, 97-101.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Characterization of Maltese goat milk cheese flavour using SPME-GC/MS

B. Chiofalo[1], A. Zumbo[1], R. Costa[1], L. Liotta[1], L. Mondello[2], P. Dugo[3] and V. Chiofalo[1]
[1]Dept. MO.BI.FI.P.A. – University of Messina, Polo Universitario dell'Annunziata, 98168 Messina, Italy
[2]Dept. Farmaco-chimico, University of Messina, Viale Annunziata, 98168 Messina, Italy
[3]Dept. Chimica Organica e Biologica, University of Messina, Salita Sperone, 98168 Messina, Italy

Abstract
The effect of lactation on the flavour of cheese made with raw milk of Maltese goats bred in Sicily (Italy) was studied. The goat cheese flavour was analyzed, for the first time, by Solid Phase Microextraction (SPME) coupled with Gas chromatography/Mass Spectrometry (GC/MS). The suitability of the analytical method was determined by calculating the coefficients of variation (CV%). Data were processed using ANOVA in relation to the stage of lactation. Forty four components (methyl ketones, free fatty acids, aldehydes, alcohols, esters, terpenes and lactones) were identified and quantified (percentage areas). The most representative fatty acids were Butyric, Caproic, Caprylic and Capric (from 30 to 75% of the total identified fraction). Many other important cheese odorants were determined giving a substantial contribution to the aroma profile. The highest percentages were, for alcohols: Isoamyl and Phenethyl alcohols at the 2nd month of lactation (6.82% and 2.81%, respectively); as regards ketones, at the 5th and 6th months of lactation: 2-Heptanone (7.88% and 10.10%, respectively) and 2-Nonanone (18.52% and 14.81%, respectively); the highest percentage of esters (2.5%) was found at the 7th month of lactation. The lactation significantly influenced the flavour components. Good CV% were obtained (less than 5.0). This easy and fast method permitted a quali-quantitative description of the goat's cheese flavour in relation to the lactation. The results testify the difficulty in attributing the variations to a single effect so as to standardize this product, even if this analytical method could help to give some indications, before marketing, regarding the consumer's perception and acceptance.

Keywords: Goat's cheese; cheese flavour; SPME-GC/MS.
#Corresponding author; E-mail: biagina.chiofalo@unime.it

Introduction
Goat's milk has played an important role in human nutrition for a long time because of its nutritional and dietetic characteristics (Morand-Fehr *et al.*, 2000). It is often processed into cheese. Goat's cheese is of a hard-texture, made with full-cream raw milk. Curdling is carried out in woody tubs at 35°C for 45 min by adding lamb's rennet. The ripening ranges from a few days to some months (Rubino, 1996). Its sensorial profile is particularly appreciated among cheese tasters. Cheese flavour originates from bio-degradation processes occurring during ripening, lipolysis and proteolysis being the most important ones. Flavouring molecules, such as methyl ketones (e.g. 2-nonanone: fruity) or secondary alcohols (e.g. 2-pentanol: mild green) are often distinctive character-impact flavour compounds, even at trace levels (Urbach, 1973). Dairy farmers are today more concerned about the knowledge of the chemistry of flavours, because this can help the assessment of a cheese quality and authenticity. Since the flavour somewhat reflects what is in the cheese itself, the aroma screening can provide more information about the manufacturing, the diet of the animals and the ripening time (Wilson, 1993). Substantially, it can satisfy the increasing demand for food safety and the food products' traceability.

The flavour chemistry is a quite recent development of food chemistry, mostly due to the introduction of gas chromatography and mass spectrometry (Fennema, 1985). The analysis of flavours requires initial isolation of volatiles from the sample matrix and their simultaneous concentration; this should be carried out without distorting the flavour chemical composition. In this perspective, a useful tool has proved to be Solid Phase Microextraction (SPME), a solventless extraction technique introduced in the early 1990s (Pawliszyn, 1997). It mainly consists of a special holder (that features as a syringe for GC) provided with a silica support coated with a stationary phase (fibre). Chemical compounds are absorbed onto the fibre, which is exposed to the sample headspace, and then desorbed into the hot GC injector.

Since the composition of milk, consequently of the cheese manufactured from it, is influenced by many variables, such as stage of lactation, feeding regime, age and breeding system, this paper represents a first step towards a more extensive evaluation of the cheese aroma composition.

Peer-reviewed paper: 8th International Conference on Goats

The purpose of this study was to investigate the variations of the flavour of goat cheese during lactation, through the application, for the first time, of an easy, fast and reliable analytical method.

Materials and methods

The research was carried out on six batches of cheese processed using milk of the same goats of the Maltese race at a different stage of lactation. The animals, of different ages (from 2 to 5 years) and order of kidding, were bred in extensive conditions on mixed pasture in the province of Agrigento (Italy) and during the winter they received 400 g/head/d of concentrate (DM=90.88%; on a DM basis: CP=20.5%, EE=2.31%, CF=5.55%) and 1 kg/head/d of meadow hay (DM=94.03%; on a DM basis: CP=10.19%, EE=0.97%, CF=32.81%). The chemical composition of the feed was determined according to the A.O.A.C. (2000) official methods. Every month, from the 2nd to the 7th month of lactation (from November to April), individual milk samples were taken from the same animals by hand milking and processed using the traditional method of cheese making (Rubino, 1996). The batches of cheese, weighing 500 g each, were ripened for 1 month; at the end of the ripening each batch of cheese was divided into three samples; all the samples were put under vacuum and kept at –18°C until analysis. For the analyses, each sample of cheese was defrosted at room temperature and freed of the rind before grinding. Samples of approximately 3 g each were placed in a 10 ml vial and then sealed.

For the SPME process an AOC-5000 (Shimadzu) autosampler was used, equipped with a fibre, provided by Supelco (Milan, Italy) coated with the following sorbent material: Divinylbenzene/Carboxen/Polydimethylsiloxane. The sample extraction was as follows: the vial containing the cheese was heated at 60°C for 10 min and agitated (clockwise-anticlockwise alternate rotation) at 500 rpm. Subsequently, the SPME fibre was exposed to the cheese headspace for 50 min at 60°C under the aforementioned agitation parameters. The fibre was then inserted in the GC injector and held for 5 min. GC analyses were performed on a Shimadzu gas chromatograph GC-2010 (Shimadzu, Milan, Italy), equipped with an FID detector and a GC Solution software for data acquisition (Shimadzu). The capillary column was an RTX-1301 (Restek, PA, USA) 30 m x 0.25 mm x 0.25 μm and temperature programmed as follows: 40°C (5 min) to 230°C at 5°C/min. The GC was equipped with a split/splitless injector (250°C), operated in a splitless mode for 5 min, then with a split ratio of 20:1. The carrier gas was helium at a linear velocity of 35 cm/sec. FID temperature: 280°C. Detector gases: H_2, at 50 mL/min; air, at 400 mL/min; makeup, at 50 mL/min (Air/N_2). GC/MS analyses were carried out on a Shimadzu GCMS 2010 (Shimadzu, Milan, Italy) in order to identify cheese aroma compounds by comparing their MS spectra with those present in reference libraries of the mass spectrometer. The gas chromatographic conditions were the same as for GC-FID analyses, except for column pressure (44.5 kPa).

The suitability of the analytical method was determined only in one batch of cheese (3rd month of lactation) by calculating the coefficient of variation (CV% = (mean value of three percentage areas/standard deviation of three percentage areas) x 100) for each chemical component relative to the three (one for each sample) repeated measurements. Data were processed using ANOVA (GLM proc. – SAS, 2001) considering the variable: month of lactation.

Results and Discussion

Tables 1, 2, 3, 4, 5 show the mean values of the 44 components expressed as percentages of the total identified fraction, the root standard error of the means (SEM), the statistical significance of differences (*P*) in relation to lactation and the coefficient of variation (CV %) values referred to the 3rd month of lactation.
Among the flavour components the acids (ranging from C_4 to C_{12}) were the most abundant (37-79%), followed by ketones (4-32%), alcohols (2-10%), esters (1-2%), terpenes (0.8-1.7%) and aldehydes (0.06-0.6%). The higher levels of Caprylic, Capric and Lauric acids at the 2nd, 3rd, and 4th month of lactation (table 1) could be correlated to the integration of concentrate and hay in the feeding regime of the goats during the winter months (November, December and January) as reported by Urbach (1979).

As regards alcohols (Table 2), isoamyl alcohol and phenethyl alcohol showed the highest level in the 2nd month of lactation; ketones (table 3) were more concentrated in the 5th and the 6th months of lactation; esters (Table 4) account for about 2.5% in the 7th month of lactation. In addition, the presence of two terpenes (table 5), β-pinene and limonene, must be highlighted responsible for the green/grassy flavour of the milk fat, both being typical constituents of the volatile fraction in citrus essential oils; the presence of these terpenes can be noticed more at certain seasons of the year (Wilson, 1989) and it is strictly correlated to the

Peer-reviewed paper: 8th International Conference on Goats

diet of the goats (e.g. administration of citrus by-product, Chiofalo *et al*., 2004). Flavour components (tables 1, 2, 3, 4, 5) were influenced ($P < 0.0001$ and $P < 0.001$) by the lactation, except the Lauric acid which showed no differences ($P>0.05$) in relation to the month of lactation (Table 1).

Table 1 Mean (% of the total identified fraction), SEM and Probability values of the acids in the flavour of goat cheese processed using milk from the 2nd to the 7th month of lactation.

Compound (%)	2nd	3rd	4th	5th	6th	7th	*P*	SEM	CV%*
Acetic acid	3.909	1.961	2.333	5.458	2.726	4.288	0.005	0.944	2.69
Isobutyric acid	0.098	0.1	0.104	0.402	0.074	0.078	<0.0001	0.012	0.21
Butyric acid	5.118	6.561	8.666	5.347	8.6	9.164	<0.0001	0.317	1.79
Isovaleric acid	0.511	0.577	0.548	0.670	0.619	0.288	<0.0001	0.022	2.24
2-Methyl butyric acid	0.103	0.166	0.124	0.165	0.13	0.084	<0.0001	0.008	3.20
Caproic acid	26.18	26.715	19.603	11.968	21.016	31.352	<0.0001	4.351	0.63
Heptanoic acid	0.19	0.297	0.217	0.107	0.175	0.307	<0.0001	0.074	2.69
Caprylic acid	18.254	23.566	28.615	6.335	11.207	17.847	<0.0001	0.949	3.09
Benzoic acid	0.18	0.067	0.038	0.029	0.045	0.32	<0.0001	0.019	0.85
4-Methyl octanoic acid	0.017	0.038	0.06	0.041	0.133	0.041	<0.0001	0.015	2.55
Nonanoic acid	0.124	0.192	0.141	0.084	0.106	0.136	<0.0001	0.019	2.01
Capric acid	14.542	17.859	16.991	6.195	7.573	11.224	<0.0001	1.101	5.73
Lauric acid	0.776	1.118	1.199	0.401	0.217	0.444	0.0544	0.417	1.09

* values referred to the 3rd month of lactation

Table 2 Mean (% of the total identified fraction), SEM and Probability values of the alcohols in the flavour of goat cheese processed using milk from the 2nd to the 7th month of lactation.

Compound (%)	2nd	3rd	4th	5th	6th	7th	*P*	SEM	CV%*
Ethyl alcohol	0.419	4.942	1.591	3.986	3.526	5.427	<0.0001	0.303	4.59
2-Pentanol	0.057	0.4	0.091	0.421	0.696	0.188	<0.0001	0.020	3.11
Isoamyl alcohol	6.824	0.835	0.191	0.242	0.456	1.73	<0.0001	0.195	3.20
2-Heptanol	0.182	1.545	0.123	0.363	1.14	0.302	<0.0001	0.043	4.75
2-Decanol	0.045	0.44	0.171	0.266	0.739	0.129	<0.0001	0.062	4.47
Phenethyl alcohol	2.806	0.304	0.105	0.186	0.38	0.768	<0.0001	0.017	2.26

* values referred to the 3rd month of lactation

Table 3 Mean (% of the total identified fraction), SEM and Probability values of the ketones in the flavour of goat cheese processed using milk from the 2nd to the 7th month of lactation.

Compound (%)	2nd	3rd	4th	5th	6th	7th	*P*	SEM	CV%*
Acetone	1.025	1.294	1.114	0.54	1.338	1.167	<0.0001	0.119	3.44
2-Pentanone	0.354	0.108	0.577	4.056	5.122	0.27	0.0002	1.101	4.18
2-Heptanone	1.143	1.104	1.705	7.877	10.104	1.381	<0.0001	0.439	4.98
2-Octanone	0.013	0.023	0.017	0.201	0.156	0.007	<0.0001	0.022	3.92
8-Nonen-2-one	0.024	0.075	0.15	0.348	0.466	0.085	<0.0001	0.019	2.35
2-Nonanone	1.772	1.604	2.674	18.521	14.812	3.48	<0.0001	1.045	3.62
2-Undecanone	0.024	0.013	0.015	0.392	0.006	0.065	<0.0001	0.456	3.94

* values referred to the 3rd month of lactation

Table 4 Mean (% of the total identified fraction), SEM and Probability values of the esters in the flavour of goat cheese processed using milk from the 2nd to the 7th month of lactation.

Compound (%)	2nd	3rd	4th	5th	6th	7th	*P*	SEM	CV%*
Ethyl butyrate	0.744	0.162	0.116	0.449	0.205	0.322	<0.0001	0.609	2.75
Ethyl caproate	0.055	0.449	0.392	0.820	0.62	1.07	<0.0001	0.036	3.95
Isoamyl butyrate	0.427	0.039	0.043	0.031	0.037	0.265	<0.0001	0.019	4.41
Ethyl caprylate	0.063	0.506	0.298	0.285	0.417	0.476	<0.0001	0.017	2.89
Ethyl caprate	0.071	0.497	0.256	0.154	0.142	0.333	<0.0001	0.014	3.91
Ethyl laurate	0.007	0.023	0.011	0.019	0.013	0.015	<0.0001	0.002	2.10

* values referred to the 3rd month of lactation

Peer-reviewed paper: 8th International Conference on Goats

Table 5 Mean (% of the total identified fraction), SEM and Probability values of the miscellaneous compounds in the flavour of goat cheese processed using milk from the 2nd to the 7th month of lactation.

Compound (%)	2nd	3rd	4th	5th	6th	7th	*P*	SEM	CV%*
Hexanal	0.155	0.366	0.058	0.133	0.07	0.084	<0.0001	0.018	1.89
Nonanal	0.037	0.117	0.057	0.397	0.076	0.108	<0.0001	0.415	0.01
Decanal	0.009	0.022	0.006	0.082	0.006	0.021	<0.0001	0.005	3.59
□-Pinene	0.144	0.06	0.01	0.117	0.21	0.06	0.0005	0.054	4.44
Limonene	1.032	0.623	1.038	0.693	1.536	0.255	<0.0001	0.079	0.69
Acetonitrile	0.266	0.756	0.201	0.573	0.343	0.195	<0.0001	0.099	2.75
Hexane	0.155	0.366	0.058	0.133	0.07	0.084	<0.0001	0.018	1.89
1,3-Dimethoxy Benzene	0.008	0.193	0.089	0.059	0.043	0.063	<0.0001	0.028	4.31
Tetradecane	0.113	0.016	0.011	0.033	0.007	0.018	<0.0001	0.010	3.18
□-Decalactone	0.039	0.039	0.028	0.066	0.028	0.024	<0.0001	0.005	3.27
Heptadecane	0.01	0.011	0.022	0.02	0.008	0.052	<0.0001	0.457	2.41

* values referred to the 3rd month of lactation

All the data obtained in this research are in agreement with those provided by the specific literature (Larràyoz *et al.*, 2001), as many components identified in the samples analyzed are considered typical of the flavour of goat cheese. Among these, Caproic, Caprylic and Capric acids and their corresponding esters, have already been reported in other works, where the extraction of the cheese aroma was carried out not only by SPME, but also by means of conventional techniques such as SDE (Simultaneous Distillation Extraction) solvent extraction, dynamic and static headspace (Sablè & Cottenceau, 1999).

The analytical method developed in the present study is based on the use of an automated SPME system that permitted to draw from the analyses CV% values slightly higher than 5.0 (Capric acid = 5.73%), an astonishing result if considering that when operating SPME by hand it is often difficult to obtain CV% values that are less than 10. In addition, the use of an SPME autosampler permits to avoid artefact formation (ghost peaks in the chromatogram) often due to the several steps needed for sample preparation. It could be combined with the sensorial (Rouel *et al.*, 2002), GC/sniffing and GC/olfactometer (GC/O) analyses (Moio, 1998) to evaluate in detail the effects of changes within the sensory profile of a dairy product (Wilson & Ken, 1998).

Conclusions

For the first time solid phase microextraction hyphenated with gas chromatography/mass spectrometry (SPME-GC/MS) has been applied to the analysis of the aroma of goat cheese.

In relation to the influence of lactation, the results show remarkable quantitative fluctuations obtained for each component of the cheese flavour and they suggest, for these products, the difficulty in evaluating separately the different variables (stage of lactation, season, availability of pasture, breeding system and so on) which influence the sensorial profile of the milk and of the cheese manufactured from it where, moreover, various biochemical events occur. Nevertheless, in Sicily, it is very difficult to standardize the breeding conditions of the goat as well as its productions; this is due to the typical breeding system of these animals which is the semi-extensive condition, in order to allow the exploitation of marginal areas, greatly represented in this region.

Acknowledgements

Research financed by P.R.A. - 2000 (A. Zumbo) and P.R.A. - 2002 (V. Chiofalo).

References

A.O.A.C., 2000. Official Methods of analysis (17th ed.). Association of Official Analytical Chemists, Suite 500, 481 North Frederick Avenue, Gaithersburg, Maryland USA.

Bourbouze, A., 1982. Utilisation de la végétation de type méditerranéèn par des caprins. Fourages, 92, 95-106.

Chiofalo B., Todaro M., Costa R., Alicata M.L., Chiofalo V. & Giaccone P., 2004. Influenza del pastazzo di limone sulla qualità del formaggio pecorino. Proceedings of the 16th National Congress of Società Italiana di Patologia e Allevamento degli ovini e dei caprini – S.I.P.A.O.C.. *In press*.

Peer-reviewed paper: 8th International Conference on Goats

Fennema, O.R., 1985. Flavours. In: Food Chemistry. Ed. Marcel Dekker, Inc., New York and Basel, 585-627.

Larràyoz, P., Addis, M., Gauch, R. & Bosset, J.O., 2001. Comparison of dynamic headspace and simultaneous distillation extraction techniques used for the analysis of the volatile components in three European PDO ewes' milk cheeses. Int. Dairy J. 11, 911-926.

Moio L., 1998. L'identificazione dei marcatori molecolari della "tipicità" sensoriale dei prodotti lattiero-caseari. Caseus 3, 62-64.

Morand-Fehr, P., Sanz Sampelayo, M.R., Fedele, Y.V., Le Frileux, Y., Eknaes, M., Schmidely, P.H., Giger Reverdin, S., Bas, P., Rubino, R., Havrevoll, Ø. & Sauvant, D., 2000. Effects of feeding on the quality of goat milk and cheeses. Proceedings of the 7th International Conference on Goats I, 53-58.

Pawliszyn, J., 1997. Solid Phase Microextraction, theory and practice. Ed. Wiley-VCH, New York, 1-228 pp.

Rouel J., Gaborit P., Chabosseau J.M., Raynal K., Ferlay A., Lauret A. & Chilliard Y., 2002. Effect of forage type and lipid supplementation on milk fatty acid composition and sensorial quality of goat dairy products. Proceedings of the 9èmes Rencontres Recherches Ruminants, 359-362.

Rubino R., 1996. L'allevamento caprino. Ed. Associazione Nazionale della Pastorizia, Roma, 1-279 pp.

Sablè, S., Cottenceau, G., 1999. Current knowledge of soft cheeses flavour and related compounds. J. Agric. Food Chem. 47, 4825-4836.

SAS, 2001. Statistical Analysis System user's guide (vers. 8.2), SAS Institute Inc., Cary, NC.

Urbach, G., 1979. The flavour of milk fat. Proceedings of the Milk Fat Symp. Dairy Research Laboratory, Division of Food Research, CSIRO, Aust. Soc. Dairy Technol., Highett, Victoria, Australia, page 18.

Wilson R.D., 1989. Flavour volatile from New Zealand milkfat. Proceedings Int. Conf. Fats, "Fats For the Future" II, Auckland, NZ, R. Soc. N.Z., Wellington, NZ.

Wilson, R.D., 1993. The effect of feed on the flavour components of milkfat. Proceedings of the Milkfat Flavour Forum 1992., Ed. New Zealand Dairy Research Institute, Palmerston North, New Zealand, 68-71.

Wilson R. D. & Ken A.R., 1998. The effect of feed-type on milkfat flavour. Caseus 3, 34-41.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Fleece and skin traits of goats of different genetic types reared in southern Italy

A. Di Trana[1#], P.Celi[1], L. Sepe[2], S. Desantis[3], and R. Rubino[2]
[1]Dipartimento di Scienze delle Produzioni Animali, Università della Basilicata, 85100 Potenza, Italy,
[2]Istituto Sperimentale per la Zootecnia, 85010 Bella-Muro, Italy,
[3]Dipartimento Sanità e Benessere, Università di Bari, 70010 Valenzano, Italy.

Abstract

The aim of this study was to evaluate the qualitative and quantitative characteristics of down fibre production and of the percentage of active hair follicles in several genetic types of Italian goats. The trial was carried out in two regions of southern Italy, *Basilicata* and *Calabria*. Two hundred and eighty adult female goats of five different genetic types were used in this study: *Azzara* population, *Nicastrese* population, Red Syrian breed, Garganica breed and *Calabrese* population. A significant effect (P<0.05) of genetic type on cashmere diameter, standard deviation of cashmere diameter, yield, down length, guard hair length, crimps, secondary and active primary hair follicles was noted. *Calabrese* goats presented the lowest diameter values (13.03 μm) while the highest diameter was observed in the Red Syrian breed (13.88 μm). Cashmere yield was higher in *Calabrese* (9.6 %), *Nicastrese* (9.1 %), and Red Syrian (7.7 %), than in other genetic types. Cashmere length values were higher (P<0.05) in the *Nicastrese* (31 mm) and Calabrese (30 mm) groups than *Azzara* and Garganica groups. Guard hair length was lowest in *Azzara* population (88 mm) and highest in Garganica breed (233 mm). Active secondary follicles were higher in the *Calabrese, Azzara* and *Nicastrese* (57.9%, 51.5%, 43.9%) goats compared to Red Syrian and Garganica groups. The proportion of active primary follicles was similar in *Azzara*, *Nicastrese* and *Calabrese* goats, and it was lower than in Red Syrian and Garganica breeds.

Keywords: Goats, genetic type, cashmere fibre, yield, cashmere length, diameter, secondary follicles
[#]Corresponding author. E-mail: ditrana@unibas.it

Introduction

The size of the Italian goat herd has been estimated to be about 1,375,000 head, and 81 % of them are reared in the southern regions (FAO, 2002). The majority of Italian goats are represented by breed-populations characterised by different productive traits which depends on the variability of environmental and genetic factors. Goat farming is mainly oriented to dairy and meat production but, recently, attention has been focused on the production of animal fibre (Celi *et al*., 1999)**.** The body surface of goats with a double-coat is covered by two types of hair, one is long and coarse (guard hair) and the other one is short and fine (down hair): they originate, from the primary and secondary hair follicles respectively (Ryder, 1966). The growth of the fibre that originates from the secondary follicles, also known as cashmere, normally occurs between the summer and winter solstices. The sustainability of fine fibre production from the local breed-population of goats would be of great economic relevance since it would diminish the import of fine fibre. Furthermore it would represent an additional income for the farmer in addition to that from milk and meat production**.** Previously, we have observed that down fibres are produced by a local population of goats (Rubino *et al*., 2000). The aim of this study was to evaluate the qualitative and quantitative characteristics of down fibre production and of the percentage of active hair follicles in several genetic types of Italian goats.

Materials and Methods

The trial was carried out in two regions of southern Italy, *Basilicata* (41°N) and *Calabria* (39°N). Adult female goats of five different genetic types were used in this study: *Azzara* population (n=34), *Nicastrese* population (n=51), Red Syrian breed (n=65), Garganica breed (n= 68) and *Calabrese* population (n= 62). A hair patch sample of 10 cm^2 was taken from the mid-side of each animal using surgical clippers. Fibre samples were collected between the end of December and January of 2000/01. Fibre samples were placed in a temperature (20 ± 2°C) and relative humidity (65 ± 2%) controlled room overnight, as recommended by IWTO (1989). The hair patches were weighed, and then guard hair (GH) and down hair (D) were manually separated and their length (GHL and DL) measured. The samples were then placed in a temperature controlled room overnight. GH and D were individually weighed and the weight of the down fibres compared to that of the entire patch represented down yield (Y). Mean down fibre diameter (MFD)

Peer-reviewed paper: 8th International Conference on Goats

and standard deviation of mean down fibre diameter (MFD-sd) were measured in each animal using the OFDA (Optical Fibre Diameter Analyser), according to fibre diameter of measurement programme of Macaulay Animal Fibre Evaluations Laboratory. The number of crimps (CR) in down was counted on some fibres and scored. Undercoat fibre colour was recorded as white or coloured. Skin biopsies were taken from all animals using curved scissors, under local anaesthesia, from the same point as the fibre patches. The number of active primary (P) and secondary (S) hair follicles were determined via histological examination of skin biopsies chosen randomly from 10 subjects of each genetic type (SACPIC method as modified by Nixon, 1993).

The statistical analysis of MFD of the down, MFD-sd, Y, DL, GHL, CR, active secondary hair follicles and active primary hair follicles was carried out with the analyses of variance procedure, using SYSTAT (1992) statistical package with a monofactorial model (effect of genetic type**).** Data expressed as proportions were subject to an angular transformation before analysis. The differences between means were tested using the least significant difference.

Results and Discussion

A significant effect (P<0.05) of genetic type on MFD, MFD-sd, Y, DL, GHL and CR was noted (Table 1). *Calabrese* goats presented the lowest MFD and MFD-sd values while the highest MFD and MFD-sd was observed in the Red Syrian breed. No differences in MFD and MFD-sd were found between the other groups**.** *Calabrese* population presented the highest yield and Garganica the lowest; *Azzara*, *Nicastrese* and Red Syrian genotype groups had intermediary values for down yield compared to the previous groups. DL values were lower (P<0.05) in the *Azzara* and Garganica genetic types than the *Nicastrese* and Calabrese genetic types. Red Syrian goats presented intermediary values of DL. GHL was lowest in *Azzara* population and highest in Garganica breed. GHL was similar in *Nicastrese,* Red Syrian and *Calabrese* goats and it was longer than 100 mm. CR score was higher in Red Syrian, Garganica and *Azzara* groups than in *Nicastrese* and *Calabrese* genetic types. Secondary fibre colour was white in the *Azzara* and *Calabrese* goats and it was coloured in the Red Syrian, Garganica. *Nicastrese* goats fibres were 50% white and 50% coloured.

Table 1 Least squares means for mean fibre diameter (MFD), standard deviation of mean fibre diameter (MFD-sd), yield (Y), down length (DL), guard hair length (GHL) and crimps (CR)

Genetic type	MFD µm	MFD-sd µm	Y %	DL mm	GHL mm	CR score
Azzara	13.21 ab	3.64 ac	6.1 ab	23 a	88 a	4.3 a
Nicastrese	13.29 ab	4.03 ac	9.1 ac	31 b	125 b	3.0 b
Red Syrian	13.88 a	4.56 a	7.7 ac	26 ab	102 ab	4.6 a
Garganica	13.24 ab	2.95 bc	3.8 b	24 a	233 c	4.4 a
Calabrese	13.03 b	2.42 b	9.6 c	30 b	119 b	2.5 b
Pooled SE	0.30	0.51	1.32	2.11	9.23	0.3

a,b,c column means with different superscripts differ (P<0.05)

The percentage of active secondary hair follicles and active primary hair follicles (Table 2) were significantly affected by genetic type (P<0.05). The proportion of active secondary hair follicles was highly variable between genetic types, with the highest percentage (P<0.05) recorded in the *Calabrese* goats. The percentage of active secondary follicles were higher (P<0.05) in the *Azzara, Calabrese* and *Nicastrese* goats compared to that observed in Red Syrian and Garganica groups. The percentage of active primary follicles was similar in *Azzara*, *Nicastrese* and *Calabrese* goats, and it was lower (P<0.05) than in Red Syrian and Garganica breeds.

Table 2 Least squares means of percentage of active secondary follicles and primary follicles of skin

Genetic type	Secondary follicles (%)	Primary follicles (%)
Azzara	51.54 a	81.64 a
Nicastrese	43.92 a	88.83 a
Red Syrian	2.31 b	44.38 b
Garganica	0.47 b	54.40 b
Calabrese	57.99 a	82.51 a
Pooled SE	7.70	5.61

a,b,c column means with different superscripts differ (P<0.05)

Peer-reviewed paper: 8th International Conference on Goats

Similar parameters for down fibre and skin traits of different genetic types were reported by other authors, however these studies cannot be clearly compared to ours. Holst *et al*. (1982) reported fibre and skin characteristics of Australian feral does and bucks; Bishop and Russel (1994) described productivity of Scottish feral goats, but in this study the animals were 5-month-old kids. Vegara *et al*. (1999) reported down production levels of Norwegian dairy goats and these data seems to be close to the values in our study; moreover, our research was supported by skin characteristics.

Conclusions

This study showed that the breed-populations used produce a very fine cashmere fibre. The observed values of down yield and the percentage of active secondary follicles suggest that the *Azzara*, *Nicastrese* and *Calabrese* populations have the potential to produce textile fibre of high quality**.** The observed values of down length represent a limiting factor for cashmere production, even if some genetic types (*Nicastrese* and *Calabrese*) exhibited interesting down length values.

Acknowledgements

The authors would like to thank the APA of Catanzaro for their support in the farms. This research was financially supported by MURST (Cofin. 1999-01).

References

Bishop, C. S., Russel, A.J.F., 1994. Cashmere production from feral and imported cashmere goat kids. Anim. Prod. 58, 135-144.

Celi, R., Di Trana, A., Toteda, F., Facciolongo, A. M., Colonna, M. A., Rubino, R., 1999. Cashmere production in Italy: current status and future perspectives. EFFN 6, 15-16.

FAO, 2002. Statistical database. http://www.apps.fao.org

Holst, P.J., Clarke, W.H., Maddocks, I.G., 1982. Skin and fleece characteristics of groups of feral goats. Aust. J. Exp. Agric. Anim. Husb. 22, 173-176.

International Wool Textile Organisation (IWTO), 1989. Specification ITWO-8-89E International Wool Secretariat, Ilkley, UK, 1-17.

Nixon, A.J., 1993. A method for determining the activity state of hair follicles. Biot. Histoch. 68(6),316-325.

Rubino, R., Di Trana, A., Sepe, L., 2000. First appearance of Cashmere in a local goat breed in Italy. Proceedings of 7th International Conference on Goats, 656.

Ryder, M.L., 1966. Coat structure and seasonal shedding in goats. Animal Production 8, 289-302.

SYSTAT, 1992. Statistics, Version 5.2 Edition. Evanston, IL, USA.

Vegara, M., Ådnøy, T., Ådnøy, L.O., Eik, L.O., Standal, N., 1999. Down production of Norwegian dairy goats. Small. Rum. Res. 33, 293-297.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Yield, composition and cheese making potential of Dahlem Cashmere goat milk

O. Dimassi#, P. Herold, and A. Valle Zárate
Institute of Animal Production in the Tropics and Subtropics (480a), Universität Hohenheim, 70593 Stuttgart, Germany.

Abstract

Empirical results, obtained by commercially processing milk of Dahlem Cashmere (DC) goats, indicate the suitability of milk of DC goats for processing. Thus a project was designed to study the processing properties of milk from DC goats and to investigate the factors behind its suitability for cheesemaking taking into consideration DC goats' milk yield and milk composition. For this purpose individual milk samples from 10 DC goats (parity 2 and 3) and 5 German Fawn (GF) goats (parity 2) were taken fortnightly in 2001 over a lactation period of 28 weeks and tested for milk yield [kg] (total and corrected to the equivalent of 4g/100g fat milk yield) and composition (protein and casein [g/100g]).Using a cheese simulation method, milk to cheese conversion value (CCV) [100 x cheese (g)/skim milk (g)] and subsequently protein and casein to cheese conversion values (PrtCV and CnsCV, resp.) [100 x cheese(g)/protein(g) and 100*cheese(g)/casein(g), resp.] were calculated. By correcting milk yield to the equivalent of 4% fat corrected milk no more differences between the two breeds in milk yield could be detected. Milk from DC goats had higher protein and casein contents and higher CCV than milk from GF goats. Interestingly, PrtCV and CnsCV of milk from DC goats were higher than that of GF goat milk. The higher PrtCV and CnsCV indicate that protein and casein of milk from DC goats differ not only in quantity but also in quality from that of GF goat milk.

Keywords: Goat breed, milk components, cheese conversion value
#Corresponding author; E-mail: odimassi@uni-hohenheim.de

Introduction

Dahlem Cashmere (DC) is a composite goat breed developed at the end of the 1980s, based on Angora and dairy goats, in particular the German White dairy goat with some influence of the Anglo Nubian. Along with the valuable cashmere fibre, DC goats are used for milk and meat production (Lammer *et al.* 1999). Following increasing economic relevance of goat cheese production, scientific interest in genetic influences on the potential of goat milk for cheese production has risen (Clark & Sherbon, 2000). Empirical results, obtained by commercially processing milk from DC goats, indicated its the suitability for cheese processing properties. This has led to the need to investigate the technological potential of milk from Dahlem Cashmere (DC) goats and study the reasons behind it by comparing these properties to that of a conventional German dairy breed, German fawn (GF) goats.

Materials and Methods

Two groups with five DC goats at two and three parturitions, respectively, and one group of five GF goats after two parturitions were studied over a lactation period of 28 weeks. Morning and evening milk yield of each goat was measured three times a week. Furthermore, individual milk samples from morning and evening milk of goats were collected fortnightly, combined to one sample of the respective individual and stored at 4° C for further analysis. Part of the stored individual milk samples was sent fortnightly to the "Milchprüfring Baden-Württemberg e.V" center at Neuenstein, Germany to determine, using near infrared spectroscopy, milk major components (fat, total protein, and total casein).

A goat cheese-simulation method, similar to the method used by Othmane *et al.* (2002) for estimating cheese yield of ewe's milk was developed and used to estimate rennet-based cheese conversion value. Raw milk was heated in a water bath to 35°C, and defatted by centrifugation (1500g for 15 minutes). The resulted skim milk was weighed and heated again in a 35°C water bath. At 35°C a 1% v/v of 2% rennet was added. After one hour skim milk plus rennet mixture was centrifuged at 2400g for 15 minutes resulting in whey supernatant and cheese precipitate. In order to calculate the milk to cheese conversion value (CCV) curd weight [g] and dry matter [g/100g] was measured. Subsequently, the milk components to cheese conversion values (CCV), i.e. protein and casein, were estimated. [Equations 1&. 2]

Peer-reviewed paper: 8th International Conference on Goats

$$\text{Milk to cheese conversion value} = \frac{\text{Cheese weight [g] x Dry matter [g/100g]}}{\text{Weight skim milk [g]}} \quad \text{Eq. 1}$$

$$\text{Milk component to cheese conversion value} = \frac{\text{Cheese weight [g] x Dry matter [g/100g]}}{\text{Weight skim milk [g] x Milk component [g/100g]}} \quad \text{Eq. 2}$$

All statistical comparisons between milk of DC and GF goats were done for the 7 months lactation period using SAS V 8.0 statistical software. ANOVA analysis was used to compare total milk and milk content yields between breeds. In order to adjust for month, time of sampling and animal, a repeated measurement model was used. Contrast analysis was used after applying ANOVA and repeated measurement model to estimate the level of significance between the two breeds.

Results and Discussion

The total milk yield of DC goats was significantly lower from that of GF goats (Table 1). However, when the total milk yield of DC and GF goats were corrected to an equivalent of 4 g/100g fat corrected milk, no statistical differences between both breeds remained (Table 1). Thus the higher fat content ($p<0.05$) (Table 2) of milk from DC goats compared to that of milk from GF goats compensated for the lower milk yield.

Table 1 Mean (± s.e.) lactation yield (kg) and fat corrected milk yield (kg) of DC and GF goats

	DC (n=10)	GF (n=5)	Significance (P)
Lactation [d]	210	210	
Milk Yield [kg]	526.8 ± 83.4	717.9 ± 83.4	0.043
FCM (4%) [kg]	528.0 ± 85.3	594.5 ± 85.3	0.455

s.e.: standard error; d: days; P: Probability of significance.
FCM: Fat corrected milk yield; FCM = (0.34 x Milk yield) + (16.42 x Fat yield) (Gall *et al*. 2001)
DC: Dahlem Cashmere, GF: German Fawn, n: number of animals

Although total milk yield of DC goats were lower than those of GF goats, protein yield [kg in 210 days] of DC and GF goats (19.54 ± 1.66 and 21.90 ± 1.54, respectively) and casein yield [kg in 210 days] of DC and GF goats (14.77 ± 1.29 and 16.01 ± 1.01, respectively) were comparable. Thus the lower milk yield of DC goats ($p<0.05$) compared to that of GF goats was compensated by higher protein ($p<0.01$) and casein ($p<0.01$) contents (Table 2). GF goat milk protein and fat content are comparable to those mentioned by Gall (1996). Furthermore, DC goat milk protein and fat content seemed higher than those mentioned for Saanen and Alpine goats and comparable to those of Anglo-Nubian goats (Clark & Sherbon, 2000) indicating its suitability for processing.

Table 2 Mean (± s.e.) contents of protein, casein and fat in DC and GF goat milk (g/100g)

	DC (n = 140)	GF (n = 70)	Significance (P)
Fat [g/100g]	4.0 ± 0.2	3.1 ± 0.2	0.014
Protein [g/100g]	3.6 ± 0.1	3.0 ± 0.1	0.002
Casein [g/100g]	2.7 ± 0.1	2.2 ± 0.1	0.004

s.e.: standard error; DC: Dahlem Cashmere, GF: German Fawn; n: total number of samples; P: Probability of significance

Concurrent with the higher ($p<0.01$) protein and casein content (Table 2) in DC goat milk compared to that of GF goat milk, milk to cheese conversion values (CCV) (Table 3) of DC goat milk is higher ($p<0.01$) than that of GF goat milk. The higher ($p<0.01$) CCV of milk from DC goats compared to that of milk from GF goats compensated for the higher ($p<0.05$) total milk yield eliminating the differences between the two breeds on total monthly cheese yield basis (Figure 1). However, higher ($p<0.01$) protein and casein contents do not explain the higher ($p<0.001$) protein to cheese and casein to cheese conversion values (Table 3) of milk from DC goats compared to that of milk from GF goats.

Peer-reviewed paper: 8th International Conference on Goats

Table 3 Mean (± s.e.) milk and milk components to cheese conversion values (g/100g)

	DC (n = 140)	GF (n = 70)	Significance (P)
CCV [g cheese / 100 g skim milk]	4.2 ± 0.1	3.2 ± 0.2	0.000
PrtCV [g cheese / 100 g protein]	117.0 ± 0.1	107.0 ± 1.8	0.000
CnsCV [g cheese / 100 g casein]	155.5 ± 2.5	147.2 ± 2.5	0.001

s.e.: standard error; DC: Dahlem Cashmere, GF: German Fawn; n: total number of samples;CCV: Milk to cheese conversion value; PrtCV: Protein to cheese conversion value; CnsCV: casein to cheese conversion value; P: Probability of significance

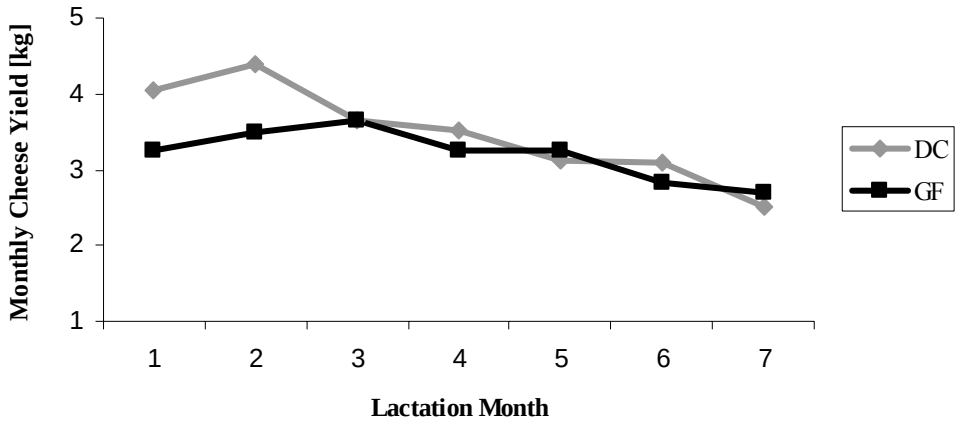


Figure 1 Total monthly cheese yield [kg] of Dahlem Cashmere (DC) and German Fawn (GF) goats

Conclusions

The high cheese production potential of DC goat milk could be shown by remarkably high CCV and casein contents. Higher protein and casein contents in the milk of DC goats explain the fact that milk of DC goats possesses higher CCV, however, it does not explain the more efficient casein to cheese conversion, indicating that the difference in milk protein, in particular that of casein, is not only in quantity but also in quality. Thus further investigations of the casein fractions are being carried out.

Acknowledgements

The authors would like to express their gratitude to C. Gall for his valuable comments and to H. P. Piepho for his valuable statistical advice. Furthermore, the authors would like to thank O. Leyrer, L. Mertz and J. Migliore for their valuable technical help.

References

Clark, S. & Sherbon, J.W., 2000. αs1-casein, milk composition and coagulation properties of goat milk. Small Rum. Res. 38, 123-134

Gall C., 1996. Goat Breeds of the World, CTA Weikersheim, Margraf

Gall, C., 2001. Ziegenzucht, (2nd ed.). E. Ulmer, Stuttgart, Germany. 501 pp.

Lammer, S., Valle Zárate, A., & Tholen, E., 1999. Fine fibre production with Dahlem Cashmere goats in Germany. EFFNnews 6, 13-15.

Othmane, M.H., Carriedo, de la Fuente Crespo, J.A. & San Primitivo, L.F.F., 2002. An individual laboratory cheese-making method for selection in dairy ewes. Small Rum. Res. 45, 67–73.

SAS, 2001. Statistical Analysis Systems user's guide. (8th ed.) SAS Institute Inc., Raleigh, North Carolina.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Variation in terpene content and profile in milk in relation to the dominant plants in the diet of grazing goats

V. Fedele#, S. Claps, R. Rubino, L. Sepe and G. F. Cifuni
Istituto Sperimentale per la Zootecnia, Via Appia, Bella Scalo - 85054 Muro Lucano, Italy

Abstract

The objective of this study was to evaluate during three seasons the effect of the two most ingested plants by goats on the content and the profile of terpenes in milk samples. Fifteen non-supplemented lactating goats (G) grazed for 8 hours/day from March to July. Six grazing lactating goats fitted with rumen cannulae were used. For six consecutive days, 500 g/day of fresh herbage were introduced (infusion) through the cannulae (infusion) into the rumen. *Lolium perenne* and *Dactylis glomerata* in winter; *Geranium molle* and *Asperula odorosa* in spring; *Cichorium intybus* and *Galium verum* in summer were tested. The results showed that each plant modified the profile and the content of mono and sesquiterpenes of milk samples. In every season sequiterpenes appeared the most abundant compounds. In summer the sesquiterpenes reached elevated values and plants infusion enriched goat milk more and more.

Keywords: terpenes, goat, milk, plant
#Corresponding author: E-mail vincenzo.fedele@isz.it

Introduction

Terpene content and profile in milk and dairy products are influenced by feed and especially by grazed herbage. This relationship could allow to discriminate milk, or cheese, from grazing or no grazing systems (Fedele *et al*., 2000; Rubino *et al*., 2002), or to trace the geographical origin, or production site (Viallon *et al*., 2000).

The diet of more selective animals, such as goats, is very diversified from one season to another. Goats grazed more willingly grasses during winter, while legumes and forbs increased from spring to summer (Fedele *et al*., 1993). Forbs reached the maximum contribution to the diet (over 50%) during summer. Generally, the dicotyledons enrich dairy products more than the monocotyledons (Mariaca *et al*., 1997). While on these general aspects the knowledge increases more and more, there is little information about the effect exerted by the single plant. The knowledge of this relationship could allow using these plants as markers: 1. of cheese origin; 2. of cheese sensory characteristics; 3. of grazing season and, finally to know which are those plants that better characterize the sensory properties of dairy products in order to increase their proportion into the pasture. The objective of this study has been to evaluate, during three different seasons, the effect of the two most ingested plants by goats on the content and profile of terpenes in milk samples.

Materials and methods

A native herbaceous pasture in a Basilicata valley (Southern Italy) at 360 m.s.l. was used for this experiment. Fifteen non-supplemented lactating goats (G) grazed for 8 hours/day an area of 1.2 ha from March to July. During March, May and July on five areas of 2x2 m, randomly distributed in the pasture, the contribution of each species to the diet was estimated. It was calculated for each species by the ratio between the number of plants grazed for a single species, and the number of plants, for the same species, present in the delimited area before grazing.

In order to evaluate the effect of the two preferred plants on milk terpenes, six grazing lactating goats fitted with rumen cannulae were used. For six consecutive days, 500 g/day of fresh herbage, of the following species were infused: *Lolium perenne* (Lp) and *Dactylis glomerata* (Dg) in winter; *Geranium molle* (Gm) and *Asperula odorosa* (Ao) in spring: *Cichorium intybus* (Ci) and *Galium verum* (Gv) in summer. Each specie for each season was introduced through the cunnula (infusion) into the rumen of three goats (250 g/day in the morning and 250 g/day in the afternoon). Terpenes analyses were performed on three cumulative milk samples for each season. Milk terpens were determined by a modified headspace technique (Fedele *et al*., 2000). VOC were analysed by HRGC-MS and identified on the basis of their mass spectra.

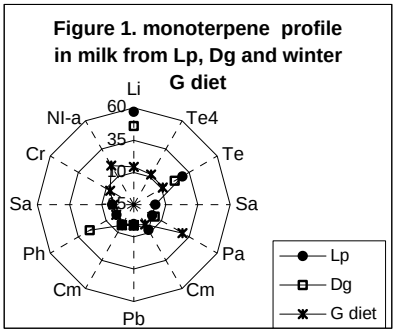
Results and discussion

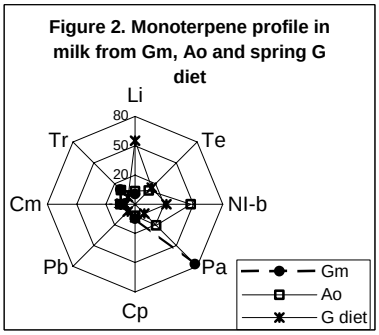
During winter goats grazed especially Lolium (44.5%) and Dactylis (14%). Milk from these two treatments showed respectively lower terpene content (100 ng/l and 132 ng/l respectively) than milk from G

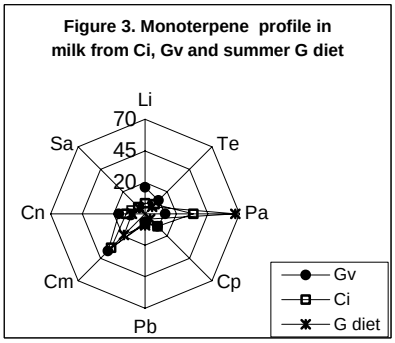
Peer-reviewed paper: 8th International Conference on Goats

goats (1,1889 ng/l). Differences were observed also in the terpene profile (Figure 1). Dg milk was poorest in monoterpenes (6 molecules), while milk from Lp and G goats was richest (9 and 12 molecules respectively). In the two treated groups the dominant terpenes was the Limonene (56.8% Lp and 45.8% Dg), while in G group the α-Pinene (28.6%).

The general profile from G milk was almost similar to that from Lp. Probably, the high contribution to the diet of this species (44.5%) exerted an influence on the G milk profile. In the last milk, two molecules, Δ-3- Carene and a not identified terpene (mono NI-a), absent in the others milk, were found. The low capacity of Orchard Grass to enrich the dairy products in monoterpenes was observed also by Coulon *et al*. (2000) in their investigation. They observed that cheese from Dg hay was poorer than cheese from pasture . At the approach of spring legumes and forbs in the diet increased, but monoterpenes in G milk decreased (343 ng/l). During this season Ao (8%) and Gm (6.0 %) were the two most grazed species. These two species, in comparison to winter species, increased milk monoterpenes content (284 ng/l and 227 ng/l respectively) and modified also its profile. The α-Pinene (76.7%) was the dominant terpenes in Gm milk, a not identified terpene (mono NI-b) was dominant (47.2%) in Ao and Limonene (55.2%) in G milk. Also in this season the profile of G milk was almost similar to the dominant specie in the diet (Ao). The fact that the mono NI-a terpenes has been found only in G winter, G spring and Ao milk, brought to hypothesise that the source was the Ao of the diet.





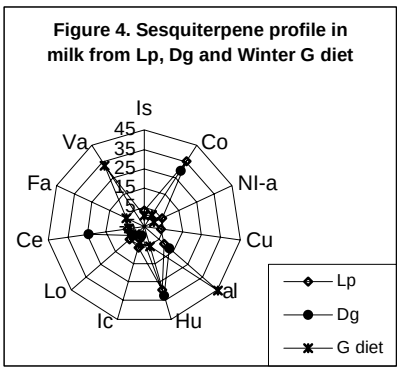


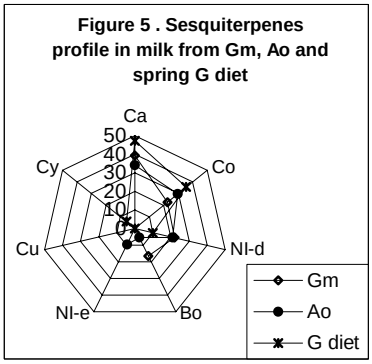
Cr=Δ -3-Carene;Cp=Camphene; Li=Limonene; NI-a, Ni-b=Not Identified: Pα=α-Pinene; Pβ=β-Pinene; a=Sabinene; Te=α+γ Terpineol; Te4=4-Terpineol; Sa=Sabinene; Cm=p-Cymene; Ph=ß-Phellandrene, Tr=Tricyclene;

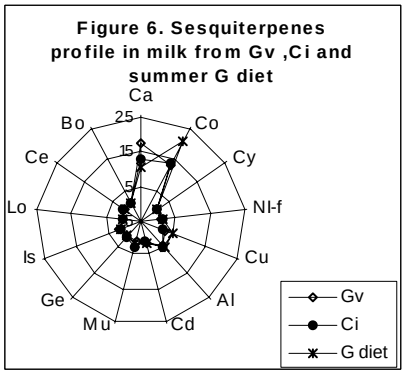
During summer goats selected especially Ci (14.5%) and Gv (9%). The treatment with these two species decreased the terpene content in the milk at the same level of the winter (respectively 76 ng/l and 116 ng/l), while they slightly increased the content in milk of the non treated group (478 ng/l). Also in this case the terpene profile of G milk was similar to the species most grazed (Figure3). The p-Cymene was the most representative terpenes in milk from Ci and Gv treatment (33.2% and 36.8% respectively), while the α-Pinene was the most representative in G milk. In all seasons the enrichment of diets by plant infusion into the rumen induced a decrease of monoterpenes in milk in comparison to non infused goats (G). At the moment there is no explanation for this phenomena; it is probable that the excess of herbage in the rumen altered the digestive and metabolic process limiting the absorption of terpenes by the rumen wall or, diversely, that a portion of terpenes (more volatile) escaped through the rumen cannulae, impoverishing the rumen environment. Sesquiterpene content in all milk samples was higher than the monoterpene content. The plant infusion into the rumen caused a decrease only in winter. Milk from no treated goats (G) showed in spring the lowest value (1,183 ng/L), while that from summer the highest (16,484 ng/l).

In winter (figure 4) α-Copaene was the dominant terpene in both treated groups, while Alloaromadendrene was dominant in G. Similar sesquiterpene profile showed for Lp and G milk, as observed for the monoterpenes, but in this last milk Valencene and β-Farnesene were found which were not recovered in the other milks. In spring the sesquiterpenes content and the number of molecules decreased (4 in Dg milk and 5 in both Lp and G one). In all milk samples (figure 5) β-Caryophyllene, α-Copaene and Sequi NI-d were the dominant terpenes. The Sequi NI-e terpenes were recovered only in the Ao treatment, probably because of contents only in this species. During summer the sesquiterpenes reached the maximum contents and their profile was more diversified. The content ranged from 16.484 ng/l of G milk to 41.484 ng/l of Gv.

Peer-reviewed paper: 8th International Conference on Goats







Al=alloaromadendrene; Bo=Boubonene; Ca=β-Caryophyllene; Cd=Cadidene; Ce=β-Cedrene; Co=α-Copane; Cu=Cubebene; Cy=cycloisantivene; Fa=β-Farnesene; Ge=Germanene; Hu=α-Humulene; Ic=isocaryophyllene; Is=Isolongifilene; Lo=Longifilene; Mu=Muurulene; NI-c, NI-d, NI-e= Not identified; Va=Valencene.

No substantial differences in the sesquiterpene profile were observed and in all milk samples β-Caryophyllene and α-Copaene were the dominant terpenes. Since Ci and Gv were more than 25% in the G diet it is probable that this level is sufficient to characterize the sesquiterpene profile, or diversely that the other grazed plants had the same effect of the tested one.

Conclusions

By changing the contribution of species to the goat diet, the terpene content and profile changed. At the quantitative level these results showed that the sesquiterpenes in every season and for every tested species assumed a greater importance than the monoterpenes. This last category seemed to depend especially on grasses. Some emerged phenomena are not simple to explain in the light of the general knowledge. The impoverishment in spring of terpenes in all milks, in spite of the diets being rich in terpene species, was similar to the effect observed when the plants were infused into the rumen. The higher herbage intake in spring (30-40% more than in the other seasons) probably modified the digestive and metabolic processes. Consequently the terpenes were less available for absorption. In summer when intake generally decreased and the herbage was less fermentable, sesquiterpenes reached the highest value and the profile was very enriched.

References

Fedele,V., Pizzillo, M., Claps, S., Morand-Fehr, P. & Rubino, R., 1993. Grazing behaviour and diet selection of goats on native pasture in Southern Italy. Small Rum. Res., 11, 305-322.

Mariaca, R., Berger, T., Gauch, R., Imhof, M., Jeangros, B. & Bosset, O.J., 1997. Occurrence of volatile mono-and sesquiterpenoids in highland and lowland plant species as possible precursors for flavour compounds in milk and dairy products. J. Agric. Chem., 45(11), 4423-4434.

Viallon, C., Martin, B., Verdier-Metz, I., Pradel, P., Garel, J.P., Coulon, J.B. & Bedagué, J.L., 2000. Transfer of monoterpenes and sesquiterpenes from forages into milk fat. Lait, 80, 635-641.

Rubino R., Claps S. & Fedele V., 2002. Herbe Paturée et qualité organoleptique-nutritionelle du lait et du fromage de chèvre. In : quality and promotion of animal products in mountain. REU technical serie 66, FAO, 48-54.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Seasonal retinol variation in goat milk associated with grazing compared to indoor feeding

V. Fedele[1#], R. Rubino[1], S. Claps[1], P. Manzi[2], S. Marconi[2], L. Pizzoferrato[2]
[1]Istituto Sperimentale per la Zootecnia, Via Appia, Bella Scalo - 85054 Muro Lucano, Italy
[2]Istituto Nazionale di Ricerca per gli Alimenti e la Nutrizione -Via Ardeatina, 546 – 00178 Roma, Italy

Abstract

Forty-five Siriana goats were divided into three groups and assigned to three feeding treatments: i) grazing (G), ii) grazing plus 600 g/d of mixed barley and chickpeas grain (GBC), iii) grazing plus 600 g/d of mixed maize and broad beans (GMB). These grazing groups were compared to a control group (I) of fifteen Siriana goats fed indoor with pasture hay plus 600/g day of commercial concentrate. Retinol contents of bulk milk samples were determined and correlated with the herbage intake.

Feeding treatments significantly influenced all trans and total retinol contents: milk from un-supplemented grazing goats (G treatment) showed the highest all-trans and total retinol content, while milk from I treatment showed the lowest value. From zero herbage intake (I treatment) to 381.7 g/day DM (GBC and GMB treatments), and to 568.7 g/day DM (G treatment), total retinol in milk increased by 20% and 30% respectively. From spring to winter, the ratio between total retinol content and milk production (R/MP) showed an opposite trend in comparison to milk production: the more milk production decreased, the more R/MP ration increased. The differences observed in summer and winter between grazing treatments were probably due to different herbage intake. The mean ingested herbage intake of the GMB group was 28% less than that of the G group, and 36% less than the GBC group. This low intake caused the R/MP ratio to decrease by 41% and 62% in the G and the GBC groups respectively. In the Spring, the herbage intake was higher (meanly 39%) than in the other two seasons, but no differences were observed between treatments.

The influence of feeding treatment observed on milk retinol content could be explained on the basis of: i) a different retinol precursor content in the animal diet, or ii) a different precursor bioavailability for animal synthesis.

Keywords: Retinol, Milk goat, feeding treatment
[#]Corresponding author: E-mail vincenzo.fedele@isz.it

Introduction

All-transretinol, the main form of vitamin A, is found in animal products such as milk, meat and eggs, while provitamin A (carotenoids) may be found in fruits, vegetable oils, and other vegetables (Scott *et al*., 2000). Carotenoids, which include, among many others, β- and α-carotene and β-cryptoxanthin, do not show the same conversion capacity to vitamin A. The most potent retinol precursor is β carotene.

Vitamin A level in milk may be influenced by the animal diet. In forage, β-carotene is degraded during drying and preservation as a consequence of exposure to light (Park *et al*., 1983) and milk from grazing animals or those fed on pasture herbage contains higher level of vitamin A than milk from animals fed on a diet consisting of hay and concentrate (Pizzoferrato *et al*., 2000; Martin *et al*., 2002).
In the Mediterranean area, goat feeding systems are based on rangeland or natural pasture resources, but in some developed countries (especially France), preserved feed is largely used. Grazing animals, and especially goats, browse preferably the green parts of plants, especially in the summer when a large part of the vegetation is dried (Fedele *et al*., 1993).

The aim of the present study was to investigate the seasonal evolution of retinol levels in milk from grazing goats with or without concentrate supplementations, compared with a zero fresh herbage treatment (control).

Materials and methods

A native herbaceous pasture in a Basilicata valley (Southern Italy) at 360 m above sea level was used for this experiment. According to climatic conditions, which are cold in winter (from –6° to 8 °C), temperate in spring (from 16° to 23 °C) and hot in summer (from 26 to 32 °C), the pasture botanical composition changes considerably. Grasses, ind particular *Lolium perenne, Dactylis glomerata* and *Bromus spp.,* grow in winter, while legumes (*Medicago polimorpha*, *Trifolium repens*, *Vicia spp*.) and certain forbs (*Ranunculus bulbosus*, *Asperula odorosa*, *Daucus carota*,

Peer-reviewed paper: 8th International Conference on Goats

Geranium molle, etc.) grow in the spring, and forbs such as *Galium verum*, *Rumex sp*., *Cichorium intybus*, *Plantago* spp in summer. Forty-five Siriana goats, in their 3rd lactation, were divided into 3 groups. An area of 6 ha was divided into six equal paddocks, two of which were alternately grazed by each group, offered the following treatments: G: (grazing) for 8 hours/day; GBC: (grazing) plus 600 g/d of mixed barley and chickpeas grain (CP 14% and NDF 18%); GMB: (grazing) plus 600 g/d of mixed maize and broad beans (CP 14% and NDF18%). These grazing groups were compared to a control group (I) of fifteen goats fed indoor with pasture hay plus 600/g day^{-1} of commercial concentrate (15% CP and 18% NDF). Herbage intake was estimated by difference between the herbage mass measured on an un-grazed area and that measured post-grazing in experimental grazed areas, on five sampling units 2x2 m. During winter (from March to middle April), spring (from middle April to early June) and summer (from early June to middle July), three cumulative milk samples for each season were collected and analysed. Retinol isomers were determined by HPLC after saponification and extraction according to the method of Panfili *et al*. (1996). Results, standardized for dry matter and individual milk goat production, were statistically evaluated using SAS GLM procedure (1990). Effect of feeding treatment and season was tested for each studied variable.

Results and discussion

All-trans, 13-cis, all-trans plus 13-cis (total) concentrations, and the cis/trans retinol ratio of the milk samples are reported in Table 1. Feeding treatments influenced only all-trans and total retinol concentrations ($P>0.05$). Milk from unsupplemented grazing goats (G treatment) showed the highest all-trans and total retinol content (633.01 and 650.48 μg/100 DM respectively), while milk from I treatment the lowest value (481.57 and 498.60 μg/100 DM respectively).

Table 1 Retinol content (μg/100 DM) in milk samples (mean ± sd)

Retinol	I		G		GBC		GMB		F
All-Trans	481.57[b]	51.8	633.01[a]	132.0	566.57[b]	124.9	591.46[ab]	100.3	*
13-Cis	17.03	6.9	17.47	14.2	14.47	9.1	18.61	14.4	NS
Total	498.60[b]	49.9	650.48a	133.9	581.04[b]	129.4	610.07[ab]	102.9	*
Cis/trans	3.53	1.7	2.76	2.1	2.55	1.5	3.15	2.5	NS

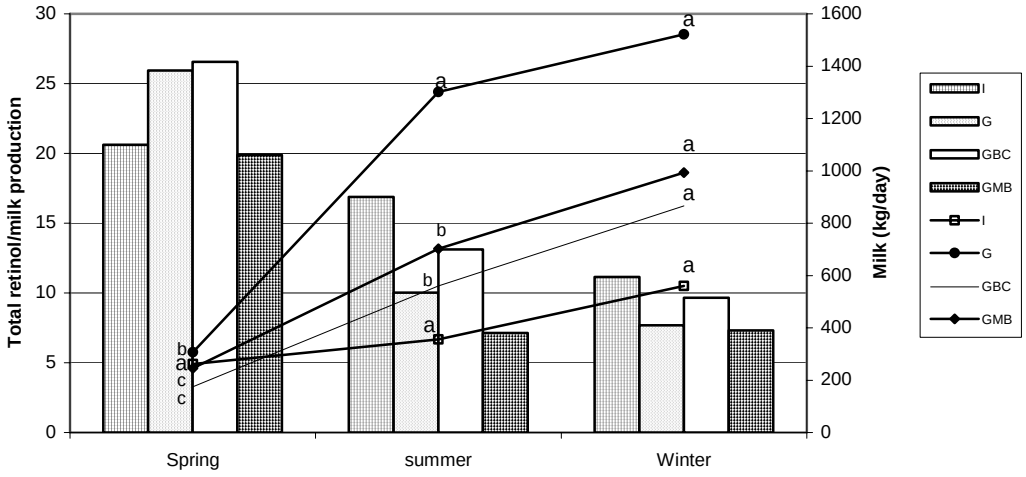
a,b -values with the same letter are not statistically different ($P>0.05$)

From these results, herbage intake seemed to positively influence the trans retinol level in milk. In fact, passing from zero herbage intake (I treatment) to 381.7 ± 96.5 g/day DM (GBC and GMB treatments), and to 568.7 ± 69.4 g/day DM (G treatment), total retinol in milk increased by 20% and 30% respectively. This conclusion can be supported by data showed in Figure 1.

While the ratio R/MP (total retinol content /milk production) increased from spring to winter, the MP (milk production) values showed an opposite trend, as already observed by Jensen *et al*. (1999) using milk cows. The R/MP value increased more in unsupplemented grazing goats (G) from spring to winter than in indoor goats (I). The herbage contribution to the diet seemed to influence the retinol content in milk. In fact, the differences between grazing treatments in summer and winter could be explained on the basis of the different herbage intake levels: the respective herbage ingestion of the GMB and GBC groups was 28% and 36% on average less than in G group. The relevant decrease of R/MP ratio was 41% and 62% respectively.
In spring, a particular result was observed. In this season the herbage intake was the highest and no differences were observed in the milk production from the various feeding treatments. During this season, vegetation grows quickly and goats browse floral shoots and flowers in abundance. During this phase, plants especially synthesize defensive secondary compounds (Strauss *et al*., 2004), probably decreasing vitamin synthesis. They may also synthesize compounds not completely bio-available for ruminal microflora. As a consequence, the vitamin amount in milk decreases.

Peer-reviewed paper: 8th International Conference on Goats

Figure 1. Seasonal variation of total retinol/milk production ~~ratio~~ in relation to milk production



a,b,c Lines means with common superscript do not differ (P>0.05)

Conclusions

This study suggests that the influence of feeding treatment on milk retinol content may be explained on the basis of i) a different retinol precursor content in the diet, or ii) a different precursor bioavailability for animal synthesis. The grazing herbage positively influences the trans retinol level in milk and seems to be the most critical factor. Actually, the present results show that the higher the herbage intake, the higher the retinol concentration in milk in summer and winter, with the exception of spring, when this relationship is not valid .

References

Fedele,V., Pizzillo, M., Claps, S., Morand-Fehr, P.& Rubino, R., 1993. Grazing behavior and diet selection of goats on native pasture in Southern Italy. Small Ruminant Res., 11, 305-322.

Martin B., Ferlay A., Pradel P., Rock E., Grolier P., Dupont D., Gruffat D., Besle J.M., Ballon N., Chilliard Y.& Coulon J.B., 2002. Variabilité de la teneur des laits en constituents d'intérèt nutritionell selon la nature des fourages consommés par les vaches latières. Recontres Recherche Ruminants, 9, 347-350.

Panfili G., Manzi P.& Pizzoferrato L., 1996. Normal and reversed phase HPLC methgods for more complete evaluation of tocopherols, retinols, carotenes and sterols in dairy products. Chromatographia, 43, ½, 89-93. Analyst, 119, 1161-1165.

Park Y.W., Anderson M.J., Walters J.L.&Mahoney A.W., 1983. Effect of processing methods and agronomic variables on carotene contents in forages and predicting carotene in alfalfa hay with near-infrared-reflectance spectroscopy. Journal of Dairy Science, 66, 235-245.

Pizzoferrato L., Manzi P., Rubino R., Fedele V.& Pizzillo M., 2000. Componenti bioattivi in prodotti lattiero-caseari caprini: influenza del sistema alimentare. IV Congresso Nazionale di Chimica degli Alimenti, 28-30 June, Ferrara (Italy), 426-431.

Scott K.Y. & Rodriquez-Amaya D., 2000. Pro-vitamin A carotenoids conversion factors: retinol equivalents – fact or fiction?. Food Chemistry, 69, 125-127.

Strass S.Y., Irwin R.E. & Lambrix V.M., 2004. Optimal defence theory and flower petal colour predict variation in the secondary chemistry of wild radish.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Comparison of textural properties of low-fat chevon, beef, pork, and mixed-meat sausages

K. M. Gadiyaram and G. Kannan#
Agricultural Research Station, Fort Valley State University, Fort Valley, Georgia 31030, USA

Abstract

Chevon (goat meat) is an ideal source of red meat for the preparation of heart-healthy products because of its lower fat content. This study was conducted to compare the texture attributes of low-fat chevon sausages to those of beef and pork sausages. Two batches each of chevon, beef, pork, and mixed-meat sausages with no added fat were manufactured under identical conditions using a commercial sausage seasoning. For each batch, six Spanish goat carcasses, and beef chuck and pork leg cuts from different carcasses were used. The mixed-meat sausage was prepared using equal proportions of chevon, beef, and pork lean. Sausages were cooked in a convection oven to an internal temperature of 75°C, drained, and then sampled for analysis. Cooking losses were the lowest in chevon sausages. Fat contents were 2.29, 7.07, 2.77, and 3.02 %, respectively, in chevon, beef, pork, and mixed-meat sausages. Hardness and chewiness were not influenced by sausage type. Springiness was higher in chevon, pork, and mixed-meat sausages compared to that of beef sausages. Cohesiveness was high in beef and pork sausages, low in chevon sausages, and intermediate in mixed sausages. The results suggest that textural attributes of chevon sausages are comparable to those of other sausages studied. Incorporation of chevon in mixed-meat sausages may result in a low-fat product with superior water-holding and textural properties.

Keywords: Low-fat sausages, Chevon, Texture profile analysis
#Corresponding author. E-mail: govindak@fvsu.edu

Introduction

The demand for chevon (goat meat) in the United States has increased in the recent years (Glimp, 1995). Chevon is particularly attractive to a health conscious American consumer due to its lower fat compared to other types of red meat (Park *et al*., 1991). However, chevon is lower in tenderness and flavor than lamb, beef, or pork (Smith *et al*., 1974). Developing value-added products using chevon may mask its characteristic texture and flavor, thus widening the existing market and increasing the number of consumers benefited by this low-fat red meat.

Chevon may be an excellent resource in the preparation of low-fat diets, since the fat content of lean is significantly less (James & Berry, 1997). Textural properties of chevon products have not been adequately investigated. Texture profile analysis (TPA) is a useful tool to assess the palatability of a meat product since the objective attributes correlate well with sensory evaluation (Lyon *et al*., 1980). The objective of the present experiment was to compare the textural properties of low-fat chevon sausages with those of beef and pork sausages.

Materials and Methods

The trial was conducted using two batches of sausages. Each batch of chevon sausages was manufactured using meat from six Spanish goat carcasses. Beef chuck and pork leg portions from several carcasses were used for preparing beef and pork sausages respectively. A mixed-meat sausage with equal proportions (by weight) of chevon, beef, and pork was also prepared. Equal weights of chevon, beef, or pork lean with no added fat was ground through a 1.27 cm breaker-plate, to which sausage seasonings (A. C. Legg Packing Co., Inc., Birmingham, AL, USA) were added and mixed thoroughly. The seasoning was a blend of salt, red pepper, sage, sugar, and black pepper. The mix was ground again through a 0.4 cm-plate and stuffed into natural hog casings using a sausage stuffer.

Sausages were individually weighed, placed on aluminum pans covered with foil, and cooked in a convection oven (Lindberg/Blue, Model GO 1350SC, Ashville, NC, USA) to an internal temperature of 75°C. Cooked sausages were cooled, drained of the fluid, and then weighed again to assess cooking losses. The products were kept at 2°C for 24 h to facilitate removal of cores. The sausages were cut into 1.25 cm-thick slices and 1-cm cores were removed from the center of each slice for TPA. The TPA tests were carried out using a TA-XT2 Texture Analyzer (Texture Technologies Corp., Scarsdale, NY, USA) with a 25-kg load

Peer-reviewed paper: 8th International Conference on Goats

cell, a test speed of 360 mm/min, and the cross head set at 75% strain. The cylindrical core samples were placed upright (sample height 1.25 cm) on the stationary perspex platform and compressed by a cylindrical perspex probe (diameter 2.5 cm) attached to the crosshead. In each batch, ten sausages per product type were evaluated for TPA. The texture attribute value of each sample was an average of values obtained from 4-6 cores.

Proximate composition of sausages (n = 10/batch) was determined according to AOAC (1984) procedures. The data were analyzed as a Randomized Complete Block Design using the General Linear Models procedures in SAS (SAS Institute, 1992), with batch as the blocking factor. When significant differences were observed by ANOVA, the means were separated using the Least Significant Difference test (LSD).

Results and Discussion

Among the products studied, fat content was the lowest ($P < 0.05$) in chevon sausage. The fat contents were 2.29, 7.07, 2.77, and 3.02 %, respectively, in chevon, beef, pork, and mixed-meat sausages. Protein contents of the different types of sausages studied were similar. The protein contents were 20.00, 20.47, 21.39, and 22.03 %, respectively, in chevon, beef, pork, and mixed-meat sausages. The superior nutritional properties of chevon have been well documented. Chevon is naturally low in fat, probably due to reduced subcutaneous fat deposition in goat carcasses (Kirton, 1970).

Table 1 Texture Profile Analysis of low-fat chevon, beef, pork, and mixed-meat sausages

Sausage type Attribute\ (ANOVA)	Beef	Pork	Chevon	Mixed-meat	Pooled SEM	P-value
Hardness (g)[1]	2271.79	1716.35	1120.75	1785.83	472.15	0.26
Fracturability[2]	398.31	414.05	1084.14	525.33	444.19	0.30
Springiness (cm)[3]	0.64[b]		0.71[a]	0.74[a]	0.72[a]	0.042 0.01
Cohesiveness[4]	0.29[a]		0.29[a]	0.25[b]	0.27[ab]	0.019 0.01
Gumminess[5]	652.82	500.48	282.27	476.77	152.13	80.17
Chewiness[6]	418.39	354.83	227.22	345.75	79.84	90.46
Resilience[7]	0.12[a]		0.11[ab]	0.10[b]	0.11[b]	0.006 0.05

[ab]Means with different superscripts differ significantly by Least Significant Difference (LSD) test ($P < 0.05$).
[1]Peak force of the first compression
[2]Occurs where the first bite curve has its first significant peak
[3]Distance of the detected height of the product on the second compression / Original compression distance
[4]Area under second curve / Area under first curve
[5]Hardness × Cohesiveness
[6]Hardness × Springiness × Cohesiveness
[7]Area during the withdrawal of the first compression / Area of the first compression

An example of a typical first bite and second bite compression curves obtained for a core sample of chevon sausage is shown in Figure 1. Among the texture attributes, only springiness, cohesiveness, and resilience were significantly influenced by sausage type (Table 1, $P < 0.05$). The distance sample recovers between first and second bites (also known as springiness) was higher in chevon, pork, and mixed sausages compared to that of beef sausages. Cohesiveness was high in beef and pork sausages, low in chevon sausages, and intermediate in mixed sausages. The ability of the core sample to resume its original shape (resilience) was the lowest for chevon. The results suggest that textural attributes of chevon sausages are comparable to those of other types of sausages, since several important attributes were not influenced by sausage type. There is immense potential for chevon to be included in the manufacture of low-fat processed meat foods, without a major influence on the textural properties.

Peer-reviewed paper: 8th International Conference on Goats

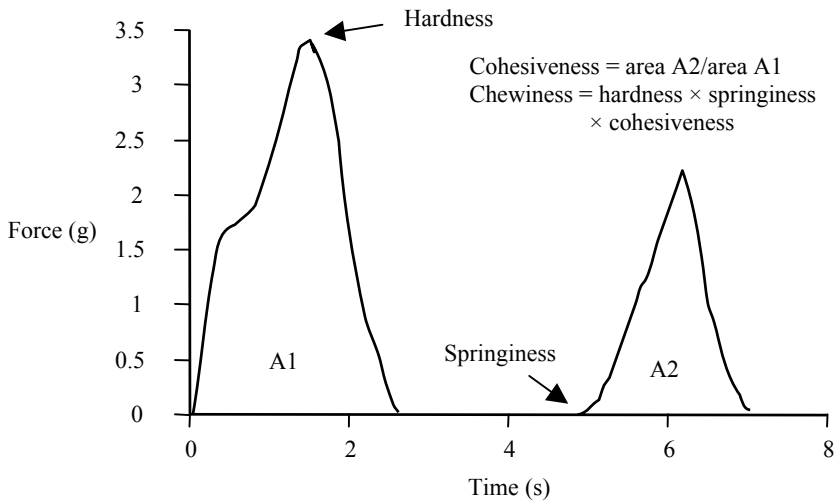


Figure 1 Texture Profile Analysis of low-fat chevon sausage tested using TA-XT2 Texture Analyzer, showing typical first and second bite compression curves

Cooking losses were the lowest ($P < 0.05$) for chevon sausages compared to the other types of sausages. The cooking losses were 5.52, 19.88, 7.46, and 10.02 %, in chevon, beef, pork, and mixed-meat sausages, respectively. Babiker *et al*. (1990) reported that chevon had lower cooking loss than lamb. The authors stated that superior water-holding capacity of chevon was responsible for its lower cooking loss.

Conclusions

The results indicate that the textural properties of chevon sausages are similar to the other types of sausages studied. Incorporation of chevon in mixed-meat sausages may result in a low-fat product with superior water-holding, nutritional, and textural properties. Further studies are required to determine the shelf life of chevon products.

References

AOAC, 1984. Official Methods of Analysis (14th Ed.). Association of Official Analytical Chemists, Arlington, VA.

Babiker, S. A., El Khider, I. A. & Shafie, S. A., 1990. Chemical composition and quality attributes of goat meat andlamb. Meat Sci. 28, 273-277.

Glimp, H. A., 1995. Meat goat production and marketing. J. Anim. Sci. 73:291-295.

James, N. A. & Berry, B. W., 1997. Use of chevon in the development of low-fat meat products. J. Anim. Sci. 75,571-577.

Kirton, A. H., 1970. Body and carcass composition and meat quality of the New Zealand feral goat (*Capra hircus*).NZ J. Agric. Res. 13, 167-181.

Lyon, C. E., Lyon, B. G., Davis, C. E. & Townsend, W. E., 1980. Texture Profile Analysis of patties made frommixed and flake-cut mechanically deboned poultry meat. Poultry Sci. 59, 69-76.

Park, Y. W., Kouassi, M. A., Chin, K. B., 1991. Moisture, total fat and cholesterol in goat organ and muscle meat. J.Food Sci. 56, 1191-1193.

SAS Institute, 1992. SAS/STAT^R Software: Changes and Enhancements, Release 6.07 SAS Technical Report, SAS Institute Inc., Cary, NC.

Smith, G. C., Pike, M. I. & Carpenter, Z. L., 1974. Comparison of the palatability of goat meat and meat from four other animal species. J. Food Sci. 39, 1145-1146.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Oxidative stability of chevon as influenced by dietary Tasco supplementation in Boer goat bucks

S. Galipalli[1], K.M. Gadiyaram[1], B. Kouakou[1], T.D. Pringle[2] and G. Kannan[1#]
[1]Agricultural Research Station, Fort Valley State University, Fort Valley, Georgia 31030, USA
[2]Department of Animal and Dairy Science, The University of Georgia, Athens, Georgia, USA

Abstract

Tasco seaweed (*Ascophyllum nodosum*) extract has been reported to improve vitamin E status and carcass characteristics in meat animals, but its effects have not been studied in goats. This study was conducted to determine the effects of Tasco feed supplementation on color and oxidative stability of goat meat (chevon). Mature intact Boer goats were fed an alfalfa pellet diet and a Tasco supplement either with (Treatment) or without (Control) seaweed extract (2% of daily intake) for 8 weeks (n = 16/treatment group). The animals were transported 6 h to the slaughter facility on two different days, held in pens without feed, and slaughtered. Color values (CIE L*, a*, b*), visual scores, percent metmyoglobin (metMb) and thiobarbituric acid reactive substance (TBARS) of loin/rib chops (2.5 cm thick) were recorded on 1, 3, 5, and 7 days of display. The L* values increased from d-1 to d-3 ($P < 0.05$), but did not change thereafter. Both a* and b* values decreased gradually until 5 days of display. However, after 5 days, the a* value remained unchanged, while the b* value increased ($P < 0.05$). Percent metMb and TBARS increased over display time ($P < 0.05$). MetMb formation was less in the treated group than in the control group ($P < 0.01$). TBARS increased rapidly during the first 3 days of display, but did not change significantly thereafter ($P < 0.05$). Visual scores decreased over display time ($P < 0.01$), and were negatively correlated with percent metMb ($r = -0.62$; $P < 0.01$) and TBARS values ($r = -0.40$; $P < 0.01$). Seaweed extract supplementation increased color stability of loin/rib chops, although there was no effect on lipid oxidation.

Keywords: Goats, Chevon color, TBARS
[#]Corresponding author. E-mail: govindak@fvsu.edu

Introduction

Tasco livestock feed supplement, which contains an extract from brown seaweed (*Ascophyllum nodosum*), is known to have positive effects on vitamin E status and meat quality characteristics of cattle (Montgomery *et al*., 2001). The mode of action has not been elucidated, although it is known that the brown seaweed contains some of the natural antioxidants such as substituted phenols, poly phenolic compounds, and vitamin precursors like α-tocopherol (Le Tutor, 1990).

Goat meat (chevon) may be prone for rapid lipid and pigment oxidation on refrigerated display (Kannan *et al*., 2001) because of its higher unsaturated fatty acid content (Park & Washington, 1993) compared to other types of red meat. Montgomery *et al*. (2001) reported that Tasco increased the shelf life of beef by preventing or delaying muscle pigment and lipid oxidation. The effect of Tasco on the shelf life of chevon has not been investigated so far. Thus, this experiment measured the effects of Tasco feed supplementation on the color and oxidative stability of chevon.

Materials and Methods

Thirty two mature intact Boer goats were housed in pens (4 bucks/ pen) and fed a pelleted alfalfa diet supplemented with Tasco either with (Treatment, 4 pens) or without (Control, 4 pens) seaweed extract for 8 weeks. Goats were randomly allocated to the treatment groups. The diet contained 60% alfalfa pellets and 40% Tasco feed, so that the treated group received seaweed extract at 2% of daily intake. At the end of the feeding trial, the goats were transported 6 h and slaughtered on two different days. Goats were held in pens overnight without feed, but with access to water prior to slaughter and processing. Animals were stunned using a captive-bolt pistol prior to exsanguinations.

Carcasses were not subjected to electrical stimulation and were chilled for 24 h before fabrication. Loin/rib chops (2.5 cm thick) for determination of L* (lightness), a* (redness), b* (yellowness) values (CIE, 1976) were placed on styrofoam trays and wrapped with polyvinyl chloride film (oxygen transmission rate = 3000 cc/m^2/24 h at 5ºC). Trays were placed in a display case (2ºC) to simulate retail conditions. Color measurements were made on the cut surface using a Hunter Lab chroma meter (Miniscan^{TM} XE plus, Model

Peer-reviewed paper: 8th International Conference on Goats

D/8-S) at 1, 3, 5, and 7 days (d-1, d-3, d-5, & d-7) of display. Three chops were used to measure color at each time period. The chops were also evaluated visually at each time period by 8 trained persons. Visual color values were determined based on color intensity (redness) and homogeneity using a scale from 1 to 10, with higher scores representing a more attractive and homogeneous red color. After color analysis, the chops were used for analysis of percent metmyoglobin and thiobarbituric acid reactive substances (TBARS) according to the procedures described by Krzywicki (1982) and Buege and Aust (1978), respectively.

The data were analyzed as Randomized Complete Block Design with split-plot arrangement using GLM procedures in SAS (SAS, 1995). When treatment was significant in ANOVA ($P < 0.05$), the means were separated using the LSD test. Pearson correlation analysis was used to determine the relationships among visual scores, percent metMb, TBARS, and a* values.

Results and Discussion

Meat surface discoloration is mainly associated with the oxidation of myoglobin to metMb (Faustman & Cassens, 1990). In this study, display time altered the color values (L*, a*, b*) and visual scores of chevon loin/rib cuts, probably due to metMb accumulation (Table 1). However, the color values and visual scores were not influenced by dietary supplementation of Tasco seaweed extract. The L* value did not change significantly after an initial increase from d-1 to d-3 of display. Both a* and b* values decreased gradually during the first 5 days of display, thereafter, a* values remained unchanged. Visual scores for red color intensity and homogeneity, decreased with increasing display time.

Table 1 Color values (CIE L*, a*, b*), visual score (VS), metmyoglobin (metMb, %), and thiobarbituric acid reactive substances (TBARS, mg MDA/kg meat) as influenced by Tasco feed supplementation in Boer bucks

		Display time (Time)					P-value		
Variable	Treatment (Trt)	d-1	d-3	d-5	d-7	SEM	Trt	Time	Trt x Time
L*	Tasco	39.9	44.7	41.9	43.9	0.87	0.66	0.01	0.87
	Control	39.4	44.7	40.5	43.6	0.85			
a*	Tasco	12.0	11.6	9.1	9.2	0.33	0.69	0.01	0.48
	Control	11.8	11.4	9.3	9.8	0.32			
b*	Tasco	15.5	10.3	9.1	10.7	0.49	0.89	0.01	0.58
	Control	14.8	10.4	8.6	11.3	0.48			
VS	Tasco	10.0	5.8	5.0	3.2	0.29	0.67	0.01	0.99
	Control	10.0	5.6	4.9	3.1	0.28			
MetMb	Tasco	18.7	20.8	22.3	24.7	0.47	0.01	0.01	0.68
	Control	21.6	24.3	25.8	27.3	0.46			
TBARS	Tasco	2.2	3.4	3.3	4.6	0.49	0.17	0.01	0.42
	Control	1.8	3.6	3.7	3.5	0.47			

L* = Lightness, a* = redness, b* = yellowness

MetMb accumulation increased from d-1 to d-7 of refrigerated display of chops in both control and treated groups. The lower metMb levels at 24 h postmortem (d-1 sampling) in the treated group may be due to the antioxidant effect of the Tasco seaweed extract. After 24 h postmortem, the rate of oxidation was the same in both treated and control groups. Montgomery *et al*. (2001) reported that improvement in color stability of meat resulting from Tasco supplementation may be related to elevated antioxidant activity in the steers.

The TBARS values were not affected by Tasco seaweed extract supplementation in this study (Table 1). Goats tend to have lower intramuscular and subcutaneous fat compared to other species. This may have prevented the accumulation, and thereby the influence, of fat soluble antioxidants in the muscles. TBARS increased rapidly during the first 3 d of display, and thereafter the changes were not significant. Kannan *et al*. (2001) reported that lipid oxidation increased with increasing refrigerated display time in case-ready chevon cuts from Spanish goat carcasses.

Peer-reviewed paper: 8th International Conference on Goats

Visual scores were negatively correlated with metMb % ($r = -0.62$; $P < 0.01$) and TBARS values ($r = -0.40$; $P < 0.01$), and positively correlated with a* values ($r = 0.47$; $P < 0.01$). The a* values were negatively correlated with metMb percent ($r = -0.41$; $P < 0.01$) and TBARS values ($r = -0.30$, $P < 0.01$). This relationship indicates that redness decreased with increasing metMb accumulation and lipid peroxidation. Percent metMb was not significantly correlated with TBARS ($P = 0.08$) in the present study, although Kannan *et al*. (2001) reported a positive correlation between lipid and pigment oxidation in chevon cuts. The relationships observed among TBARS, percent metMb, and visual scores suggest that perceivable redness decreased with increasing metMb formation and lipid oxidation in chevon.

Conclusions

Tasco supplementation minimized metMb formation during the first 24 h postmortem. The positive effect may be related to the antioxidant properties of the Tasco seaweed extract. However, Tasco supplementation did not influence lipid oxidation, probably due to the lower intramuscular fat in goats. Further studies are required to evaluate the effects of different levels and durations of seaweed extract supplementation on lipid oxidation in chevon.

Acknowledgements

This research was supported by the Agricultural Research Station at FVSU. The authors would like to thank Nealie Moye and Shirley Wang for technical assistance.

References

Buege, C. E. & Aust, S. D. 1978., Microsomal lipid peroxidation. Methods Enzymol. 52, 302-304.

CIE (Commission Internationale de l'Eclairage), 1976. Recommendation on uniform color space – color deference equations, psychometric color terms. Suppl. 2 to CIE, Publication No. 15 (E-1.3.1) 1971/ (TC-1-3), Paris, France.

Faustman, C. R. & Cassens, R. G., 1990. The biochemical basis for discoloration in fresh meat: a review. J. Muscle foods 1, 217-243.

Kannan, G., Kouakou, B. & Gelaye, S., 2001. Color changes reflecting myoglobin and lipid oxidation in chevon cuts during refrigerated display. Small Ruminant Res. 42, 67-75.

Krzywicki, K., 1982. The determination of haem pigments in meat. Meat Sci. 7, 29-36.

Le Tutour, B., 1990. Antioxidative activities of algal extracts, synergistic effect with vitamin E. Phytochemistry, 29, 3759-3765.

Montgomery, J. L., Allen, V. G., Pond, K. R., Miller, M. F., Wester, D. B., Brown, C. P., Evans, R., Bagley, C. P., Ivy, R. L. & Fontenot, J. P., 2001. Tasco forage: IV. Influence of seaweed extract applied to tall fescue pastures on sensory characteristics, shelf life, and Vitamin E status in feedlot finished steers. J. Anim. Sci. 79, 884-894.

Park, Y. W. & Washington, A. C., 1993. Fatty acid composition of goat organ and muscle meat of Alpins and Nubian breeds. J. Food Sci. 58, 245-253.

SAS, 1995. SAS Institute Inc, SAS/STAT User's Guide. SAS Institute Inc, Cary, NC.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Meat quality of crossbred progeny from Boer goats

Z Hongping#, L Li and C Shengou
Animal Scientific and Technological College of Sichuan Agricultural University, Ya'an, 625014, CHINA

Abstract

Under pastoral conditions, crossbred goats of similar age namely 6(3♂, 3♀)F_1 progeny from Boer×Nanjiang Yellow(BN) and 6(3♂,3♀) Nanjiang Yellow (NN) were selected at random and slaughtered at an age of approximately 8-months. Meat samples were analyzed. Results showed that meat samples from NB were comparable compared to those from NN in terms of tenderness and juiciness and no significant differences were observed for water loss, water-holding capacity, losses in store and cooking, shear value and myofibril diameter between the two breed types(P>0.05). Meat of BN is rich in protein and a high content of lysine, phenylalanine and methionine that are essential to human nutrition.

Keywords: Goat; Cross; Protein; Meat quality
#Corresponding author. E-mail: zhp2847@sohu.com.

Introduction

Boer goats are infamous for their good carcass conformation, meat quality characteristics, rapid growth, high prolificacy and strong adaptability worldwide. China introduced Boer goats in 1995. The authors started using frozen semen of Boer goats in 1995 to cross with Nanjiang Yellow goats in an attempt to improve the latter, which resulted in improved growth, body conformation, enlarged body size and improved meat quality (Zhang 1996,1999,2000). It merits to care of is that if their progeny could keep the fine meat properties of that of Nanjiang Yellow (Wang 1997). Casey et al. (1982,1985) pointed out from their studies that meat of Boer goats is inferior to that from sheep and its kids, probably owing to scanty tenderness (Van Niekerk, 1985). This study was conducted to study the meat quality of the hybrid descendants of Boer × Nanjiang Yellow goats as part of the ongoing pure breeding and hybrid use of Boer goats.

Materials and Methods

Under the same pasture conditions without any supplements, 6 medium sized Boer×Nanjiang Yellow F1 goats (3♂,3♀) (BN) and 6 pure Nanjiang Yellow goats (3♂,3♀) (NN) of approximately 8 months of age were selected at random and slaughtered. Samples of m. triceps humeralis, m. longissimus dorsi and m. biceps femoris were obtained for evaluating the chemical composition and sensory properties of meat. The contents of water, crude protein, crude fat and ash in m. longissimus dorsi were studied using standard AOAC procedures(1995). The lean meat was evaluated for sensory quality by 10 trained judges (AOAC, 1995; Dhanda 1999a). Meat colour was tested on uncooked samples, while tenderness, juiciness and acceptability were evaluated on cooked meat samples without adding spices. The samples that received a score of more than 80 % was excellent, 60-80 % good, 40 to 60 % satisfactory and below 40 % was not acceptability. Similar samples of the three muscles mentioned above, were mixed and the amino acid content analysed using the OPA-FMOC method (Furst *et al.*1990; Godel *et al.* 1991). Other physical traits, such as water loss, water-holding capacity and pH value, store loss, cooking loss and shear-force values were also analysed (AOAC 1995; Dhanda *et al.* 1999b).

Results and discussion

Water loss, water-holding capacity, cooking loss and myofibrillar diameter of meat samples are presented in Table 1. BN's water loss, store loss, cooking loss and pH values were lower than NNs but water-holding capacity high than NNs (p>0.05). There were no significant differences (P>0.05) in shear values and myofibril diameters between BN and NN of the muscles from their three sites (m. triceps humeralis, m. longissimus dorsi and m. biceps femoris), with the exception of pH value in which NN's was, after 2hr postmortem, significantly higher than BNs(0.01<p<0.05) and no apparent differences existing in other physical traits (p>0.05).

Peer-reviewed paper: 8th International Conference on Goats

Table 1 Least square mean (LSM) of BN and NN's muscular physical traits and standard error (SE)

		BN (LSM□	NN (LSM)	SE
Water loss(%)		15.11	16.46	1.03
Water-hold capacity(%)		78.67	76.83	1.61
Store loss(%)		2.31	2.96	0.36
Cooking loss(%)		58.98	62.20	3.23
PH value		6.21	6.37	0.05
Shear force value (kg/cm^2)	M. triceps humeralis	5.15	5.60	0.43
	M. longissimus dorsi	5.09	5.99	0.51
	M. biceps femoris	5.77	5.90	0.33
Myofibrillar diameter (μm)	M. triceps humeralis	36.94	36.35	1.47
	M. longissimus dorsi	31.56	31.07	1.07
	M. biceps femoris	34.26	34.98	0.52

Sensory scores for various physical properties of meat are presented in Table 2. The sensory analysis results suggest that judges could not distinguish any differences between BN or NN for meat color, tenderness or juiciness.

Table 2 Mean percent scores for meat of BN and NN

	BN		NN	
	LSM	SE	LSM	SE
Colour	81.00	3.52	82.00	4.37
Tenderness	85.00	2.34	85.00	3.29
Juiciness	86.00	2.66	85.00	5.20

The chemical composition and nutritive of meat samples from BN and NN are presented in Table 3, and the amino acid content of these samples is presented in Table 4.

Table 3 Chemical composition of meat samples from BN and NN

(%)	BN		NN	
	LSM	SE	LSM	SE
Water	75.39	0.43	76.10	0.96
Crude protein	21.17	0.80	20.78	0.50
Crude fat	2.20	0.16	2.50	0.42
Ash	1.38	0.45	1.34	0.40

The results summarized in Table 3 show that both the protein and ash content of samples from BN were slightly higher compared to those from NN, but the crude fat content was marginally lower, both with no significant difference ($p>0.05$).

Total amino acid content of BN was higher than in NN ($P>0.05$). The total volume of amino acids in BN was 110.326g/16gN(nitrogen) for BN, while 107.709g/16gN for NN. In samples from BN, the amino acids such as argine, methionine, threonine and leucine, surpassed the essential amino acid pattern of the ideal crude protein contents in human food consumption as proposed by the FAO (Srinivasan *et al.,* 1974; Devendra 1988; FAO, 1990), while histidine, lysine and isoluecine supplied more than 90% of it. In addition, non-essential amino acids were also quite abundant in muscle samples from BN.

Peer-reviewed paper: 8th International Conference on Goats

Table 4 Composition of amino acids in BN and NN

		BN (g/16gN)	NN (g/16gN)
1	Arginine	8.500	8.171
2	Histidine	2.248	2.238
3	Lycine	7.099	7.124
4	Tryptophan	-	-
5	Phenylalanine	5.046	4.614
6	Methionine	3.321	2.808
7	Threonine	6.082	6.001
8	Isoleucine	6.074	5.153
9	Leucine	10.369	9.841
10	Valine	6.059	5.182
11	Cystine	7.052	6.980
12	Aspartic acid	11.085	10.249
13	Serine	4.748	4.737
14	Glutamic acid	13.938	16.921
15	Glycine	6.512	5.935
16	Alanine	7.724	7.537
17	Tyrocine	4.478	4.218
	Total	110.326	107.709

Conclusion

The Boer goat breed has made a significant contribution in crossbreeding programmes since their introduction to China in 1995, particularly in terms of improving the meat quality and body weight of indigenous goats (Malan 2000; Xu *et al.* 2003). Some indigenous meat goats in China are popular with local consumers because of their special flavor (Wang 1997). The comparative studies and sensory evaluation of 8-month hybrids and pure Nanjiang Yellow goats, suggest that BN did not adversely affect the meat quality attributes of the native NN goats, while improving the carcass conformation of progeny from Boer goat crossbreds.

References

AOAC International.,1995. Official methods of analysis.16th ed. AOAC international, Gaithersburg, MD.

Casey ,N.H.,1982.Carcass and growth characteristics of four South Africa sheep breeds and the Boer goat. D.Sc.(Agric.)Thesis. University of Pretoria, Pretoria.

Casey, N.H.,Van Niekerk,W.A.,1985. Fatty acid composition of subcutaneous and kidney fat depots of Boer goats and thereponse to varying levels of maize meals. S. Afr. J. Anim. Sci. 15,60.

Devendra,C.,1988.The nutritional value of goat meat. Proceedings of a workshop held in Tando Jam,Pakistan,13-18 March 1988.Goat meat production in Asia.76-86.

Dhanda ,J.S., 1999a. Evaluation of different goat genotypes for growth, carcass and meat quality characteristics. Doctor of Philosophy thesis, University of Queensland.

Dhanda ,J. S., Taylor, D. G., Murray, P. J., McCosker, J. E., 1999b.The influence of genotype on the production of Capretto and Chevon carcass. 4.Chemical composition of muscle and fatty acid profiles of adipose tissue.52:375-379.

FAO/WHO. , 1990. Protein quality evaluation report of the joint FAO/WHO expert consultation on protein quality evaluation. Held in Bethesda, MD, Dec,4-8,1989.Food and agriculture organization of the United Nations. Roma. Italy.

Furst, P., Pollack, L. & Graser T. A. *et al*. ,1990. Appraisal of four pre-column derivatization methods for the high-performance liquid chromatographic determination of free amino acids in biological materials. J Chromatogr. 499:557-569.

Gang Yi, Xu., Jia Bi, P.&Tai Yong, C. *et al*. , 2003. Utilization effects of introduced Boer goat in China. Proceeding on product and research of goats and sheep in China.15-17.

Peer-reviewed paper: 8th International Conference on Goats

Godel H., Seitz P., Verhoef M,.1991.Automated amino acid analysis using combined OPA and FMOC-Cl precolumn derivatization. LC GC Int. 5:44-49.

Hong Ping, Z., Sheng Ou, C., 1999. Study on the growth and development of hybrids of Boer goats with Nnanjiang Yellow goats. J. Sichuan Agr. Univ.17:406-410.

Hong Ping, Z., Sheng Ou,C., 2000. Study on the meat performance of hybrids of Boer goats with Nnanjiang Yellow goats. J. Sichuan Agr. Univ.18:53-56.

Hong Ping, Z., Xiang Long,L.& Sheng Ou,C., 1996. Study on the effect of Boer goat frozen Semen. J. Sichuan Anim & Veter.4,6-8.

Malan ,S. W. , 2000. The improved Boer goat. Small ruminant research.36:165-170.

Srinivasan, K. S., Moorjani, M. N., 1974.Essential amino acid content of goat meat in comparision with other meats. J. Food Sci. & Tech.11,123-124.

Van Niekerk, W.A., Spreeth, E.B.&Sthemmet, H., 1985. A comparision of fiber digestibility between the Dorper sheep and the Boer goat. Paper presented S.Afr. soc.Anim. prod. Congress, Stellenbosch.

Wei Chun,W. ,1997. Some characteristics of Nanjiang Yellow goat.1997.Chinese goats & sheep research. 17(4):1-2.

Peer-reviewed paper: 8th International Conference on Goats

Quality attributes of commercial cashmere

B.A. McGregor
Primary Industries Research Victoria, Attwood, Victoria, 3049, Australia

Abstract

Recent investigations into objectively measured attributes of commercial cashmere have differentiated cashmere produced in different regions of the world on the basis of cashmere fibre attributes. By plotting any two of mean fibre diameter, fibre curvature and resistance to compression, cashmere from different producing regions was segregated into distinct groupings. Australian cashmere had lower fibre curvature ($P < 0.05$) probably as a consequence of being longer. Improved feeding of cashmere goats produced longer and slightly coarser cashmere but with significantly lower fibre curvature ($P < 0.05$). The low resistance to compression of cashmere from new origins, mainly Australia, indicates that this cashmere is more compressible, ie is softer to handle, than cashmere from traditional sources. The composition of typical raw commercial Australian cashmere was determined as: guard hair 44.3%, cashmere 28.5%, moisture 17%, suint 4.2%, grease 3.0%, soil 2%, vegetable matter 0.9%, other impurities < 0.1%. The use of fibre curvature in the commercial trading of cashmere is discussed.

Keywords: Fibre curvature, softness, fibre diameter, impurities, nutrition, cashmere length
#Corresponding author email: bruce.mcgregor@dpi.vic.gov.au

Introduction

Cashmere, the downy fibre grown by secondary skin follicles in some breeds of goats is expensive to purchase and process into textiles (McGregor, 2000a). For such an expensive textile raw material, surprisingly little objective information has been published on measurable attributes of commercially traded cashmere in either the raw or semi-processed form used by spinners. Many of the fundamental attributes of raw cashmere that are important in wool processing have not been measured and therefore are not understood. For a commercial industry to develop in Australia, cashmere producers and commercial trading partners need to understand all the quality attributes of the raw and processed product. This paper reports recent investigations into objectively measured attributes of commercial cashmere collected from traditional and new regions of cashmere production with a focus on Australian cashmere.

Materials and Methods

Samples of commercially dehaired cashmere from a range of manufacturers and countries of origin, samples of raw cashmere from Australia and China and cashmere from nutrition studies in Australia were tested. Bales core samples were tested in accordance with IWTO-19-95 (1995) and IWTO-33-88 (1988) to determine wool base, vegetable matter content, VM base and VM type and ash content. Mean fibre diameter (MFD) and an objective measure of the fibre crimp, the fibre curvature of cashmere (FC, degree/mm, Swan 1994) were determined by mini coring cashmere and testing with the OFDA100 following aqueous scouring and using Interwool Lab calibrations (IWTO-47-95 1995, IWTO-57-96 1996). Resistance to compression (Rc) was determined on dehaired cashmere (AS 3535 – 1988). Raw cashmere fibre length was measured to the nearest mm. Further details are provided elsewhere (McGregor 1988, 2000b, McGregor 2003a,b).

MFD, Rc and FC of dehaired cashmere were modelled as a function of geographical origin and processor using multiple regression with factors (Genstat 2000). The initial geographical origins could be sensibly grouped into broader regions without losing any explanatory power of the model. The final Origins were: West Asia (Iran, Turkey, Afghanistan), Eastern Asia (China including Inner Mongolia but excluding Xinjiang Autonomous Region), Central Asia (Western Mongolia, Xinjiang Autonomous Region of China) and New (Australia, representing 85% of New samples, New Zealand, USA). For fibre curvature, Iran was a separate Origin. There was no evidence of interaction between origin and processor. Scatter plots between MFD, FC and Rc were created with the data adjusted for processor. The processor adjustment was an equal (as distinct from proportional) adjustment, with processor effects estimated from the full fitted model. There was no adjustment of processors used for the dehaired samples from Central Asia, since these processors were completely distinct from those used in other regions. Conservative least significant intervals (LSI) were calculated using a new technique (M. Hannah, unpublished data). This approach guarantees that if the LSI

Peer-reviewed paper: 8th International Conference on Goats

for 2 means do not overlap then the 2 means are definitely significantly different at the 5% level, in a pairwise comparison.

Samples of cashmere from a replicated factorial experiment designed to assess the effect of nutrition on fibre quality and production of Australian cashmere goats (McGregor 1988a), were measured for cashmere FC, fibre length and Rc. The main treatment groups were: <M; goats were fed less than maintenance energy requirements resulting in loss of live weight; M; goats were fed to maintain live weight; >M; goats were fed above maintenance energy requirements resulting in gain in live weight. Nested within M were 3 treatments to assess the effect of additional protein. Nested within >M were 3 treatments to assess the effect of level of energy intake above maintenance (1.25 M, 1.5 M and Ad libitum, representing 25% greater, 50% greater and approximately twice the energy intake of the M treatment respectively). As there was no affect of nutrition within either M or >M, results presented are the main treatments including the nested treatments. The standard error of difference between means (sed) and the probability of significant difference between means (*P*) are given.

Results

Commercial bales of Australian cashmere have relatively low levels of naturally occurring extraneous matter with an average wool base of 80% and low levels of vegetable matter and soil (Table 1).

Table 1 Mean and sd of clean washing yield, mean fibre diameter (MFD), fibre curvature (FC), resistance to compression (Rc), vegetable matter (VM), VM and wool base, ash, cashmere yield and incidence of wax and suint of commercial bales of Australian cashmere (adapted from McGregor 2003b)

Trait	Washing yield (%)	MFD (μm)	FC (deg./mm)	Rc (kPa)	VM (%)	VM base (%)	Wool base (%)	Ash (%)	Cashmere yield (%w/w)	Wax (%)	Suint (%)
Mean	96.4	17.0	51	5.8	0.8	0.7	80.4	1.9	33.3	3.0	4.2
Sd	0.8	0.8	4	0.3	0.4	0.3	0.9	0.3	1.8	0.7	0.6

MFD of dehaired cashmere samples ranged from 13.6 to 19.2 μm (Figure 1). Chinese samples were finer than those from other origins ($P < 0.05$). Cashmere from Australia was finer than that from Iran. The mean FC (SD) of dehaired cashmere was 60.7 (9.1) deg./mm ranging from 44 to 76 deg./mm. Cashmere from new origins of production (Australia, New Zealand and USA) had lower FC than that from Iran, East and Western Asia ($P < 0.05$). Rc of dehaired cashmere overlapped substantially between origin. Iranian cashmere showed the highest median value and the largest variation. Cashmere from new origins of production had the lowest Rc ($P < 0.05$).

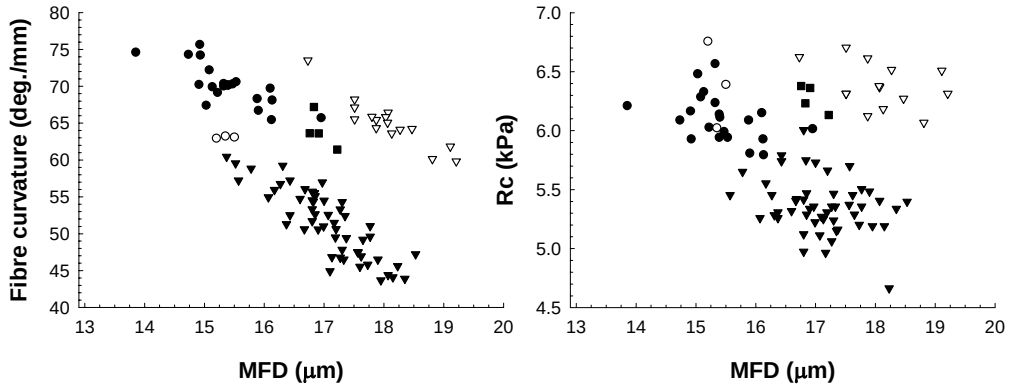


Figure 1 The mean fibre diameter (MFD), fibre curvature and resistance to compression (Rc) of dehaired cashmere from traditional and new origins of production. Legend: closed circle, East Asia, China; open circles, Central Asia; open triangle, Iran; closed triangle, Australia and other new origins; closed square, West Asia. Adapted from McGregor 2000b

In Australian goats, cashmere FC was dependant on nutrition. Goats fed to lose weight grew less cashmere that was shorter and finer with significantly increased FC compared with goats fed to gain weight

Peer-reviewed paper: 8th International Conference on Goats

(Table 2, McGregor 1988, 2003a). In raw Chinese Liaoning cashmere, there was a significant difference between each age and sex group in FC (bucks 52; does 65; kid bucks 78 deg./mm; $P<0.001$). Increasing Liaoning cashmere staple crimp frequency by 1 crimp per cm was correlated with an increase in FC of 6.5 deg./mm ($r^2 = 0.61$). In raw and dehaired Australian and Liaoning cashmere, increasing MFD and cashmere fibre length was associated with decreasing FC (for each 3 μm increase in MFD, FC declined 10 to 41 deg./mm; for each 10 mm increase in cashmere fibre length FC declined 3 to 13 deg./mm). In Australian and Liaoning cashmere, the direction of response in FC to changes in MFD and fibre length was similar.

Table 2 The effect of nutrition treatment on live weight change, cashmere production, cashmere mean fibre diameter (MFD), cashmere fibre length (FL), cashmere fibre curvature (FC) and dehaired cashmere resistance to compression (Rc). Values after adjustment for covariates. Adapted from McGregor (1988, 2003*a*)

Treatment group[1]	Live weight change (g/d)[2]	Cashmere weight (g)	MFD (μm)	FL (mm)	FC (°/mm)	Rc (kPa)
< M	-28	146	16.67	87.7	61.3	5.80
M	+2	192	16.93	99.9	53.2	5.64
> M	+38	221	17.69	102.2	47.5	5.53
$sed_{<M\ -\ other}$;		28.1;	0.38;	8.5	4.7;	0.18
P - value		0.05	0.05	NS	0.05	NS
$sed_{M\ ->M}$;		19.9;	0.27;	6.0	3.3;	0.13
P - value		NS	0.05	NS	NS	NS

[1] Nutrition feeding treatment: < M, live weight loss; M, maintenance of live weight; > M, live weight gain.
[2] Fleece-free live weight change during main period of cashmere growth from mid December to mid April.

Discussion

The composition of typical raw commercial Australian cashmere can be summarised as: guard hair 44.3%, cashmere 28.5%, moisture 17%, suint 4.2%, grease 3.0%, soil 2%, vegetable matter 0.9%, other impurities < 0.1%. The measurements of VM, ash and wax content of commercial Australian cashmere are much lower than data for cashmere from the seven main producing regions of Inner Mongolia (Ze 1989). Ze reported the wax content of Chinese cashmere ranged from 3.1 to 6.8%; VM content ranged from 0.3 to 1.2%; soil content ranged from 0.7 to 10.6%; and skin debris ranged from 3.1 to 20.5. The commercial significance of VM in greasy wool ranks just after MFD and washing yield as a physical attribute affecting processing of greasy raw wools. VM amount and type affects scouring, top making, yarn and cloth attributes (Smith 1988).

The low Rc of cashmere from new origins, mainly Australia, indicates that this cashmere is more compressible, ie is softer to handle, than cashmere from traditional sources. This work has differentiated cashmere produced in different regions of the world on the basis of cashmere fibre attributes. It was possible to segregate cashmere from different producing regions by plotting any two of MFD, FC and Rc (Figure 1). This method can also segregate other fibres such as cashgora from cashmere (McGregor 2000b).

The likely explanation as to why cashmere from new origins such as Australia is softer (ie has lower Rc) than traditional cashmere is provided in Figure 1, Table 2 and McGregor (2003a). It is likely that improved feeding of Australian cashmere goats compared with the nutrition of cashmere goats in traditional origins of supply, leads to longer and slightly coarser cashmere with significantly reduced FC. The results suggest that for Australian cashmere, only a certain number of fibre crimps are produced. As such, crimp frequency in Australian cashmere is time dependent and not length dependent (McGregor 2003a). This indicates that cashmere producers can manipulate the FC attributes of their cashmere by altering cashmere fibre length and fibre diameter via nutrition management. While age of goat, and physiological state are likely to be correlated with cashmere FC, cashmere producers could also manipulate cashmere FC directly by genetic selection (McGregor 1997). Currently FC is not included in international definitions of cashmere. The use of FC in greasy cashmere evaluation, specification, selling and classification systems needs to be clarified.

Conclusions

Dehaired cashmere shows commercially important variations in fibre attributes based on origin of cashmere. Commercial lots of Australian cashmere had low levels of impurities and vegetable matter and lower

Peer-reviewed paper: 8th International Conference on Goats

cashmere fibre curvature compared with traditional sources of cashmere. Cashmere with low fibre curvature has a lower resistance to compression and is likely to have a softer handle. Producers can manipulate cashmere fibre curvature by altering fibre length via nutrition. The use of fibre curvature in the commercial trading of cashmere has not been clarified.

Acknowledgments

Part of this work was undertaken at The University of New South Wales, Department of Textile Technology. Prof. R. Postle, Mr. K.L. Butler and participating processors are thanked. The Rural Industries Research and Development Corporation and Department of Primary Industry funded the work.

References

AS 3535-1988, 1988. Wool - Method for the measurement of resistance to compression. Standards Association of Australia, Melbourne.

Genstat, 2000. The Guide to Genstat. Ed. RW Payne, Lawes Agricultural Trust, Rothamsted.

IWTO-19-95, 1995. Determination of wool base and vegetable matter base of core samples of raw wool. International Wool Textile Organisation, Ilkley, Yorkshire, UK.

IWTO-33-88, 1988. Method for the determination of oven-dry mass and calculated invoice mass of scoured or carbonised wool. International Wool Textile Organisation, Ilkley, Yorkshire, UK.

IWTO-47-95, 1995. Measurement of the mean and distribution of fibre diameter of wool using an optical fibre diameter analyser (OFDA). International Wool Textile Organisation, Ilkley, Yorkshire, UK.

IWTO-57-96, 1996. Determination of medullated fibre content of wool and mohair samples by opacity measurement using an OFDA. International Wool Textile Organisation, Ilkley, Yorkshire, UK.

McGregor, B.A., 1988. Effects of different nutritional regimens on the productivity of Australian Cashmere goats and the partitioning of nutrients between cashmere and hair growth. Aust. J. Exp. Agric. 28, 459-467.

McGregor, B.A., 1997. Developing Faure Island Goats for Long Stapled Cashmere. Rural Industries Research and Development Corporation Research Paper Series No. 97/37, Canberra.

McGregor, B.A., 2000a. Recent advances in marketing and product development of mohair and cashmere. Proc. 7th International Conf. on Goats. Tour. Eds. Gruner, L. & Chabert, Y., INRA, France. pp. 631–637.

McGregor, B.A., 2000b. Quality attributes of cashmere. Proc. 10th International Wool Textile Res. Conf. Aachen. Eds. Höcker, H. & Küppers, B., Deutsches Wollforschungsinstitut, Germany. SF 1-10.

McGregor, B.A., 2003a. Influence of nutrition, fibre diameter and fibre length on the fibre curvature of cashmere. Aust. J. Exp. Agric. 46, 1199-1209.

McGregor, B.A., 2003b. Clean fibre, vegetable matter, wax, suint and ash content, yield and fibre attributes of commercial lots of Australian Cashmere. Wool Tech. Sheep Breeding 51, 224-241.

Smith, G.A., 1988. Processing of speciality animal fibres. Proc. 1st International Symp. Speciality Animal Fibres, Aachen. Schriftenreihe des Deutschen Wollforschungsinstitutes E. V. 103: 8-22.

Swan, P.G., 1994. Fibre specification and staple structure. In " Woolspec 94", Sydney, Eds. R.A. Rottenbury, K.A. Hansford, J.P. Scanlan, pp. G1-12, CSIRO, Sydney.

Ze, Li, 1989. The technology of dehairing cashmere goats wool. Australian National University, Canberra.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Goat milk production and processing in the NIAYES in Senegal

A. Missohou, [1#] L. Diouf,[1] R.S. Sow,[2] and C.B.A. Wollny[3]

[1]Service de Zootechnie-Alimentation, Ecole Inter-Etats des Sciences et Médecine Vétérinaires (EISMV). BP 577 Dakar, Sénégal.

[2]Institut National de Recherche Agronomique, Laboratoire de Hann, Dakar, Sénégal

[3] Georg-August University Göttingen, Institute of Animal Breeding, Section Animal Breeding and -husbandry in the Tropics and Subtropics, Kellnerweg 6, 37077 Göttingen Germany

Abstract

This study was carried out from February to December 2003 to analyse goat milk production and processing in the department of Thies and Mbour located in a sahelian area, 70 km from Dakar. Among the suppliers of the 3 processing units identified, 45 milk producers were identified and surveyed. 45 milk samples from farmers and 30 cheese samples from a processor were collected and submitted to chemical and microbiological analysis.

The flock size averaged 45 animals per household and was equally detained by men (51.1 %) and women (48.9 %). Feeding was based on extensive grazing under the control of a shepherd. Only 17.7% of the farmers fed agricultural by-products (beans and groundnut haulm) to lactating goats; 4.5 % dewormed their animals. The lactating goats were milked once a day by women (77.8 %) men (20 %) or children (2.2 %). Average daily milk production was 0.54± 0.12 l for a length of lactation of 3.6 months. The processing units collected the milk 2-3 times per week and the price paid (350-400 FCFA) was higher compared to cattle milk (300-350 FCFA). Two types of cheese were produced and sold to supermarkets and hotels. The processing yield was 12-15 %. The chemical composition of milk (dry matter:169.7±9.56g/l, protein: 50.5±1.1g/l, fat: 69±14.2g/l) was good. The low- input dairy goat system contributes to household income. It is recommended to examine possible management improvements and interventions to increase the efficiency of production in a sustainable manner. Small changes in feeding and milking management may lead to significant improvements.

Keywords: goat husbandry, milk processing, cheese, milk and cheese quality, Senegal
[#]Corresponding author; E-mail: missohou@refer.sn

Introduction

Senegal is a country where livestock accounts for 7.4 % of the national GDP and 35.5 % of the primary sector (Soned Afrique, 1999). Local milk production is low and 60% of domestic demand is met by imports (Metzer *et al.*, 1995). From 1980 to 2003, the quantity of milk products imported rose from 87 083 t in 1980 to 120 674 t in 2001 while in the mean time milk products intake dramatically decreased from 34.6 kg/caput/year to 25.4 kg /caput/year (FAO, 2002).

Goat production could contribute to self sufficiency in milk and milk products due to its fitness to the harsh environment of Senegal, its short production cycle and its ease of husbandry. Moreover, the most common Senegalese breed of goat, the Sahelian goat is reported to have good aptitude for milk production and processing (Missohou *et al.*, 2003). Despite this potential, the dairy goat is neglected in milk production improvement policies which have mainly relied on cattle (Denis & Mbaye, 1981). Due to private initiatives, an industrial sector is evolving during this last decade and is based on goat milk collection and processing. In Senegal, most of the studies available on goat production are related to rural areas (Faugere, 1990; Moulin *et al.*, 1994; Tourand *et al.*, 1996) while the suburban production and processing systems are poorly documented. The objective of the present work was to analyse goat milk production and processing in the Niayes.

Material and Methods

This study was carried out from February to December 2003 in the Niayes, precisely in the departments of Thies and Mbour, about 70 km from Dakar. In this area the climate is Sahelian with one rainy season (July to October) and an annual rainfall and temperature of 600-700 mm and 26 °C, respectively. The vegetation is grassland, and the main crops are millet, sorghum, groundnut and maize, and horticulture. Due to intense tourism activities, many hotels are located in the area.

Peer-reviewed paper: 8th International Conference on Goats

A survey was conducted in 45 households to analyse the characteristics of the goat production and processing systems. The farmers were randomly chosen from a list of suppliers available in the three milk processors identified in the working area. The survey guide was a questionnaire related to socio-economic status of the holders, flock characteristics, management and use. In every household, milk was once sampled while 30 cheese samples were collected from the main cheese producer. All samples were kept in an ice-cooled box and sent to Ecole Inter-Etats des Sciences et Médecine Vétérinaires de Dakar for analysis. pH was measured by a pH-meter and milk composition (Dry matter, protein, fat, ashes) was determined as described by Lecoq (1965). For microbiological analysis, dilution rate ranged from 10^{-1} to 10^{-7}. The isolation and enumeration of mesophilic aerobic, coliforms and *Staphylococcus aureus* were performed according to IDF (1997). These data were processed using the Statistical Package for the Social Science (SPSS).

Results and Discussion

Goat milk production characteristics of the Niayes is presented in Table 1. Goat holders were equally men (51.1 %) and women (48.9 %). Crop farmers, stock breeders or both, they were mainly of the Fulani ethnic group (93%). The herd size averaged (44.6±26.8) and was composed on average of 17 reproductive females, 7 reproductive males and 21 young animals. The relatively high number of adult males is in disagreement with previous studies in rural areas where they are early and intensive used (the use started at a very young stage and concerned almost every male) (Tourand, 1996). Animals were grazed on natural pasture under the control of a shepherd and had access to drinking water once a day. Only 17.7% of the farmers fed agricultural by-products (beans and groundnut haulm) to lactating goats. These lactating goats were hand milked once a day by women (77.8 %), men (20 %) or children (2.2 %) after allowing one to two minutes of suckling by the kid. Deworming occurred in 4.5 % of the surveyed households. Average daily milk production was 0.54±0.12 l for an average length of lactation of 3.6 months. The price of goat milk was 350-400 FCFA/l (1 euro=656 FCFA). It was higher than price paid to cattle milk in the area (300-350 FCFA) and provides to holders a substantial income averaging 2 954 FCFA/day. Two types of cheese were produced (fresh and mature) twice (2 processors) or three times (1 processor) a week with an average yield of 12-15%. The cheese was conditioned in 100-110 g units and sold to hotels and supermarkets.

Table 1: Goat milk production characteristics in the Niayes, Senegal

Socio-economic status	
Ethnic groups	
Fulani (%)	93
Serer (%)	7
Women share in ownership (%)	48.9
Flock size and composition	
Size	44.6
Number of reproductive females	16.8
Number of reproductive males	6.7
Number of young animals	21.1
Husbandry	
Supplementation (%)	17.7
Person responsible for Milking	
Women	77.8
Men	20
Children	2.2
Deworming	4.7
Milk production	
Average daily production (l)	0.54±0.12
Lactating length (months)	3.6±0.38

The pH of the milk was 6.71±0.26 (Table 2) and was in the normal range of fresh goat milk pH. It could be the proof of a low prevalence of mastitis. The dry matter (169.7±9.56 g/l) and proteins (50.5±1.1 g/l) compared favourably with results reported by Najari *et al.*. (2000) in a local breed but were higher than

Peer-reviewed paper: 8th International Conference on Goats

those obtained in European breeds by the same authors. This could be the consequence of the low level of milk production. However, Talaki (2002) reported that the Sahelian goat had a higher frequency of alleles A and B at the casein locus which , according to Grosclaude *et al.* (1987) are associated with a high level of α_{s1}-casein synthesis, milk protein and cheese yields.

Table 2: Goat milk physico-chemical properties in the Niayes, Senegal

Parameters	Mean + SD
PH	6.71±0.26
Composition	
Dry matter (g/l)	169.7±9.56
Protein (g/l)	50.5±1.1
Fat (g/l)	69.0±14.2
Ashes (g/l)	7.14±0.5

In the Niayes, the milk produced was highly contaminated (Table 3). The count averaged 19.2 10^7 cfu/ml for mesophilic aerobic, 4.9 cfu/ml for *staphylococcus aureus*, and 32.2 10^4 for coliforms. This coliform count was particularly high compared to international standards (10^3). The high contamination of milk in this study was in agreement with previous results in cattle (Nyaga *et al*., 1982; Seydi & Ndiaye, 1993) and are related to low hygiene (udder, hand, and utensil cleaning) during milking. Contrary to milk, cheese microbiological quality was more acceptable with 22.2 10^7 cfu/ml (mesophilic aerobic), 0 cfu/ml (S*taphylococcus aureus)*, and 296.3 10^4 (coliforms).

Table 3: Milk and cheese microbiological qualities in the Niayes, Dakar

Microbes	Milk (cfu/ml)	Cheese (cfu/ml)
Mesophilic aerobic	19.2 10^7	22.2 10^7
S*taphylococcus aureus*,	4.9	0
Coliforms	32.2 10^4	296.3

Conclusions

This study shows that in the Niayes the low input goat production system, in conjunction with an evolving processing sector contributed to household income. It could play a key role in poverty and malnutrition alleviation if some of its constraints are tackled in a sustainable manner. Improving the milking and processing hygiene is of primary importance. Feeding could be improved through, for instance, molasses-urea block.

References

Denis J.P. Mbaye M., 1981. Les résultats des importations de bovins laitiers au Sénégal. Dakar, LNERV. 10p.

FAO, 2002. Statistical database. Http//:www.fao.org

Faugere O, Dokes AC, Perrot C, Faugere B., 1990. L'élevage traditionnel des petits ruminants au Sénégal. II. Pratiques de conduite et d'exploitation des animaux chez les éleveurs de la région de Louga. Rev. Elev. Méd. vét. Pays trop., 43, 261-273.

IDF, 1997. International Standards 117B: Enumeration of characteristics of microorganism colony counts at 37°C. Brussels (Belgium).

Grosclaude, F., M.F. Mahé, G., Brignon, L. Di Stasio and R. Jeunet., 1987. A Mendelian polymorphism underlying quantitative variation of goat αS1-casein. Génét.Sél. Evol. 19: 399-412.

Lecoq R., 1965. Manuel d'analyses alimentaires et d'expertises usuelles. Tome I et II. ed Doin, Paris France.

Metzger R., Centres J.M., Thomas L., Lambert J.C., 1995. L'approvisionnement des villes africaines en lait et produits laitiers. Etude FAO Production et Santé Animales N° 124, Fao, Rome, Italy.

Moulin .C.H., Faugere, O., & Faugere, B., 1994. L'élevage traditionnel des petits ruminants au Sénégal. III. Pratiques de conduite et d'exploitation des animaux chez les éleveurs de la communauté rurale de Kaymor (Sine-Saloum, Sénégal). Rev. Elev. Méd. vét. Pays trop., 47, 223-234.

Missohou A., Talaki E. & Ibrahim L, 2003. Determination of genetic relationships between West African breeds of goat. 9th World Conference Animal Production, 26-31 October 2003, Porto Alegre, Brésil.

Peer-reviewed paper: 8th International Conference on Goats

Najari S. Ben Hammouda M, Khaldi G., Hatmi H. & Khorchani T., 2000. Amélioration de la production caprine en zones arides par l'utiliation des races exotiques. Proc, 7th International Conference on Goats, France, 15-21 May 2000.

Nyaga P.M, Kagiko M.M. & Gathuma J.M., 1982. Milk hygiene in nomadic herds in Kenya, evaluated by bacterial isolation, bacterial viability trials in traditionally fermented milk and drug sensitivity. Bull Animal. Hlth. Prod. Africa, 30, 19-24.

Seydi M. & Ndiaye M., 1993. Acidity and microbiological flora contaminating Senegalese reconstituted curdled milk produced on small scale. Bull de la Société Médicale d'Afrique Noire de Langue Francophone, 38, 61-67.

Soned Afrique, 1999. Etude sur le rôle et l'importance du sous secteur de l'élevage dans l'économie nationale, formulation d'une stratégie nationale de développement. Rapport définitif, 90 pages. MRA Ministère chargé des Ressources Animales/1988. Plan d'action pour l'élevage. 39 pages.

Talaki, E., 2002. Caractérisation des chèvres naines (Sénégal), Sahel (Sénégal), Guéra (Mauritanie) et rousse de Maradi (Niger): étude du polymorphisme des microsatellites et des caséines αs^1 et αs^2 du lait. Mémoire de DEA Biologie Animale, UCAD, N° 153, 76 p.

Tourand, J.F. & Landais, E., 1996. Productivités des caprins dans le système de production agricole du Delta du Fleuve Sénégal. Rev. Elev. Méd. vét. Pays trop, 49, 168 - 173.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Effect of 6 months prolonged frozen-storage on changes in organic acid composition of plain soft goat milk cheese

Young W. Park[1], Jung H. Lee[1], and Kashmiri L. Arora[2]
[1]Agricultural Research Station, Fort Valley State University, 1005 State University Drive, Fort Valley, GA 31030-4313, and [2]Department of Veterinary Science, Fort Valley State University, Fort Valley, GA 31030

Abstract

Feasibility of prolonged frozen-storage of goat milk cheeses is extremely important for profitability and sustainability of the dairy goat industry. Extended frozen-storage can be detrimental by the cheese texture and flavor compounds including organic acids. The study was conducted to evaluate effects of 6 months of frozen-storage compared to fresh control on organic acid profiles of soft goat cheese. Three lots of plain soft goat cheeses were purchased and each lot of the cheeses was subdivided into four treatment groups as fresh-unfrozen control (UFC), frozen-thaw control (FZC), 3 and 6 months frozen-storage (3FZ and 6FZ). All samples were subjected to aging at 4°C for 0, 14, 28 days. Organic acids were determined using a HPLC (Hewlett Packard; LC-1100 Series) equipped with auto sampler, quaternary pump, and fluorescence detector. Organic acid contents for all known standards ranged 0.01 - 13.0 mg/g cheese. Significant effects ($P<0.01$) were observed for most of the known acids, indicating that some variation in manufacturing parameters might have occurred during cheesemaking. Effects of storage treatments (UFC, FZC, 3FZ and 6FZ) were highly significant ($P<0.01$ or 0.001) for most organic acids, except for orotic and a few unknown acids. Aging at 4°C for 4 weeks had little influence on all organic acids except butyric acid. Concentrations of butyric, lactic, propionic, tartaric and uric acids were significantly ($P<0.01$) elevated as the frozen-storage period advanced. The UFC cheese had the highest malic and unknown-11 acids, compared to the three frozen groups. A companion study of sensory properties on the same cheeses revealed that practically no differences existed in sensory values among different storage treatments at 0 day of aging at 4°C. Prolonged frozen-storage up to 6 months may be feasible since no apparent deterioration occurred in sensory scores of the goat cheeses although elevations occurred in several organic acid contents.

Keywords: Frozestorage, organic acid, goat milk cheese
#Corresponding author; E-mail: Parky@fvsu.edu

Introduction

Organic acids are important flavor compounds of most aged cheeses, which are formed as a result of hydrolysis of milk fat during lipolysis, normal ruminant metabolic processes, bacterial growth, or addition of acidulants during cheesemaking (Adda *et al.,* 1982; Bevilacqua and Califano. 1989; Akalin *et al.,* 2002; Izco *et al.,* 2002). Organic acids are also the major products of carbohydrate catabolism by lactic acid bacteria.

Quantitative determination of organic acids is an important tool for studying flavor and nutritional quality as well as an indicator of bacterial activity of aging cheeses, since the total aroma intensity was correlated with organic acid levels in grating cheeses (Akalin *et al.,* 2002). Freezing cheeses is not a common industrial practice (Kosikowski, 1977). However, the seasonality of goat milk production necessitates certain alternative methods of the milk preservation for year-round marketing including frozen-storage of goat cheeses. The effect of freezing on food quality of goat cheeses has little been studied. The purposes of this study were: (1) to determine the effect of frozen-storage on organic acid profiles of plain soft goat cheeses, and (2) to study feasibility of prolonged frozen-storage of the goat cheese for later marketing.

Materials and Methods

Three batches of commercial soft goat milk cheeses were purchased from a grade A goat dairy in Georgia. The cheese was manufactured using a modified method of Le Jaouen (1987). Goat milk was pasteurized at 145°F for 120 minutes and by slow coagulation and natural draining, then hanging the cheese in cheesecloth for three days in cool room (72°F) before packaging. The cheese was packaged in 454g rod shapes with polyolefin shrink wrap, then shipped to the analytical laboratory in an ice pack box via overnight delivery. A 3.5 g of frozen powdered cheese samples and 20 mL of 0.5% (wt/vol) $(NH_4)_2HPO_4$ were added to a 50 mL Erlenmeyer flask. Organic acids were extracted for 1 h on a shaker at 400 rpm (New Brunswick Scientific, Edison, NJ), then the extracts were centrifuged at 6000 x g for 10 min. The supernatant

Peer-reviewed paper: 8th International Conference on Goats

was filtered through (Supelco Inc.) 0.45 μm membrane filter twice, then 50 μL sample was injected to HPLC. Organic acids of the cheese samples were analyzed using a Hewlett Packard Liquid Chromatography (LC-1100 Series) equipped with auto sampler, quaternary pump, vacuum degasser, and fluorescence detector which was set at 214 nm. The column used was ODS Hypersil 5μm (125 X 4 mm), and mobile phase was 0.5% (wt/vol) $(NH_4)_2HPO_4$. Column flow rate was 0.3 mL/min. Organic acid standards were purchased from Sigma Chemical Co. (St. Louis, MO), and individual organic acid was quantified on the basis of the external standard method.

Experimental data were analyzed for analysis of variance, correlations between parameters, and least squares mean comparison of organic acids among treated goat cheeses as described by Steel and Torrie (1960). All data were also analyzed using General Linear Model of SAS program (SAS, 1990).

Results and Discussion

Six months frozen-storage caused significant (P<0.05 or 0.01) increases in tartaric, lactic, propionic, uric and butyric acids in the plain soft goat cheese (Table 1 and 2). Acetic acid in FZC cheese was decreased by aging 4 weeks at 4°C, whereas increased by aging in fresh cheese (UFC) (Table 1). Soft cheeses are not usually aged, thereby the goat cheeses aged at 4°C for 4 weeks in this study appeared to be losing acceptable freshness and shelf-life of the product.

Table 1 Comparison of organic acid contents among fresh, 0, 3 and 6 month frozen-stored soft goat milk cheeses aged at 4°C for 4 weeks.

	UFC			FZC			3FZ			6FZ		
Organic acid	0 d	14d	28d	0 d	14d	28d	0 d	14d	28d	0 d	14d	28d
Tartaric acid	0.86	0.93	0.93	0.75	0.67	0.70	1.53	1.49	1.42	1.62	1.79	1.92
Formic acid	2.32	2.23	2.21	2.66	2.60	2.59	1.63	1.74	1.81	2.31	2.37	2.61
Orotic acid	0.042	0.011	0.012	0.043	0.014	0.013	0.011	0.037	0.036	-	-	-
Malic acid	1.13	1.32	1.44	1.22	1.40	1.21	0.42	0.44	0.30	-	-	-
Lactic acid	10.04	10.22	10.37	8.96	10.15	9.83	11.19	10.97	10.70	12.47	12.30	12.91
Acetic acid	2.86	4.20	4.34	5.01	4.03	3.69	3.24	3.32	2.65	3.04	3.41	4.41
Citric acid	0.69	0.82	0.87	0.88	0.89	0.81	2.12	1.73	1.58	0.58	0.92	1.42
Uric acid	0.017	0.02	0.015	0.029	0.038	0.034	0.037	0.043	0.040	0.083	0.085	0.084
Propionic acid	0.71	0.79	0.69	1.28	0.60	0.83	1.53	2.13	2.15	5.36	4.25	4.84
Butyric acid	1.07	1.20	1.29	1.01	1.21	1.62	1.16	1.53	1.83	2.76	2.93	4.93

Table 2 Comparison of mean concentrations of individual organic acids for pooled data across aging period for the 4 storage treatment groups.

Tartaric		Formic		Lactic		Acetic		Citric		Propionic		Butyric	
Treat	Mean	Treat	Mean	Treat	Mean	Treat	Mean	Treat	Mean	Treat	Mean	Treat	Mean
FZ6	1.777a	FZC	2.620a	FZ6	12.56a	FZC	4.173a	FZ3	1.809a	FZ6	4.82a	FZ6	3.540a
FZ3	1.480b	FZ6	2.429ab	FZ3	10.95b	UFC	3.884ab	FZ6	0.974b	FZ3	1.94b	FZ3	1.510b
UFC	0.925c	UFC	2.225b	UFC	10.26bc	FZ6	3.620ab	FZC	0.860b	FZC	0.90c	FZC	1.282b
FZC	0.708d	FZ3	1.728c	FZC	9.46c	FZ3	3.070b	UFC	0.797b	UFC	0.69c	UFC	1.185b

Means with different letters significantly differ (P<0.05 or 0.01).

Hough *et al.* (1996) showed that the flavor descriptors in Reggianito grating cheese, such as total intensity, cheesy, salty, tongue-tingling, hot and residual intensity could be predicted from organic acids. They noticed that propionic acid was a good indicator of flavor development, and total aroma intensity was well correlated by organic acid contents. Propionic acid in this study was also significantly (P<0.01) increased by frozen-storage (Table 2). The longer the frozen-storage, the greater elevation of propionic acid (Table 2). The same trend of elevations in other organic acids suggests that flavor development in the cheese has been occurred by the catabolic activities of lactic acid bacteria as well as lipolysis cheese fat by the activation of lipolytic enzymes (Akalin *et al.,* 2002; Izco *et al.,* 2002).

Lactic acid was in greatest amounts among all known organic acids in the soft goat cheese, while orotic acid was in the lowest (Tables 1). There was no pyruvic acid in the soft goat cheese, while several unknown large peaks appeared between propionic and butyric acids. Although organic acid contents were

Peer-reviewed paper: 8th International Conference on Goats

increased, the apparent sensory qualities in the goat cheese appeared to be unaffected by 6 months prolong frozen-storage. This result is in agreement with the report of Bertola *et al.* (1996) that frozen Mozzarella could be stored at -20°C without quality loss as long as the final product had been aged from 14 to 21 days before being consumed.

Conclusions

The study confirmed that tartaric and propionic acids were important organic acid predictors for the plain soft goat cheese, and the elevation of the several organic acids did not have any negative influence on the acceptability of the frozen-stored product. Six months frozen-stored, thawed and 0 day refrigerated storage showed minimal changes in organoleptic qualities of the cheese product, indicating that the six months prolonged frozen-storage appears to be feasible for the off-season marketing of the soft goat milk cheese.

References

Akalin, A.S., S. Gonc, and Y. Akbas. 2002. Variation in organic acids content during ripening of pickled white cheese. J. Dairy Sci. 85:1670-1676.

Bevilacqua, A.E., and A.N. Califano. 1989. Determination of organic acids in dairy products by high-performance liquid chromatography. J. Food Sci. 54:1076-1079.

Bertola, N.C.,Califano, A.N., Bevilacqua, .E., and Zaritzky, N.E. 1996. Effect of freezing conditions on functional properties of Mozzarella cheese. J. Dairy Sci. 79:185-190.

Hough, G., A.N. Califano, N.C. Bertola, A.E. Bevilacquoa, E. Martinez, M.J. Vega, and N.E. Zaritzky. 1996. Partial least square correlations between sensory and instrumental measures of flavor and texture for Reggianito cheese. Food Qual. Preference 7:47-53.

Izco, J.M., M. Tormo, and R. Jimenez-Flores. 2002. Rapid simultaneous determination of organic acids, free amion acids, and lactose in cheese by capillary electrophoresis. J. Dairy Sci. 85:2122-2129.

Kosikowski, F.V. 1977. Cheese and Fermented Milk Foods. 2nd ed. Edwards Brothers, Inc., Ann Arbor, MI. p. 90.

Le Jaouen, J.-C. 1987. The Fabrication of Farmstead Goat Cheese. p. 45-121. Cheesemaker's Journal, Ashfield, MA.

SAS Institute Inc. 1989. SAS System for Windows. Release 6.12. SAS Institute Inc., Cary, NC.

Steel, R.G.D. and Torrie, J.J. 1960. In: Principles and Procedures of Statistics. P. 277.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Goat milk and heat treatments

K. Raynal-Ljutovac[1#], T. Massouras[2] and M. Barbosa[3]
[1] Institut Technique des Produits Laitiers Caprins (ITPLC). BP 49 – 17700 Surgères – France
[2] Agricultural University of Athens – Department of Food Science and Technology
75 Iera Odos Street – 11855 Athens – Greece
[3] Instituto Nacional de Engenheria e Tecnologica Industrial (INETI) – Departamento de Tecnologica das Industrias Alimentares. Estrada do Paço do Lumiar 22 – 1649-038 Lisboa – Portugal

Abstract

Heat stability of goat milk has been investigated on European milks samples from France, Greece and Portugal. A variability of coagulation temperatures was observed and was directly linked to milk composition. Some technological adaptations such as the use of additives can greatly improve heat stability of French goat milk. Furthermore, some steps of UHT process itself can be detrimental and must be taken into account. It was shown that cold storage (72h at 4°C) could impair the stability of goat milk.

Keywords : goat milk, heat stability, physicochemical composition, additives, cooling.
[#]Corresponding author; E-mail: ketsia.raynal@itplc.asso.fr

Introduction

Goat milk is more sensitive to high heat treatments than bovine milk. The available reports indicate that pH (Zadow *et al.*, 1983; Ram & Sindhu, 1991; Montilla & Calvo, 1997; Anema & Stanley, 1998), micelle hydration (Thompson *et al.*, 1969), genetic polymorphism of α–S1 casein (Tziboula, 1997), non-protein nitrogen (Mukherjee *et al.*, 1993), salt balance (Ram & Sindhu, 1991), and ionic calcium (Zadow *et al.*, 1983, Montilla and Calvo, 1997) could be directly or indirectly involved in the heat sensitivity of caprine milk. As goat milk shows great variability in biochemical composition, technological properties and bacteriological quality (Anifantakis & Kandarakis, 1980; Barbosa, 1993; Jaubert & Kalantzopoulos, 1996) depending on genetic factors, environmental conditions, and goat farming practices, heat sensitivities of goat milks can be different according to European countries such as Greece, France and Portugal.

Moreover, conditions of transformation during UHT process must also be taken in consideration. Besides the use of additive to increase goat milk stability, the UHT process itself can be investigated or more specifically, all the steps prior to the UHT treatment. Besides the effect of heat treatment on colloidal stability, cooling has also negative effects. The most evident effects are solubilisation of colloidal calcium and micellar caseins, especially β-casein. Owing that cold storage is the most used way of preserving milk at the farm and at the arrival in the plant, the time of cold storage must be taken into account in the UHT process as a key step.

Materiel and Methods

Physicochemical characteristics and heat stability of French (F), Greek (G) and Portuguese (P) bulk milks collected by SMEs were evaluated as described in Morgan et al (2003). Goat breeds were Saanen and Alpine in France, indigenous breeds in Greece and Granadina, Serpentina, Alpine and Saanen in Portugal. To evaluate the impact of additive and cold storage, UHT treatment at 136°C/ 6s was realised on a French skimmed milk, before and after storage at 4°C during 72h. The additive used were disodium phosphate (3 mM), a mix of phosphate (6 mM) and trisodium citrate (3 mM).

Given the fact that most of the milk samples were unstable at 140 °C or 120 °C, the determination of heat coagulation time at a fixed temperature was not suitable in the present study. Heat coagulation temperature was measured at a fixed time (1 min), as previously described by Morgan *et al.*. (2000), rather than the heat coagulation time at 140° or 120 °C. Milk samples (60 µL) were sealed in glass-capillary tubes and heat treatment was performed in an oil bath at temperatures ranging from 80 to 140 °C for 1 min. The heat stability (HS) was defined as the maximum temperature within the range 80-140 °C at which the sample was stable during a 1-min treatment. Three replicates were carried out for the measure.

Results and Discussion

Results concerning heat stability of European goat milks are given in Table 1. Heat stability of

Peer-reviewed paper: 8th International Conference on Goats

Portuguese milk (124.5 °C) was similar to the French one F1 (125.9 °C), and the heat stability of F2 milk was the highest (133 °C). Greek milks had a very low heat stability (92-110 °C). This poor thermal stability could be related to the physicochemical (protein concentrations, low pH linked to microbiological characteristics, data not shown) of these samples owing that maximum heat stability of goat milk occurs at pH 6.9-7.0 (Tziboula, 1997 ; Anema & Stanley, 1998 ; Morgan *et al.*, 2001).

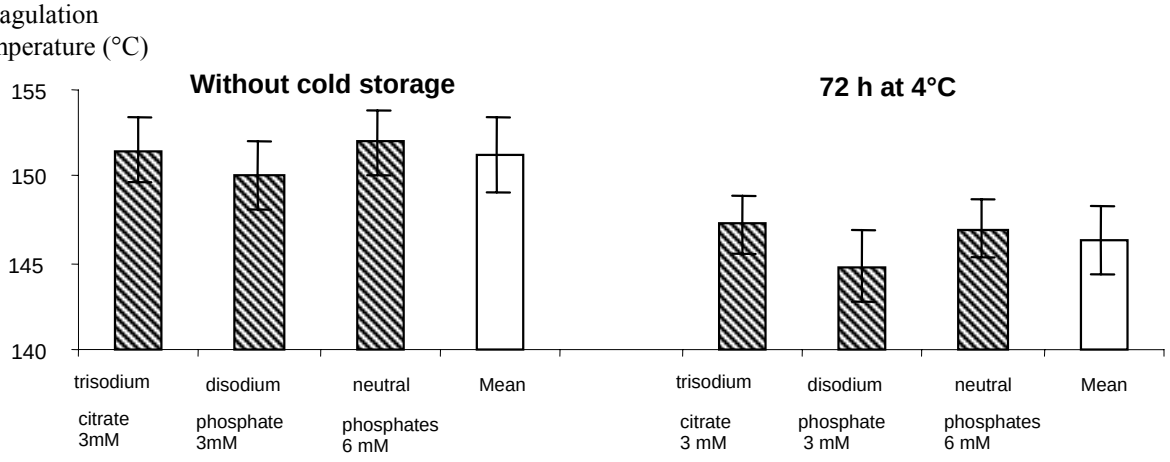
Table 1 Technological aspects of goat milk collected from small and medium enterprises in Greece (G1-G4), France (F1, F2) and Portugal (P)

SMEs		Total solids (%)	Protein (g/kg)	Casein/ Protein (%)	pH	Heat stability (°C)
G1	Mean	14.4	38.3	77.3	6.51	92.0
	SD	0.3	1.3	3.07	0.1	4.4
G2	Mean	13.8	37.6	78.0	6.55	95.0
	SD	0.7	3.0	1.6	0.08	2.6
G3	Mean	13.1	35.0	74.0	6.61	110.0
	SD	0.5	2.8	6.11	0.06	3.7
G4	Mean	13.6	36.9	76.2	6.56	105.0
	SD	0.3	1.1	2.3	0.45	3.3
F1	Mean	11.8	32.3	73.7	6.63	125.9
	SD	0.9	2.4	2.6	0.14	5.6
F2	Mean	11.6	32.6	72.2	6.75	133.0
	SD	0.6	1.5		0.10	5.9
P	Mean	12.8	34.9	nd	6.59	124.5
	SD	0.5	1.6		0.14	6.5

n.d. : not determined

Other factors like ionic calcium and whey proteins may also play a role in the thermal coagulation of goat milk (Morgan *et al.*., 2000, 2001). A negative impact of cold storage on heat stability, because of increased calcium level during cold storage (Raynal & Remeuf, 2000), may be suggested. The negative impact of cold storage before UHT treatment has been demonstrated for French milks (Figure 1). The use of trisodium citrate greatly improved heat stability of goat milk (coagulation temperature : more than 146°C compared to 136°C for fresh milk without additive : 136°C). Nevertheless, additives do not enable storedmilk to support as high temperature as non stored milk.

Figure 1 Impact of cold storage on heat stability



Peer-reviewed paper: 8th International Conference on Goats

Conclusion

Due to the low heat stability of goat milk, especially at its natural pH, technological controls (of sanitary criteria in order not to have low pH) and/or technological adaptations are needed when heat treatments are used for the production of goat milk namely, to avoid low pH goat milks with a good control of sanitary criteria, to avoid long time storage at 4°C before UHT treatment and finally to use some technological additives.

Acknowledgements

We thank the EU for financial support concerning work on composition of European goat milks in the "cadre" of craft program FAIR CT 98-9598. We also thanks French Ministry of Agricultural and Fisheries for its support in the "Aliment-Qualité-Sécurité" program.

References

Anema S.G., Stanley, D.J., 1998. Heat-induced, pH-dependent behaviour of protein in caprine milk. International Dairy Journal 8, 917-923.

Anifantakis, E.M. & Kandarakis, J., 1980. Contribution to the study of the composition of goat's milk. Milchwissenschaft (35), 617-619.

Barbosa, M., 1993. Goat's milk research in Portugal. Lait (73), 425-429.

Jaubert, G., Kalantzopoulos G., 1996. Quality of goat milk cheese and other products. 6th Int. Conf. on Goats, Beijing, China, 6-11 May, vol. 1, 274-284.

Montilla, A. & Calvo, M.M., 1997. Goat's milk stability during heat treatment. Effect of pH and phosphates. J Agric Food Chem, 45, 931-934.

Morgan, F., Micault, S., Jacquet, F., Bonnin, V. & Jaubert, A., 2000. Study on the compositional factors involved in the variable sensitivity of caprine milk to high temperature processing. Int. Dairy J., 10, 113-117

Morgan, F., Micault, S. & Fauquant, J., 2001. Combined effect of whey protein and α_{S1}-casein genotype on the heat stability of goat milk. Int. J. Dairy Technol., 54, 64-68.

Morgan, F., Massouras, T., Barbosa, M., Roseiro, L., Ravasco, F., Kandarakis, I., Bonnin, V., Fiskatoris, M., Anifantakis, E., Jaubert, G. & Raynal-Ljutovac, K., 2003. Characterisation of goat milk collected by small and medium enterprises from Greece, Portugal and France. Small Rumin. Research, 47 (1), 39-49

Ram, S. & Sindhu, J.S., 1991. Salt balance and heat stability of goat milk as affected by pH. Indian Journal of Animal Sciences 61, 753-756.

Raynal, K. & Remeuf, F., 2000. Effect of storage at 4°C on the physicochemical and renneting properties of milk: a comparison of caprine, ovine and bovine milks, J Dairy Res, 67 , 199-207

Tziboula, A., 1997. Casein diversity in caprine milk and its relation to technological properties: heat stability. International Journal of Dairy Technology 50, 134-138.

Zadow, J.G., Hardham, J.F., Kocak, H.R. & Mayes, J.J., 1983. The stability of goat's milk to UHT processing. Aust J Dairy Technol, 38, 20-23.

Peer-reviewed paper: 8th International Conference on Goats

Effect of crossbreeding between two Egyptian goat breeds on physicochemical, technological and nutritional characteristics of goat milk

SA Salem, EI El-Agamy, AM Yousseff
Department of Dairy Science, Faculty of Agriculture, University of Alexandria, Alexandria, Egypt.

Abstract

Milk samples of two different crossbreeds of Egyptian goats were analyzed for their physicochemical, technological and nutritional characteristics, in order to evaluate the effect of crossbreeding on milk properties. Crossbreed goats (50% Damascus: 50% Barky) had better milk properties than milk of the Barky breed but less than that of Damascus goats. Upgrading with Damascus goats (75% Damascus: 25% Barky) improved all milk constituents. Milk of the second crossbreed had better technological properties than that of the first crossbreed. Milk of both crossbreeds had a satisfactory balance of essential amino acids, although lower than that of milk of the parent breeds.

Keywords: Damascus goats, Barky goats, crossbreeding, milk quality.
#Corresponding author; E-mail: a_s_salem@yahoo.com

Introduction

Improving goat productivity in Egypt could be achieved through better management and genetic Programmes. Milk production varies greatly between different genotypes raised at different locations. Abdelsalam et *al.*, (2000) found that milk production (kg) and lactation period (days) differed for Damascus, Barky, and their crosses in the Desert of Egypt. In our previous work (Salem et *al.*, 2000), the different characteristics of milk of Barky and Damascus goats were evaluated. This study evaluated changes of physicochemical, technological and nutritional properties of milk of two different crossbreeds from Barky and Damascus goats.

Materials and methods

Normal individual milk samples of two types of crossbred goats; crossbreed 1 (50% Barky: 50% Damascus) and crossbreed 2 (75% Damascus: 25% Barky) were collected from fifteen animals of each, from Borg El-Arab area near Alexandria, Egypt. The samples were cooled at 4º C then transported, to laboratory for analysis, within another one hour. Titratable acidity, specific gravity, fat, total solids, chlorides and ash content were determined as described by Ling (1956), lactose by phenol sulphuric acid method (Marier and Baulet,1959). Total calcium and magnesium were determined using shimadzu atomic absorption spectrophotometer (model 2380) after ashing milk samples according to A.O.A.C. (1980), potassium and sodium by Beckman flame photometer mark II. Phosphorus was determined spectrophotometrically using hydroquinone - ammonium molybdate as described by Snell & Snell (1949). Nitrogen distribution was determined as described by Rowland (1938), the total nitrogen, non - casein nitrogen and non - protein nitrogen were determined by micro - kjeldahl method A.O.A.C (1980).Milk samples were hydrolyzed with according to the method of Nagasawa (1970), then analyzed for amino acid composition using a Beckman acid analyzer model 119c1.The number of fat globules was determined as described by King (1957).The method of Dovidov (1963) was used, for determination of weight and diameter of casein micelle, which is based on the scattering light phenomena, the method was reported by Salem *et al.*., (2000).Fatty acids were methylated as described by Vogel (1956), the methyl esters of the fatty acids were analyzed with a pye unicam gas chromatography model 104 Perkin - Elmer equipped with a dual flame channel recorder. Detector and injection temperatures were 220 and 170 º C respectively. The data were statistically analyzed by means of the S.P.S.S. (2003) statistical program.

Results and discussion

The results given in Table 1 show that the pH values varied between the milk of the two crossbreds and their parent breeds. The lowest pH value was obtained for Damascus goat milk, while the highest was in the milk of crossbreed 2 goats. Highest acidity values were in the milk of crossbreed 1 and crossbreed 2 goats compared to the milk of the Barky and Damascus goats The chloride content was lowest significantly ($P<0.01$) in crossbreeds 1 and 2 compared to the milk of Barky goats, and lowest in the milk of crossbreed

Peer-reviewed paper: 8th International Conference on Goats

2 goats. The specific gravity values differed slightly between all breeds. The total solids (TS) in the milk of crossbreed 2 goats (14.28%) was nearly equivalent to that in the milk of Damascus goats (15.88%). The fat content was also considerably higher (P<0.01) in milk of crossbreed 2 compared to that of Barky goats. Similarly, the protein content was also significantly higher in the milk of crossbreed 2 goats. This increase (P<0.01) in fat and protein contents in milk of crossbreed 2 goats suggests that they would produce milk with a better yield in cheese making compared to that from Barky goat milk. The casein content was significantly higher (P<0.01) in crossbreed 2 goat milk than that of Barky and crossbreed 1 goats, and was closer to that level of Damascus goat milk. The content of ash in crossbreed 2 and crossbreed 1 goat milk was significantly higher (P<0.01) than in Barky and Damascus goat milks. Lactose content in the milk of crossbreed 2 goats was closer to that of Damascus goat milk.

Table 1 Average composition of crossbreeds goats' milk (g/100g).

Constituents	Barky*		Damascus*		Crossbreed 1		Crossbreed 2	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Moisture[a]	87.79	0.034	84.12	0.024	87.93	0.027	85.72	0.034
Fat[a]	2.85	0.048	5.10	0.196	3.10	0.231	4.20	0.199
Protein[a]	2.15	0.053	4.35	0.060	2.32	0.023	4.22	0.243
Casein[a]	1.52	0.115	3.01	0.073	1.062	0.034	2.95	0.268
Whey protein[a]	0.63	0.120	1.34	0.044	0.70	0.016	1.27	0.131
w.p./ T.protein	29.30		30.80		30.17		30.00	
w.p./ casein	0.41		0.45		0.43		0.43	
Lactose[a]	3.85	0.092	5.46	0.210	4.09	0.240	4.82	0.329
Ash[a]	0.896	0.005	0.969	0.007	0.997	0.005	1.039	0.005
Total solids	9.75		15.88		10.51		14.28	
M.S.N.F.	6.90		10.78		7.41		10.08	
PH	6.8		6.6		6.75		6.85	
Acidity	0.171		0.171		0.189		0.186	
Chloride	0.170		0.170		0.120		0.108	
Specific gravity	1.030		1.030		1.028		1.029	

*Salem et *al.*, (2000) SD: Standard Deviation
w.p. whey protein [a]Significant P< 0.01 level.
M.S.N.F.: milk solids not fat

Table 2 shows the mineral contents of goat's milk. ratios of Ca and K were significantly higher (P<0.01) in the milk of crossbreed 2 goats compared to that of Barky and Damascus goats, while the content of Mg was close to that of Barky goat milk. While the Na content was significantly higher (P<0.01) in the milk of crossbreed 1 goats, and significantly lower in the milk of crossbreed 2 goats. The P content in milk of crossbreed goats was significantly (P<0.01) lower than in the milk of Barky or Damascus goat milk.

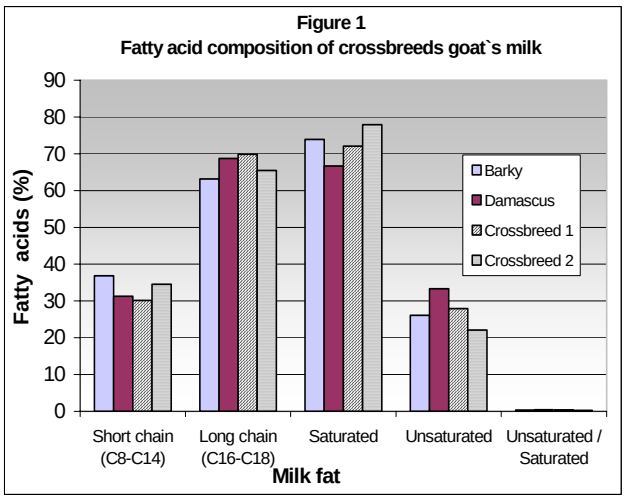
Unsaturated fatty acids in crossbreed 2 goat milk fat were lower than that of both Barky and Damascus goats. The crossbreed 1 goat milk fat had the best ratio (P<0.01) of unsaturated /saturated fatty acids than in all breeds studied (Fig 1). The ratio of essential amino acids varied considerably between the milk of parent breeds and their crossbreeds. The lowest value was in milk form crossbreed 2 goats, followed by the milk of crossbreed 1 goats. .(Fig.2). Generally, milks of both goat crossbreeds have a satisfactory balance of essential amino acids equaling or exceeding the FAO - WHO - UNU requirements for each amino acid.

Peer-reviewed paper: 8th International Conference on Goats

Table 2 Mineral contents (mean values) of crossbreeds goats' milk (mg/100ml). [a]

Mineral	Barky*		Damascus*		Crossbreed 1		Crossbreed 2	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Ca^{++}	142	1.387	133	2.426	119	3.093	146	6.010
Mg^{++}	19	1.751	16	2.374	13	2.576	18	2.789
Na^{++}	42	1.407	44	2.717	51	3.127	32	2.314
K	161	5.205	185	11.342	173	11.058	196	13.974
P^{-3}	102	1.033	99	1.804	86	2.230	92	3.654
Ca/P	1.39		1.34		1.38		1.54	
Na/K	0.26		0.24		0.29		0.44	

*Salem *et al.*, (2000) SD:Standard Deviation [a]Significant P< 0.01 level.



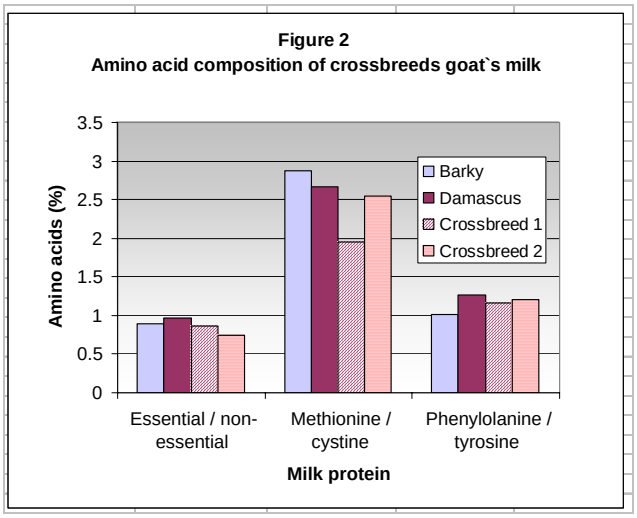


Table 3 shows that the number of fat globules was significantly decreased (P<0.01) in the milk of both crossbreeds compared to that in Barky goat milk. They were closer to the values for Damascus goat milk. On the other hand, the size of casein micelles was significantly less (P<0.01)in the milk of crossbreed 1 goats compared to Barky goat milk, while in crossbreed 2 goat milk it was closer to that of Damascus goats.

Damascus and crossbreed 2 goat milks had significantly higher (P<0.01) casein and lower fat globules diameters than Barky goat milk. This property is important in cheese making, since the higher casein content and lower fat globule diameter result in soft curd in cheese making.

Table 3 The properties of casein micelle and fat globules of crossbreeds goat's milk (mean values)

Constituents	Barky*		Damascus*		Crossbreed 1		Crossbreed 2	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Fat globules In 1ml of milk[a]	$2.9X10^9$	0.033	$4X10^9$	0.274	$2.4X10^9$	0.273	$2.6X10^9$	0.296
Diameter of globule (μ)[a]	3.09	0.019	3.01	0.021	3.12	0.023	3.07	0.023
Casein micelle diameter (A^o)[a]	922	3.586	974	3.058	884	3.173	965	3.117

*Salem *et al.*, (2000). SD: Standard Deviation [a]Significant P< 0.01 level.

Peer-reviewed paper: 8th International Conference on Goats

References

Abd El-Salam, M.M., Eissa, M., Maharm, G.& Heider, A.I., 2000. Improving the productivity of the Barky goat by crossbreeding with Damascus or Zaraibi breeds. Alex. J. Agric. Res., 45(3), 33-42.

A.O.A.C, 1980. Official methods of analysis, 13th Ed., Association of official analytical chemists, Washington DC.

Dovidov, R.B., 1963. Biotechnical and technological methods in dairying, Moscow C.F. Ph-D thesis,

Salama, F.A, 1972. Dairy Department, Academy of Agricultural sciences, Moscow.

King, J.O.L., 1957. The association between the fat percentage of cows milk and the size and number of the fat globules. J. Dairy Res., 24, 198.

Ling, E.R., 1956. A text book of Dairy chemistry vol.2 3rd Ed-London, Chapman & Hall.

Marier J.R., & Baulet, M., 1959. Direct analysis of lactose in milk and serum. J. Dairy Sci. 42, 1390.

NagaSawa, T., Kiyosoawa, I. & Kumahara, K., 1970. Acrylamide gel electrophoresis and amino acid composition of human colostral casein. J. Dairy Sci. 53, 92-94.

RowLand, S.J., 1938. The determination of nitrogen distribution. J.Dairy Res. 2, 42.

Salem, S.A., El-Agamy, E.I. & Youssef, A.M., 2000. Physicochemical and nutritional characterization of milk of two Egyptian goat breeds. 7th International conference on goats, vol. II (618-620), France, 15-21 May2000.

S.P.S.S., 2003. Statistical Package for Social Science version 12.

Snell, F.D & Snell, C.T., 1949. In colorimetric method of analysis, D. van Nostrand co. vol.2, 3rd Ed. P. 668.

Vogel, A., 1956. A textbook of practical organic chemistry 3rd Ed. London, New York Toronto, Longmans, Green co.

Peer-reviewed paper: 8th International Conference on Goats

Application of the lactoperoxidase system to improve the quality of goat milk cheese

Seifu E.[1#], Donkin E. F.[2] and Buys E. M.[1]
[1]Department of Food Science, University of Pretoria, Lynnwood Road, Pretoria 0002, South Africa.
[2]Faculty of Veterinary Science, University of Pretoria, Onderstepoort 0110, South Africa.

Abstract

Gouda cheese was made from goat milk preserved by the lactoperoxidase (LP) system and the effect of the LP system on the biochemical, microbiological and sensory properties of cheese over a ripening period of 90 days was investigated. Cheese made from LP-activated goat milk had significantly lower coliform and coagulase positive staphylococci counts as compared to cheese made from the untreated control goat milk. The LP treatment did not affect the overall chemical composition of the cheese. The level of proteolysis in both the control and the LP-treated goat milk cheeses was similar. However, the level of lipolysis of cheese made from LP-activated goat milk was significantly lower (9.7 milliequivalent/100 g fat) than that made from the control goat milk (12.3 milliequivalent/100 g fat) at the end of the ripening period. The lower lipolytic activity of cheese made from LP-activated goat milk might be of importance in reducing the strong flavour associated with goat milk cheeses. Significant differences in the overall sensory attributes were observed between cheeses made from the untreated control and LP-activated goat milk. Gouda cheese made from LP-activated goat milk had a milder flavour than the control. Thus, it can be concluded that preservation of goat cheese milk by the LP system can be used to improve the microbiological quality and flavour of Gouda cheese without any detrimental effect on the gross chemical composition of the cheese.

Keywords: Lactoperoxidase system; Gouda cheese; Goat milk.
[#]Corresponding author; E-mail: eyassu_seifu@yahoo.com

Introduction

Goat milk and milk products are important sources of protein for humans in many developing countries (Klinger & Rosenthal, 1997). However, its production and handling presents a major problem limiting its consumption. Most goat milk cheeses are manufactured from raw goat milk with or without thermal treatment (Klinger & Rosenthal, 1997). Cheeses made under these conditions may not have the minimum hygiene and sanitary guarantee necessary to obtain constant product quality. The naturally occurring antimicrobial system in milk, the lactoperoxidase (LP) system, can be used to improve the quality of goat milk cheeses. The objective of this study was therefore to assess the effect of the lactoperoxidase (LP) system on the quality of goat milk cheese.

Materials and methods

Milk samples obtained from a herd of Saanen goats kept at the Faculty of Veterinary Science, University of Pretoria, were used for the cheesemaking experiment. The milk samples were divided into two portions of 10 litres each. One portion was LP-activated as recommended by the International Dairy Federation (IDF, 1988) and the other portion was used as a control. Gouda cheese was made from the treated and the control milk samples according to Scott *et al*. (1998). A mesophilic cheese starter culture LL 50C (Anchor Biotechnologies, Johannesburg) which has previously been tested for its resistance to the LP system (Seifu *et al*., 2003) was used for the cheesemaking experiment. The parameters measured were: fat content of milk and cheese samples; salt and moisture content of cheese samples; total solids content of milk samples; protein content of milk and cheese samples using a Leco FP-528 Nitrogen/Protein Analyser (Leco Corporation, Michigan, USA); proteolysis in cheese samples by measuring the water soluble nitrogen, trichloroacetic acid soluble nitrogen and phosphotungstic acid soluble nitrogen at 30, 60 and 90 days of ripening; lipolysis in cheese samples by measuring the total free fatty acids; microbiological analysis of cheese samples and sensory analysis of cheese samples using the triangle test. All these were determined following standard methods as described by Seifu *et al*. (2004). The pH of cheese samples was measured using a penetration electrode (Sentron Inc., USA). The Wilcoxon Mann Whitney test was used to statistically analyse the data (SAS, 1999). The experiment was repeated 4 times.

Peer-reviewed paper: 8th International Conference on Goats

Results and discussion

The Saanen goat milk used for the cheesemaking experiment had a fat content of 38.3 g/kg, a protein content of 27.3 g/kg, a total solids content of 119.7 g/kg and a solids-not-fat content of 81.5 g/kg. These values are consistent with the values reported previously by Habteyohannes (2001).

Activation of the LP system did not affect the gross chemical composition and yield of Gouda cheese made from Saanen goat milk (Table 1). This finding is inline with earlier report by Santos *et al*. (1995). No difference ($P > 0.05$) in pH was observed between the control and the experimental cheeses (Table 1). This can be attributed to the use of the LP-resistant starter culture (LL 50C) during the cheesemaking experiment.

Table 1 Yield and chemical composition of Gouda cheese made from lactoperoxidase activated and control Saanen goat milk during a ripening period of 90 days (n = 4 ± s.d.)

	Day 1		Day 90	
Parameter[a]	LP cheese	Control cheese	LP cheese	Control cheese
Moisture (g/100 g)	40.8 ± 1.03	41.2 ± 0.31	40.3 ± 0.57	40.7 ± 0.32
pH	5.16 ± 0.11	5.11 ± 0.06	5.14 ± 0.07	5.09 ± 0.08
Protein (g/100 g)	23.8 ± 1.06	24.1 ± 1.11	2 4.2 ± 0.63	24.1 ± 1.14
Fat (g/100 g)	32.4 ± 2.3	32.5 ± 2.7	34.1 ± 2.2	34.2 ± 2.1
Fat in dry matter (g/100g)	56.7 ± 5.4	55.1 ± 4.2	57.1 ± 2.95	57.8 ± 3.7
Salt (g/100 g)	2.1 ± 0.29	2.0 ± 0.09	2.5 ± 0.58	2.6 ± 0.20
Salt in moisture (g/100 g)	5.3 ± 0. 61	5.1 ± 0.14	5.0 ± 1.62	5.1 ± 1.67
Yield[b]	9.9 ± 0.74	10.1 ± 0.55		

a, No difference ($P > 0.05$) was observed between the experimental and the control cheeses for all the parameters; b,Yield expressed as kg dry matter per 100 litre of milk; LP = lactoperoxidase; s. d. = standard deviation.

The level of proteolysis in the experimental cheese was comparable to that of the control cheese (Table 2). Since proteolysis in Dutch-type cheeses such as Gouda, is brought about mainly by the action of starter enzymes (Venema *et al*., 1987), the absence of significant differences ($P > 0.05$) in proteolysis between the experimental and the control cheeses might have been attributed to the use of the LP-resistant starter culture.

Table 2 Proteolytic and lipolytic changes during ripening of Gouda cheese made from lactoperoxidase activated and control Saanen goat milk (n = 4 ± s.d.)

Parameter	Cheese	Ripening time (days)		
type	30	60	90	
WSN[c]	LP	7.31 ± 0.07[a]	7.69 ± 0.03[a]	9.56 ± 0.03 [a]
	Control	7.51 ± 0.07[a]	8.02 ± 0.02[a]	10.01 ± 0.03[a]
TCASN[c]	LP	0.92 ± 0.02[a]	1.52 ± 0.02[a]	2.12 ± 0.01[a]
	Control	0.99 ± 0.03[a]	1.80 ± 0.01[a]	2.24 ± 0.01[a]
PTASN[c]	LP	-0.84 ± 0.03[a]	-0.26 ± 0.02[a]	0.28 ± 0.01[a]
	Control	-0.75 ± 0.03[a]	-0.21 ± 0.01[a]	0.23 ± 0.01[a]
FFA[d]	LP	6.98 ± 1.12[a]	8.62 ± 1.61[a]	10.19 ± 1.03[a]
	Control	8.21 ± 0.62[a]	9.70 ± 0.95[a]	12.27 ± 1.06[b]

a,b,Superscripts in the same column within a parameter with different letters were different ($P < 0.05$); c,The soluble nitrogen fractions were expressed as percent of total nitrogen; d, Free fatty acids expressed as milliequivalent/100 g fat; TN = Total nitrogen; WSN = Water soluble nitrogen; TCASN = Trichloroacetic acid soluble nitrogen; PTASN = Phosphotungstic acid soluble nitrogen; LP = Lactoperoxidase; s.d. = Standard deviation

A difference ($P < 0.05$) in the level of total free fatty acids (FFA) was observed between the experimental and the control cheeses at 90 days of ripening (Table 2). Free fatty acid generation and resulting characteristic flavour of goat milk products is due to the distribution of lipoprotein lipase in various components of the milk system (Chilliard *et al*., 1984). Ahrné & Björck (1985) reported that activation of the LP system in cow milk inhibited the activity of lipoprotein lipase and reduced the FFA levels in the milk. The lower FFA level (therefore, lower lipolysis) observed in Gouda cheese made from LP-activated goat milk can be attributed to the inhibition of lipoprotein lipase by the oxidation products of the LP system.

Peer-reviewed paper: 8th International Conference on Goats

Thus, activation of the LP system in goat cheese milk might be of significant importance in reducing the strong flavour associated with goat milk cheeses.

Out of the 120 panelists who participated in the sensory session, 52 assessors detected differences between the experimental and the control cheeses (P = 0.014). This can be attributed to the difference between the level of lipolysis (FFA level) in the two cheese types. The panelists who participated in the sensory session also commented that Gouda cheese made from LP-activated goat milk had a milder flavour than Gouda cheese made from the control. Thus, activation of the LP system in goat milk may be used to improve the flavour of goat milk cheeses by lowering the extent of lipolysis during ripening of the cheese.

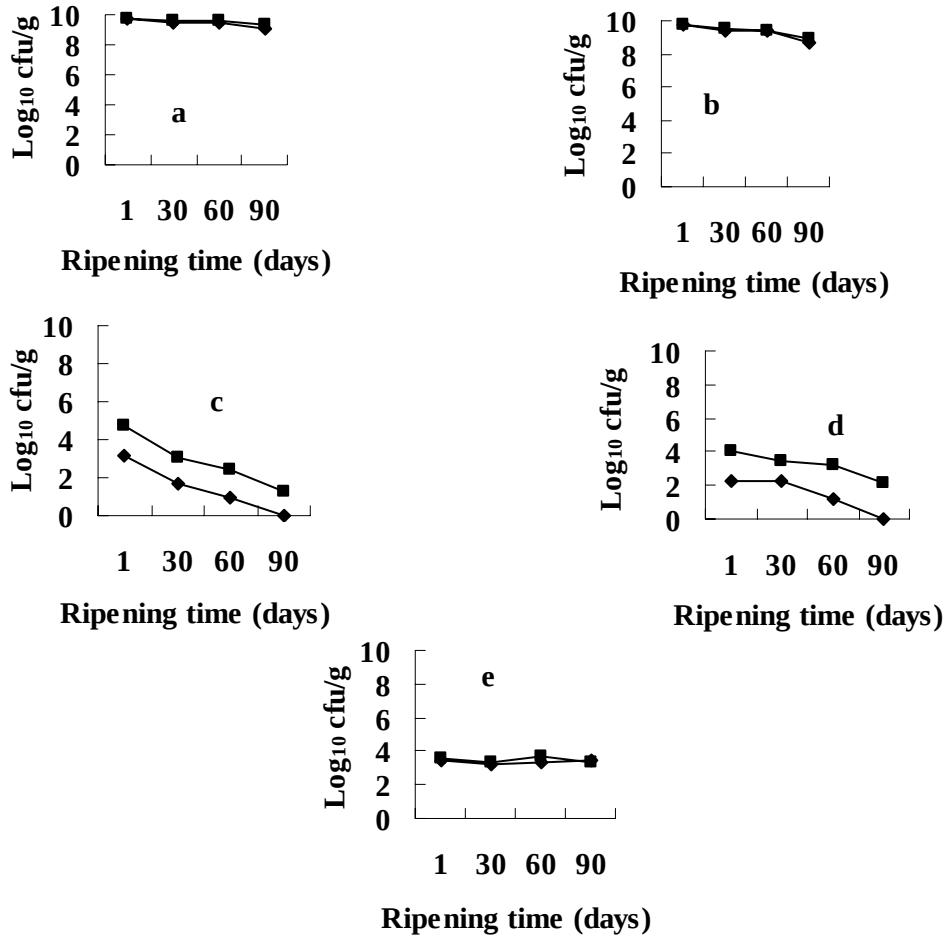


Figure 1. **Changes in the aerobic plate (a), lactic acid bacteria (b), coliform (c), coagulase positive staphylococci (d) and mould (e) counts in Gouda cheese made from lactoperoxidase activated (◆) and control (■) Saanen goat milk during a ripening**

The microbiological counts of Gouda cheese over the ripening period of 90 days showed absence of differences (P > 0.05) in aerobic plate count (APC) (Figure 1a), lactic acid bacteria (LAB) count (Figure 1b) and mould counts (Figure 1e) between the control and the experimental cheeses. However, differences (P < 0.05) were observed in coliform (Figure 1c) and coagulase positive staphylococci (CPS) counts (Figure 1d) between the experimental and the control cheeses throughout the ripening period. Since large numbers of coliforms and CPS in cheese milk can cause early blowing and enterotoxin production in cheese (Chapman & Sharpe, 1990), respectively, the decrease in coliform and CPS in cheeses made from goat milk preserved by activation of the LP system suggests that activation of the LP system in goat milk prior to cheesemaking could be of practical importance especially for small-scale cheese producers who in most instances produce cheese from unpasteurised milk.

Peer-reviewed paper: 8th International Conference on Goats

Conclusions

From the results of the current study, it can be concluded that preservation of goat cheese milk by the LP system can be used to improve the microbiological quality and flavour of goat milk Gouda cheese without any detrimental effect to the chemical composition of the cheese if an appropriate starter culture is used. Since most goat milk cheeses are manufactured from raw milk without heat treatment, preservation of goat milk by the LP system may be used to increase the safety margin of cheeses made from raw goat milk.

Acknowledgements

This study was sponsored by the Agricultural Research and Training Project of Alemaya University (Ethiopia). We also thank the University of Pretoria for providing facilities for the execution of the experiment.

References

Ahrné, L. & Björck, L., 1985. Effect of the lactoperoxidase system on lipoprotein lipase activity and lipolysis in milk. J. Dairy Res. 52, 513-520.

Chapman, H. R. & Sharpe, M. E., 1990. Microbiology of cheese. In: Dairy microbiology. Vol. 2. The microbiology of milk products (2nd ed.). Ed. Robinson, R. K., Elsevier Applied Science, London. pp. 203-289.

Chilliard, Y., Selselet-Attou, G., Bas, P. & Morand-Fehr, P., 1984. Characteristics of lipolytic systems in goat milk. J. Dairy Sci. 67, 2216-2223.

Habteyohannes, E. G., 2001. Participatory development of indigenous goat cheese product: monitoring of the chemical, nutritional and microbiological quality from milk to cheese. MSc thesis, University of the Free State, South Africa.

IDF, 1988. Code of practices for the preservation of raw milk by the lactoperoxidase system. Int. Dairy Fed. Bull. 234. International Dairy Federation, Brussels. pp. 1-15.

Klinger, I. & Rosenthal, I., 1997. Public health and the safety of milk and milk products from sheep and goats. Rev. Sci. Tech. 16, 482-488.

Santos, J. A., López-Díaz, T. M., García-Fernández, M. C., García- López, M. L. & Otero, A., 1995. Antibacterial effect of the lactoperoxidase system against *Aromonas hydrophila* and psychrotrophs during the manufacturing of the Spanish sheep fresh cheese Villalón. Milchwiss. 50, 690-692.

SAS, 1999. Statistical Analysis Systems users guide (Version 8). SAS Institute Inc., Cary, North Carolina.

Scott, R., Robinson, R. K. & Wilbey, R. A., 1998. Cheesemaking practice. 3rd ed. Aspen Publishers Inc., Gaithersburg, Maryland. 449 pp.

Seifu, E., Buys, E. M. & Donkin, E. F., 2003. Effect of the lactoperoxidase system on the activity of mesophilic cheese starter cultures in goat milk. Int. Dairy J. 13, 953-959.

Seifu, E., Buys, E. M. & Donkin, E. F., 2004. Quality aspects of Gouda cheese made from goat milk preserved by the lactoperoxidase system. Int. Dairy J. 14, 581-589.

Venema, D. P., Herstel, H. & Elenbaas, H. L., 1987. Determination of the ripening time of Edam and Gouda cheese by chemical analysis. Neth. Milk Dairy J. 41, 215-226.

Peer-reviewed paper: 8th International Conference on Goats

Post-mortem metabolic status, pH and temperature of chevon from South African indigenous goats slaughtered under commercial conditions

L. Simela[1], E. C. Webb[1#] and L. Frylinck[2]
[1]Department of Animal and Wildlife Sciences, University of Pretoria, Hatfield, Pretoria 0002, South Africa; [2]Meat Science Centre, ARC-Animal Nutrition and Products Institute, Private Bag X2, Irene 0062, South Africa

Abstract

The study was conducted to investigate the effects of sex, age and pre-slaughter conditioning on post-mortem pH, temperature and glycolytic metabolite concentrations in *M. longissimus thoracis* (LT) of South African indigenous goats. At 3 hours post-mortem, the 2-teeth group had the highest temperature and lowest pH values ($P<0.05$). The group had a pHu that was 0.15 units significantly lower than that of the 8-teeth group ($P<0.05$). Pre-slaughter conditioning resulted in higher post-mortem temperature ($P<0.05$) but had no effect on pH values ($P>0.05$). Sex, age and pre-slaughter conditioning had a low impact on glycolytic metabolite concentrations. Overall the goats in this study had a high pHu, high initial lactate concentration and low GP which suggest that they suffered both chronic and acute stress during pre-slaughter handling.

Keywords: glycolytic metabolites, glycogen, lactate, pH, temperature, age, sex, pre-slaughter conditioning
Corresponding author: Email: Edward.webb@up.ac.za

Introduction

Although substantial research has been conducted on goat carcass and meat quality, little attention has been paid to the biochemical changes taking place in the meat immediately post-mortem. This is despite the fact that these changes are highly influential in determining the quality of the meat yielded from a carcass.

The aim of this study was to investigate the effects of sex, age and pre-slaughter conditioning on immediate post-mortem metabolic status of chevon from South African indigenous goats that were slaughtered under commercial conditions.

Materials and Methods

LT samples (N=74) were from a flock of South African indigenous goats consisting of recently weaned kids to 4–6 teeth intact and castrated males and to full-mouthed females. The flock was purchased and kept at a farm on a maintenance diet of Silgro® ewe and lamb pelleted concentrate mix fed at 0.03% of total animal weight per pen. Clean water and *Eragrostis curvula* hay were available *ad libitum*.

The goats were slaughtered in the non-conditioned (slaughtered within two months of purchase) and pre-slaughter conditioned (slaughtered between six to ten months of purchase) states. Chronological age was estimated from dentition. All the goats were slaughtered at a research abattoir under conditions similar to those employed in the meat industry of South Africa. Goats designated for slaughter were weighed before feeding and then held in a separate enclosure with their daily ration of feed and water the day prior to slaughter. They were later transported to the abattoir (about 30km/20 minutes drive) where they were held in lairage overnight for about 17 hours with clean water *ad libitum* but no feed. At slaughter, the goats were stunned using 300V of electricity. Temperature and pH (pH_3 and pHu, respectively) of the *M. longissimus thoracis* (LT) were recorded at 3 and 24 hours post-mortem.

Assays for glycolytic metabolites were done on samples cut out from the LT ±15minutes after slitting the throat of each goat and immediately frozen at -70°C. Glycolytic metabolites were extracted using the method of Dalrymple and Hamm (1973) and the concentrations were determined using the methods of Keppler and Decker (1974) for glycogen; Lamprecht et al. (1974) for ATP, glucose-6-phosphate and creatine phosphate, and Gutmann and Wahlefeld (1974) for lactate. Glycolytic potential (GP) was calculated according to Monin and Sellier's (1985) formula, as follows:

$$GP = 2([glycogen] + [glucose] + [glucose\text{-}6\text{-}phospahte]) + [lactate]$$

All data were analysed using SAS (1990) GLM procedures. Sex, age, pre-slaughter conditioning and the first order interaction effects were tested on all variables. Spearman correlations were computed between the glycolytic metabolites and pH_3 and pHu. Where the correlation coefficients were significant, the data

Peer-reviewed paper: 8th International Conference on Goats

were then grouped into three pH_3 and pHu groups and the variations of the glycolytic metabolites with each set of pH groups were analysed using GLM models.

Results

There were no significant sex effects ($P>0.05$) on pH and temperature readings. The mean pH_3 of the 2-teeth group (6.16±0.25) was the lowest and significantly 0.27 and 0.33 units lower than pH_3 means for the milk-teethed and 2-6 teeth groups, respectively. The mean pH_3 of the 8-teeth group (6.36±0.29) did not differ from either extreme ($P<0.05$). Mean pHu values of the 2-teeth (5.88±0.12) and 8-teeth (6.03±0.19) groups only significantly differed ($P<0.05$). Means for the milk teeth (5.94±0.10) and 4-6 teeth (5.94±0.13) were similar and did not differ from either extreme.

At 3 hours post-mortem, the 2-teeth group had the highest temperature ($P=0.010$) of all age groups (16.33±4.05°C vs. 11.05±3.45°C) but the final temperature did not differ ($P>0.05$) amongst the four age groups (mean =3.67±3.58°C). There was a slight tendency ($P=0.081$) that mean pH_3 of the non-conditioned goats (6.45±0.22) was higher than that of the pre-slaughter conditioned group (6.16±0.25). However, the pHu means were similar (5.93±0.12 and 5.92±0.16). Three-hour (17.82±1.78) and final (7.02±2.32) temperatures of the latter group were higher than those of the non-conditioned group by 8.3°C and 6.2°C, respectively ($P<0.0001$). The overall means, minimum and maximum concentrations of the glycolytic metabolites, the main effects of sex, age and pre-slaughter conditioning on all the traits are presented in Table 1.

Table 1 Effects of sex, age, pre-slaughter conditioning and their first order interactions on glycolytic metabolite concentrations in *M. longissimus thoracis* of South African indigenous goats

	Mean ± S.D.	Min	Max	Sex	Age	Pre-slaughter conditioning
N	74					
Glycolytic potential (µmol/g)	101.74 ± 23.21	56.29	153.81	NS	NS	NS
Lactate (µmol/g)	30.19 ± 10.57	8.88	75.16	NS	NS	NS
Glycogen (µmol/g)	32.82 ± 11.39	8.84	59.75	NS	NS	NS
Lactate %	15.37 ± 5.57	6.04	31.07	NS	NS	NS
Glycogen %	31.60 ± 6.28	14.40	42.20	NS	NS	NS
Glucose (µmol/g)	1.70 ± 0.53	0.76	3.37	NS	NS	NS
Glucose-6-phosphate (µmol/g)	1.25 ± 0.69	0.29	4.00	*	NS	NS
ATP (µmol/g)	5.17 ± 0.74	2.36	6.75	NS	NS	NS
Creatine phosphate (µmol/g)	3.74 ± 1.16	1.86	9.73	NS	*	NS

NB: NS – not significant; * Significant ($P<0.05$).

Glucose-6-phosphate content only was significantly affected ($P=0.029$) by the sex of the goats. The monosaccharide was lowest in the LT of the females (mean=1.01±0.67µmol/g) by 0.34µmol/g and 0.60µmol/g less than the content in the LT of castrates and intact males, respectively. Age significantly affected creatine phosphate content only ($P=0.030$). The metabolite was lowest in the 4-6 teeth group (3.40±1.05µmol/g) and highest in the milk-teethed kids (4.04±1.70µmol/g).

Pre-slaughter conditioned intact males had the lowest ATP concentration (2.95±0.37µmol/g), which significantly differed from the concentration in the females of the same group (4.34±1.93µmol/g). Means for all castrates, non-conditioned females and intact males not differ from either extreme. Creatine phosphate concentration was generally higher in pre-slaughter conditioned females and castrates but lower in pre-slaughter conditioned intact males.

Only 22% of the LT were glycolysing at a rate fast enough to attain a $pH_3<6.1$ (Table 2). Most of the LT (54%) were glycolysing so slow that their pH_3 was above 6.3. The $pH_3<6.1$ group had a significantly higher 3-hour temperature ($P<0.0001$) and lower pHu ($P=0.039$) than LT with $pH_3>6.3$. The group also had the highest initial lactate concentration ($P=0.042$) and tended to have a lower creatine phosphate concentration ($P=0.052$), which suggest a high rate of peri-mortem glycolytic activity.

Peer-reviewed paper: 8th International Conference on Goats

Table 2 Effect of early pot-mortem pH (pH_3) on glycolytic metabolite concentrations and ultimate pH of the *M. longissimus thoracis* (means ± S.D.) of South African indigenous goats

	pH_3< 6.1	pH_3 =6.1 to 6.3	pH_3> 6.3	*P*-value
N	16	18	40	
pH_3	5.94 ± 0.17[a]	6.20 ± 0.07[b]	6.52 ± 0.15[c]	<0.0001
Phu	5.88 ± 0.08[a]	5.89 ± 0.17[ab]	5.96 ± 0.14[b]	0.0394
3 hr temperature (°C)	16.38 ± 3.48[b]	15.34 ± 4.19[b]	11.21 ± 4.00[a]	<0.0001
Lactate (µmol/g)	36.71 ±13.48[b]	28.25 ± 5.34[ab]	27.81 ± 8.81[a]	0.0420
Glucose (µmol/g)	1.96 ± 0.59	1.65 ± 0.42	1.59 ± 0.47	0.1083
Lactate %	17.13 ± 5.63	15.54 ± 5.99	14.44 ± 4.94	0.4824
Glycogen %	29.56 ± 6.19	31.47 ± 6.67	32.64 ± 5.65	0.3478
Creatine phosphate (µmol/g)	3.33 ± 0.71	3.44 ± 0.63	4.06 ± 1.62	0.0515

[a, b, c] Means within the same row with different superscripts differ significantly (P<0.05)

An LT pHu<5.8 was attained by 16% of the carcasses while the majority (55%) were between pH 5.8 and 6.0 (Table 3). On average, carcasses with pHu>6.0 had 27.73µmol/g lower GP, 11.5µmol/g less glycogen, 0.52µmol/g less ATP than carcass with a pHu ≤ 6.0 (*P*<0.05).

Table 3 Variation of initial glycolytic metabolite concentrations in the *M. longissimus thoracis* (means ± S.D.) of South African indigenous goats with ultimate pH (pHu)

	pHu < 5.8	pHu =5.8 to 6.0	pHu > 6.0	*P*-value
N	12	41	21	
Phu	5.76 ± 0.02[a]	5.89 ± 0.06[b]	6.10 ± 0.10[c]	<0.0001
Glycolytic potential (µmol/g)	114.82 ± 15.89[b]	105.18 ± 21.61[ab]	87.09 ± 23.68[a]	0.0041
Glycogen (µmol/g)	37.83 ± 9.90[b]	34.60 ± 10.35[ab]	26.36 ± 11.71[a]	0.0057
ATP (µmol/g)	5.39 ± 0.81[b]	5.26 ± 0.74[ab]	4.87 ± 0.77[a]	0.0329
Lactate %	14.59 ± 5.97	14.62 ± 4.00	17.27 ± 7.83	0.1822
Glycogen %	32.75 ± 6.40	32.47 ± 4.55	29.23 ± 7.83	0.0988

[a, b, c] Means within the same row with different superscripts differ significantly (P<0.05)

Discussion

Of the three factors that were investigated, pre-slaughter conditioning had the greatest influence on post-mortem temperature, possibly due to the insulating effect of higher carcass fat content. However, contrary to expectation, pre-slaughter conditioning did not improve post-mortem pH or the peri-mortem glycogen reserves (Warner et al., 1998) of the goats. If there were differences between the two groups prior to slaughter, then conditioning did not improve the goats' tolerance for stress, which would nullify any differences in stored glycogen (Fernandez and Tornberg, 1991).

Sex, age and pre-slaughter conditioning had little impact on early post-mortem glycolytic metabolite concentrations. However, the generally high pHu, high initial lactate concentration and low GP in this study suggest that the goats suffered both chronic and acute stress during pre-slaughter handling. Low GP is associated with stress that occurs earlier in handling, such as during transportation, deprivation of food and lairage, and high lactate concentration immediately after slaughter is associated with acute pre-slaughter stress occurring during the handling between the lairage and the stunning area (Yambayamba et al., 1996). Goats have been shown to be highly susceptible to these stressors (Kannan et al., 2003).

High pHu values for goat muscles (pHu>5.8) are prevalently reported (e.g. Kannan et al., 2003) but are evidently not an inherent characteristics of chevon. Since such a high incidence of high pHu meat often occurs amongst temperamental animals such as young bulls, heifers on heat and boars, chevon pHu values suggest that goats are generally highly prone to stress caused by handling.

Conclusion

Age, sex and pre-slaughter conditioning were not the major determinants of glycolytic metabolite concentrations. High pHu is not an intrinsic characteristic of chevon but is a consequence of low peri-mortem GP possibly caused by stressful peri-mortem handling.

Peer-reviewed paper: 8th International Conference on Goats

Acknowledgements

The authors wish to thank the National Research Foundation (NRF) and Third World Organisation for Women in Science (TWOWS) for their financial support, the Meat Industry Centre at the Agricultural Research Council for assistance with analyses and STATOMET at the University of Pretoria for the statistical analysis of the data.

References

Dalrymple, R.H. & Hamm, R., 1973. A method for the extraction of glycogen and metabolites from a single muscle sample. *J. Food Technol. 8*, 439-444.

Fernandez, X. & Tornberg, E., 1991. A review of the causes of variation in muscle glycogen content and ultimate pH in pigs. J. Muscle Foods 2, 209-235.

Gutmann, I. & Wahlefeld, A.W., 1974. L-(+) lactate determination with lactate dehydrogenase and NAD. In: *Methods of Enzymatic Analysis, Volume 3, 2nd edition*. H.U. Bergmeyer (ed.). Verlag Chemie, GmbH, Weinheim. Pp 1464-1468.

Kannan, G., Kouakou, B., Terrill, T.H., Gelaye, S. & Amoah, E.A., 2003. Endocrine, blood metabolite, and meat quality changes in goats as influenced by short term pre-slaughter stress. J. Anim. Sci. 81, 1499-1507.

Keppler, D. and Decker, K., 1974. Glycogen determination with amyloglucocidase. In: *Methods of Enzymatic Analysis, Volume 3, 2nd edition*. H.U. Bergmeyer (ed.). Verlag Chemie, GmbH, Weinheim. Pp 1127-1131.

Lamprecht, W., Stein, P, Heinz, F and Weisser, H., 1974. Creatine phosphate In: *Methods of Enzymatic Analysis, Volume 3, 2nd edition*. H.U. Bergmeyer (ed.). Verlag Chemie, GmbH, Weinheim. Pp 1777-1785.

Monin, G. and Sellier, P. (1985). Pork of low technological quality with normal rate of pH fall in the immediate post-mortem period: the case of the Hampshire breed. Meat Sci. 13, 49–63.

SAS (1990). *SAS/STAT user's guide*. (Version 6, Fourth Vol. 2) (5th ed.). Cary, NC: SAS Institute Inc.

Warner, R.D., Walker, P.J., Edridge, G.A. & Barnett, J.C., 1998. Effects of marketing procedure and live weight change prior to slaughter and beef carcass and meat quality. Anim. Prod. Aust. 22, 165-168.

Yambayamba, E.S.K., Aalhus, J.L., Price, M.A. & Jones, S.D.M., 1996. Glycogen metabolites and meat quality in feed restricted re-fed beef heifers. Can. J. Anim. Sci. 76, 517-522.

Peer-reviewed paper: 8th International Conference on Goats

Effect of sex, age, and pre-slaughter conditioning on pH, temperature, tenderness and colour of indigenous South African goats

L. Simela[1], E.C. Webb[1#] and L. Frylinck[2]
[1]Department of Animal and Wildlife Sciences, University of Pretoria, Hatfield, Pretoria 0002, South Africa
[2]Meat Science Centre, ARC-Animal Nutrition and Products Institute, Private Bag X2, Irene 0062, South Africa

Abstract

Sex, age and pre-slaughter conditioning effects on pH, temperature, colour and tenderness properties of *M. semimembranosus* (SM) of South African indigenous goats were investigated. Sex and age had no effect on pH ($P>0.05$). However female goats cooled significantly slower than intact males ($P<0.05$). 2-teeth goats had the slowest and the 4–6-teeth goats the fastest cooling rates ($P<0.05$). Pre-slaughter conditioned goats had higher temperature and lower pH than the non-conditioned goats at both three and 24 hours post-mortem. Of the meat quality traits, sex and age mainly affected colour. Intact males had lower a*24 and chroma24 values than the females and castrates ($P<0.05$). 2-teeth goats had higher a* and chroma24 values than the milk-, 4–6- and 8-teeth groups ($P<0.05$) and the milk-teeth goats had a lighter colour (L*96) than the 8-teeth goats ($P<0.05$). Pre-slaughter conditioning resulted in longer SL ($P<0.001$), lower WBS ($P<0.001$) and generally a better meat colour. Tenderness and colour properties of chevon were found to be highly dependent on post-mortem pH and temperature as well as the pHu attained by the carcasses. Carcasses that chilled slowly and had a fast rate of pH of decline yielded better quality chevon.

Keywords: Chevon quality, shear force, colour, pH, temperature, age, sex, pre-slaughter conditioning
Corresponding author: Email: Edward.webb@up.ac.za

Introduction

To a large extent, meat quality is affected by the rate of post-mortem carcass pH and temperature decline and ultimate pH (pHu) attained (Watanabe *et al*., 1996). Ideal pH and temperature profiles result in meat that is acceptably tender, and with a normal colour. Any deviations result in abnormalities that may be reflected in post-slaughter myofibrillar changes, colorimetric values and meat tenderness. The aim of this study was to investigate the effects of sex, age, and pre-slaughter conditioning of marketed South African indigenous goats on early post mortem and ultimate pH and temperature, colour and tenderness related properties.

Materials and methods

M. semimembranosus (SM) samples were from a flock of South African indigenous goats (N=74) consisting of recently weaned kids to 4–6 teeth intact and castrated males and to full-mouthed females. The flock was purchased and kept at a farm on a maintenance diet of Silgro® ewe and lamb pelleted concentrate mix fed at 0.03% of total animal weight per pen. Clean water and *Eragrostis curvula* hay were available *ad libitum*. The goats were slaughtered in the non-conditioned (slaughtered within two months of purchase) and pre-slaughter conditioned (slaughtered between six to ten months of purchase) states. Chronological age was estimated from dentition.

All the goats were slaughtered at a research abattoir under conditions similar to those employed in the meat industry of South Africa. Goats designated for slaughter were weighed before feeding and then held in a separate enclosure with their daily ration of feed and water the day prior to slaughter. They were later transported to the abattoir (about 30km/20 minutes drive) where they were held in lairage overnight for about 17 hours with clean water *ad libitum* but no feed. At slaughter, the goats were stunned using 300V of electricity. Temperature and pH (pH_3 and pHu, respectively) of the SM were recorded at 3 and 24 hours post-mortem.

Both the left and right SM were cut out 24 hours post-mortem for the determination of sarcomere lengths (SL), Warner-Bratzler shear force (WBS), L*, a*, b* and chroma values. Left SM samples were vacuum packed in and immediately stored at -20°C for the 24-hour determinations (i.e. SL24, WBS24, L*24 etc). Right SM were aged for a further 72 hours at about 4°C and then stored at -20°C for 96-hour determinations (i.e. WBS96, L*96, etc). SL samples were prepared according to Hegarty & Naudé (1970) and SL determined using light microscopy. WBS was determined as outlined by Honikel (1998). Colour was

Peer-reviewed paper: 8th International Conference on Goats

measured using a Minolta colorimeter (Tokyo, Japan) on freshly cut surfaces that had been wrapped in oxygen permeable polythene film and bloomed for 3 hours at 2–4°C with light.

All data were analysed using SAS (1990) GLM procedures. Sex, age, pre-slaughter conditioning and the first order interaction effects were tested on all variables. First order interactions were predominantly not significant and hence results of the main effects only are presented. Spearman's correlations between the meat quality traits and pH_3 and pHu were computed. Where the correlation coefficients were significant, the data were then grouped into three pH_3 and pHu groups and the variations of the meat quality traits with each set of pH groups were analysed using GLM models.

Results

Sex and age of the goats had no effect on SM pH_3 and pHu (P>0.05). However, female carcasses cooled more slowly than intact males such that their mean 3-hour temperature was 1.34°C higher than the 15.25±3.97°C of the latter (P=0.036). At three (P=0.046) and 24 (P=0.032) hours post-mortem the 2-teeth group had the highest (18.78±3.42°C and 6.34±3.25°C) and the 4-6 teeth group the lowest (13.05±1.85°C and 0.55±1.32°C) temperature readings. Temperatures of the milk and 8-teeth groups were similar but significantly different from the two extremes (P<0.05).

Mean pH_3 of the non-conditioned goats (6.44±0.23) was 0.27 (P=0.008) units higher than that of the pre-slaughter conditioned group but the pHu means of the two groups were similar. The means were 5.93±0.13 and 5.95±0.18, respectively. Both the 3-hour (13.473±2.22°C) and 24-hour temperature (1.36±1.70°C) of the non-conditioned goats were lower than those of the pre-slaughter conditioned group by 6.06°C and 5.85°C, respectively (P<0.0001). The effects of sex, age, pre-slaughter conditioning on SL, WBS and colour quality traits are summarised in Table 1.

Table 1 Effects of sex, age and pre-slaughter conditioning on tenderness-related characteristics and colour co-ordinates of chevon from South African indigenous goats

Characteristics	Mean ± S.D.	Min	Max	Sex	Age	Pre-slaughter conditioning
N	74					
Sarcomere length (μm) 24hr[1]	1.72 ± 0.16	1.24	2.15	NS	NS	***
Shear force (N) 24 hr[1]	74.81 ± 17.70	38.37	119.96	NS	NS	***
Shear force (N) 96hr[2]	66.94 ± 17.21	25.03	113.33	*	NS	***
L* 24hr[1]	38.57 ± 2.42	32.71	43.81	NS	NS	*
a* 24hr[1]	13.78 ± 2.37	4.00	19.32	**	**	*
b* 24hr[1]	9.60 ± 1.52	5.69	12.77	NS	NS	NS
Chroma 24hr[1]	16.88 ± 2.49	10.21	22.54	*	**	NS
L* 96hr[2]	38.14 ± 2.29	32.97	43.22	NS	*	*
a* 96hr[2]	14.30 ± 2.20	4.99	19.01	NS	NS	**
b* 96hr[2]	9.72 ± 1.38	5.46	12.00	NS	NS	NS
Chroma 96hr[2]	17.34 ± 2.35	12.08	22.42	NS	NS	*

NB: NS – not significant; * Significant (P<0.05); ** Significant (P<0.01); *** Significant (P<0.001).

1- Determinations were done on unaged samples (frozen 24 hours post-mortem)

2- Determinations were done on samples that were aged for 3 days (frozen 96 hours post-mortem)

Sex did not significantly affect SL (P>0.05). However, castrates (mean WBS96= 64.28±17.09N) tended to have a 3.8N lower WBS96 (P=0.052) than females and intact males. The 2-teeth group tended to have the lowest WBS96 (mean= 59.87±20.15N) by some 10 to 17N (P=0.074) while SM of the 8-teeth group was the toughest, with WBS96 of 77.39±18.54N.

Mean SL24 of the non-conditioned goats (1.59±0.17μm) was 0.73μm shorter (P<0.0001) than the SL of the conditioned goats. WBS of the non-conditioned goats were 82.41±16.06N and 74.95±16.76N at 24- and 96-hours post-mortem, respectively, and were significantly higher than those of the pre-slaughter conditioned group by about 17N (P<0.0001) at both ageing periods. The mean a*24 value of intact males (12.34 ± 3.30) was 1.86 units lower (P=0.003) than the average mean for females and castrates. In turn the mean chroma24 value (15.73 ± 2.90) was a significant 1.87 units lower than the mean chroma24 of the castrates. The a*24 value for the 2-teeth group (15.56±2.36) was between 2.45 and 4.15 units higher than the values for the milk-, 4–6- and 8-teeth groups (P=0.002). Accordingly, the 2-teeth group had the highest

Peer-reviewed paper: 8th International Conference on Goats

chroma24 (*P*=0.003) of the four age groups (18.49±2.59 vs.15.65±2.64). Chevon from the milk-teeth group was significantly lighter in colour (mean L*96 = 38.96±2.44) than that from the 8-teeth group only by 2.10 units of L*96 (*P*=0.039). L*24 of the non-conditioned goats (39.42±2.35) was 1.83 units larger (*P*=0.029) and a*24 (12.62±2.97) was 2.52 units smaller (*P*=0.048) than the corresponding values of the pre-slaughter conditioned group. At 96 hours post-mortem, the SM of non-conditioned goats had a mean L* (38.73±2.26) that was 1.35 units lighter (*P*=0.039) and a* (13.18±2.22) that was 1.45 units less red, and hence a less vivid chroma96 (*P*=0.034).

Only 16% of the SM were glycolysing so as to attain pH_3<6.1 (Table 2). Fast glycolysing SM had higher early post-mortem temperature (P<0.001), the longest SL24 (*P*=0.0004), and higher a*24 values (*P*=0.006). The lesser values of these traits were associated with carcasses that had a SM pH_3>6.3. These slow glycolysing carcasses made up 58% of the SM samples.

Table 2 Effect of early post-mortem pH (pH_3) on chevon tenderness and colour of the *M. semimembranosus* (means ± S.D.) of South African indigenous goats

	pH_3< 6.1	pH_3=6.1 to 6.3	pH_3> 6.3	*P*-value
N	12	19	43	
3 hr pH (pH_3)	5.90 ± 0.16[a]	6.20 ± 0.05[b]	6.49 ± 0.17[c]	<0.0001
3 hr temperature (°C)	20.04 ± 2.43[b]	17.01 ± 4.25[ab]	14.86 ± 306[a]	0.0001
Sarcomere length (µm) 24hr[1]	1.85 ± 0.20[b]	1.78 ± 0.20[b]	1.65 ± 0.19[a]	0.0004
Shear force (N) 24hr[1]	67.05 ± 18.14	73.41 ± 16.48	77.67 ± 20.55	0.1311
A* 24 hr[1]	15.71 ± 1.99[b]	14.36 ± 2.80[ab]	12.96 ± 3.17[a]	0.0058
Chroma 24hr[1]	18.39 ± 2.19	17.38 ± 2.72	16.25 ± 3.06	0.0691
A* 96hr[2]	15.50 ± 2.33	14.73 ± 2.09	13.86 ± 2.55	0.0531
Chroma 96 hr[2]	18.51 ± 2.32	17.34 ± 2.65	16.99 ± 2.44	0.0998

NB: [a, b, c] Means within the same row with different superscripts differ significantly (*P*<0.05)

1- Determinations were done on unaged samples (frozen 24 hours post-mortem)
2- Determinations were done on samples that were aged for 3 days (frozen 96 hours post-mortem)

Generally, carcasses with SM pHu<5.8 had the higher a*, b* and chroma (*P*<0.01) values at both ageing times (Table 3). Moreover they had a mean WBS96 that was 18N (*P*=0.005) less than the average 70N of the carcasses with a SM pHu <5.8. Only 20% of the carcasses were in the pHu<5.8 category compared to the 45% with a pHu between 5.8 and 6.0 and the 35% with pHu > 6.0.

Table 3 Variation of tenderness and colour of the *M. semimembranosus* (means ± S.D.) of South African indigenous goats with ultimate pH (pHu)

	pHu< 5.8	pHu=5.8 to 6.0	pHu > 6.0	*P*-value
N	15	33	26	
Phu	5.74 ± 0.03[a]	5.90 ± 0.06[b]	6.10 ± 0.08[c]	<0.0001
Shear force (N) 96hrs	52.57 ± 14.87[a]	70.71 ± 18.91[b]	69.88 ± 20.03[b]	0.0048
L* 24hr	39.33 ± 1.67	38.78 ± 2.22	37.93 ± 3.10	0.2115
A* 24hr	15.83 ± 2.83[b]	13.51 ± 2.99[a]	12.98 ± 2.85[a]	0.0071
B* 24hr	10.46 ± 0.90[b]	9.90 ± 1.15[b]	8.75 ± 1.70[a]	0.0013
Chroma 24hr	19.01 ± 2.66[b]	16.84 ± 2.71[a]	15.75 ±2.79[a]	0.0026
L* 96hr	38.57 ± 2.05	38.58 ± 2.24	37.48 ± 2.61	0.2098
A* 96hr	16.46 ± 1.69[b]	14.12 ± 2.24[a]	13.46 ± 2.52[a]	0.0004
B* 96hr	10.48 ± 0.96[b]	9.91 ± 1.04[ab]	9.19 ± 1.36[a]	0.0094
Chroma 96hr	19.52 ± 1.88[b]	17.23 ± 2.29[a]	16.23 ± 2.33[a]	0.0004

[a, b, c] Means within the same row with different superscripts differ significantly (*P*<0.05)

1- Determinations were done on unaged samples (frozen 24 hours post-mortem)
2- Determinations were done on samples that were aged for 3 days (frozen 96 hours post-mortem)

Discussion

The results indicate that tenderness and colour of chevon were affected by both the rate and extent of glycolysis such that chevon suffered less sarcomere shortening and attained lower WBS values when the carcasses chilled slowly and/or attained a pHu below 5.8. As such, the 2-teeth group and the castrates, which

Peer-reviewed paper: 8th International Conference on Goats

chilled slowly, tended to have lower WBS96 and better colour quality than their contemporary groups. Likewise, carcasses of the pre-slaughter conditioned goats chilled slowly, had a fast pH decline, and hence yielded more tender and redder chevon with a more vivid colour than the non-conditioned goats. In contrast, carcasses which chilled fast and were glycolysing slowly, suffered some sarcomere shortening and had a low a* value that indicated a possible dark cutting (DFD) condition (Onyango *et al*., 1998). Similarly, whereas low pHu carcasses had better colour quality, high pHu carcasses yielded chevon with a mean a* value approaching 12 and a low chroma value. At such low a* and chroma values, meat tends have a dull appearance (Onyango *et al*., 1998) and a low shelf life (Wiklund *et al*., 2001).

Conclusion

Tenderness and colour properties of chevon are highly dependent on the pH and temperature profiles post-mortem as well as the pHu attained by the carcasses. Better quality chevon could be obtained by handling the goats in such a way that they may attain a low pHu and ensuring appropriate chilling conditions that allow a slow rate of carcass temperature decline and attainment of a low pH early post-mortem.

Acknowledgements

The authors wish to thank the National Research Foundation (NRF) and Third World Organisation for Women in Science (TWOWS) for their financial support, the Meat Industry Centre at the Agricultural Research Council for assistance with analyses and STATOMET at the University of Pretoria for the statistical analysis of the data.

References

Hegarty, P.V.J. & Naude, R.T., 1970. The accuracy of measurement of individual skeletal muscle fibres separated by a rapid technique. Laboratory Practice 19, 161-163

Honikel, J.L., 1998. Reference methods for the assessment of physical characteristics of meat. Meat Sci. 49, 447-457.

Onyango, C.A., Izumimoto, M. & Kutima, P.M., 1998. Comparison of some physical and chemical properties of selected game meats. Meat Sci. 49, 117-125.

SAS, 1990. *SAS/STAT user's guide*. (Version 6, Fourth Vol. 2) (5th ed.). Cary, NC: SAS Institute Inc.

Watanabe, A., Daly, C.C., & Devine, C.E., 1996. The effects of the ultimate pH of meat on tenderness changes during aging. Meat Sci. 42, 67-78.

Wiklund, E., Stevenson-Barry, J.M., Duncan, S.J. & Littlejohn, S.J., 2001. Electrical stimulation of red deer (*Cervus elaphus*) carcasses – effect on rate of pH decline, meat tenderness, colour stability and water holding capacity. Meat Sci. 59, 211-220.

Peer-reviewed paper: 8th International Conference on Goats

The accuracy of Video Image Analysis (VIA) and Optical Fibre Diameter Analysis (OFDA) to measure fibre diameter of cashmere

W.A. van Niekerk[#], S. Keva, M. Roets[1*] and R.J. Coertze
Department of Animal and Wildlife Sciences, University of Pretoria, Pretoria 0002, South Africa
[1]ARC-ANPI, Private Bag X2, Irene, 0062, South Africa

Abstract

The aim of this study was to evaluate two techniques, Optical Fibre Diameter Analysis (OFDA) and Video Image Analysis (VIA) that were used to measure fibre diameter of cashmere and guard hair produced by South African indigenous goats. The fibre measured by the OFDA technique was less fine than those measured by the VIA technique. The VIA technique resulted in more precise and accurate results.

Keywords: VIA, OFDA, cashmere, diameter
[#]Corresponding author. E-mail: willem.vanniekerk@up.ac.za
*Present Address: P.O. Box 67822, Highveld Park Ext. 12, 0169, South Africa

Introduction

South Africa has a potential market for its unexploited cashmere hair. Extra income can be generated if the entrepreneur processes cashmere fibre into products. An accurate technique is needed to quantify the quality of cashmere in terms of fibre diameter which will provide opportunities for creating employment in rural areas. With the Optical Fibre Diameter Analysis (OFDA) technique a minimum sample size of 3 g is required for the analysis of clean cashmere yield and fibre diameter. With the Video Image Analysis (VIA) technique a sample of any size can be analyzed. The OFDA is available in the portable form that makes it easy for use in the field when one wants immediate results. The VIA can be used in the laboratory when accurate and precise results are required. According to Stanford *et al*. (1998) the VIA technique shows potential as an objective, accurate, cost-effective method.

Materials and Methods

Cashmere collected from different production areas in Gauteng (Irene, University of Pretoria, Roodeplaat) and Limpopo (Delftzyl, Mara) provinces in South African, was spread out on a black velvet-working surface. A representative sample was placed into a glass tube using a pair of tweezers. The sample was washed two times with ether and dried using filter paper. The sample was cut into small pieces using scissors and mounted on a glass slide and covered with a small plastic top slide. The slides were left to dry for a few days. These slides were viewed with a Video Image Analyzer at 40 X enlargement for fibre diameter analysis. Using a computer mouse pointer the sides of the hair was selected and a computerized calculation was made for minimum and maximum fibre diameter, mean value, sum of all measurements, the variance and the standard deviation (Snyman, H., 2001, personal communication, ANPI-ARC, Irene, Pretoria).

The remaining part of the total yield was sent to the CSIR, Division of Textile Technology, in Port Elizabeth, South Africa, to determine fibre diameter by means of the completely automated OFDA-method. The samples were mixed thoroughly by hand and a 50g sub-sample was taken. The sample was minicored using the pneumatic minicore sampler. Thereafter, the fibre snippets were spread over a slide and 3000 measurements per sample were made automatically by the computer. In this method cashmere and guard hair diameter were measured simultaneously, but were separated into two parameters, fibre diameter and fibre diameter distribution, which were previously programmed into the computer (Hermann & Wortmann, 1996). The relationship between the OFDA and VIA was determined by using the Proc GLM procedure of SAS (1994). Significance of difference between least square means was determined by the Fischer Test (Samuels, 1989).

Peer-reviewed paper: 8th International Conference on Goats

Results and Discussion

The variation in fibre diameter of guard hair from different areas, using the two techniques is presented in Table 1.

Table 1 The influence of area on guard hair of indigenous goats using the VIA and OFDA techniques

Area	Diameter (µm) by VIA	Diameter (µm) by OFDA
Irene	69[a] (±3.61)	89[a] (±5.72)
University of Pretoria	58[b] (±2.68)	89[a] (±4.57)
Roodeplaat	62[b] (±2.91)	95[a] (±4.76)
Delftzyl	60[b] (±2.86)	89[a] (±5.71)
Mara	60[b] (±3.14)	85[a] (±5.32)

[ab]Column means with common superscripts do not differ significantly (P > 0.05)
(±) = Standard deviation

The differences in cashmere diameter from different areas, using the two techniques, are presented in Table 2.

Table 2 The influence of area on cashmere diameter of indigenous goats using the VIA and OFDA techniques

Area	Diameter (µm) by VIA	Diameter (µm) by OFDA
Irene	12[a] (±0.32)	17[a] (±0.95)
University of Pretoria	10[b] (±0.24)	14[bc] (±0.76)
Roodeplaat	9[c] (±0.26)	14[bc] (±0.79)
Delftzyl	9[c] (±0.26)	15[bc] (±0.95)
Mara	10[b] (±0.28)	15[ac] (±0.89)

[abc]Column means with common superscripts do not differ significantly (P > 0.05)
(±) = Standard deviation

The guard hair diameter and cashmere diameter measured by the OFDA were on average 27 µm and 5 µm respectively coarser than those measured by the VIA technique. The regression coefficient between the OFDA and VIA techniques was low (for cashmere and guard hair 27.1 and 16.0 respectively). Several inaccuracies could be present in the OFDA method. A possibility is that the computer used for measurements (a total of 3000) decided according to the predetermined criteria for fibre diameter and fibre diameter distribution, which fibre will be identified as cashmere and which as guard hair. When predetermined criteria, as mentioned, is used, no leeway is allowed. The result is that there will be fibre that the computer cannot differentiate between and those will probably be ignored. It is therefore possible that the pre-determined parameters set on the OFDA, may have considered finer guard hair as cashmere. There is also the possibilities that fibre which was not measured due to this lack of differentiation, will result in incorrect data (Baxter *et al.*, 1992). However with the VIA method 20 measurements of each hair type are made manually. According to this method one may determine to which category the hair belongs. This will determine the difference between cashmere and guard hair. The VIA method is therefore producing probably the most accurate data.

Conclusion

The fibre diameter measured by the VIA was finer than those measured by the OFDA technique. The VIA is regarded as the most accurate technique compared to the OFDA, which supported published results.

References

Baxter, B.P., Brims, M.A. & Taylor, T.B., 1992. Description and performance of the Optical Fibre Diameter Analyzer (OFDA). J. Text. Inst. 83(4), 507-525.

Herrmann, S. & Wortmann, F.J., 1996. Opportunities for the simultaneous estimation of essential fleece parameters in raw cashmere fleeces. Livest. Prod. Sci. 48, 1-12.

Stanford, K., Jones, S.D.M. & Price, M.A., 1998. Methods of predicting lamb carcass composition. Small Rum. Res. 29, 241-254.

Samuels, M.L., 1989. Statistics for life sciences. Collier MacMillan Publishers, London.

SAS, 1994. Statistical Analysis Systems User's Guide. Statistics Version 6. SAS Inst., Inc. Cary, NC., USA.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Quantitative and qualitative milk characteristics of Nebrodi goats

A. Zumbo#, B. Chiofalo, L. Liotta, A. Rundo Sotera and V. Chiofalo.
Dept. MO.BI.FI.P.A. - University of Messina, Polo Universitario dell'Annunziata, 98168 Messina, Italy

Abstract

This research should contribute to the knowledge of the "*Nebrodi goat*" with investigations on the milk quality and quantity during lactation. 40 *Nebrodi goats*, of different ages and order of kidding were studied. Every month, from the start of the first lactation, the individual daily yield was registered and at the same time individual milk samples were taken to determine fat, protein, lactose, somatic cell count (SCC), pH, titration acidity (°SH) and clotting properties using the parameters *r* (clotting time), k_{20} (curd firming time) and a_{30} (curd firmness) by Formagraph according to the ASPA method. Data obtained were submitted for statistical analysis using ANOVA, considering the factors: parity and type of kidding, and Pearson's correlation**.** Results show that the daily milk yield was higher for the goats of the third and higher parity ($P < 0.01$), while the protein and fat levels were higher in the primiparous goats. Goats with a multiple kidding showed significant differences ($P < 0.01$) for daily milk yield (942g *vs* 761g), lactose percentage (4.63 *vs*. 4.73) and SCC ($\log_{10}$ 5.86 *vs* $\log_{10}$ 5.63). As regards the elastometric parameters the milk of primiparous goats showed higher values of "r" and " a_{30}". The clotting time and curd firmness of the milk from goats that had had multiple kidding, were higher than from goats with single kids. Pearson's analysis showed a negative correlation in fat and protein percentages and daily milk production ($r = -0.235$ and $r = -0.179$, respectively). A negative correlation between curd firmness (a_{30}) and somatic cell content was observed, but the latter was correlated positively with clotting time, testifying the negative role of these cells on the milk clotting properties.

Keywords: Autochthonous populations, goat, milk quality.
#Corresponding author; E-mail: alessandro.zumbo@unime.it.

Introduction

In Sicily autochthonous races are protected by regional politics through local, national and European operative programmes under different Institutions. These are animals that could give production through the exploitation of marginal areas. From this point of view, autochthonous caprine races and populations are well-adapted. Interest in caprine breeding was minimal, but is improving. Probably this is related both to the exploitation of the forage resources of the mountain and hill areas that are not useful in other ways, and to the dietetic and nutritional characteristics of milk, cheese, and meat of this ruminant.

In Sicily (Italy) over 200.000 goats are reared; the highest density is in the province of Messina where the animals are bred with extensive methods and systems of transhumance.

These goats often have different morphological characteristics, even if they belong to the same population called " *Nebrodi goat*". It is a rustic and frugal goat, with a not well-defined colour: some are black, but there are also grey and reddish colours. Feeding is on pasture, except during adverse climatic conditions, when the animals need a supplementation of hay and concentrate.

The "*Nebrodi*" or "*Messinese*" goat, as it is also called, lives free in woody areas and only at night, during the winter season, they are enclosed in yards. Genetic improvement is carried out by breeders on prolificacy and resistance to weather conditions, in spite of milk production (Giaccone *et al*., 2001).

Materials and Methods

Forty *Nebrodi goats*, of different ages and order of kidding, belonging to a farm in the province of Messina were used. Feeding was on mixed pastures. Kids were raised in a small shelter and fed only on their mothers' milk twice daily, at 7.00 a.m and 6.00 p.m.. Every month, from the start of the first lactation, the quantity of milk produced was registered individually by two daily milkings, at 7.00 a.m. and 4.00 p.m.; at the same time individual milk samples were taken to determine fat, protein, lactose and somatic cell count (SCC), with a Combifoss 6200 (Foss Electric) instrument. On each sample: pH, titration acidity (°SH) and the clotting properties using the parameters *r* (clotting time), k_{20} (curd firming time) and a_{30} (curd firmness) were determined using a Formagraph (Foss Electric), according to the A.S.P.A. method (1995).

Peer-reviewed paper: 8th International Conference on Goats

Data obtained were submitted for the statistical analysis using ANOVA (SAS, 2001) considering the factors: parity and type of kidding. Parity of kidding was divided in first, second, and the third and over. Pearson's correlation was carried out to analyse for type of kidding (single and multiple).

Results and Discussion

Daily milk yield (Table 1) was higher in the milk of the goats of the third and higher parity of kidding ($P < 0.01$), which is in agreement with the results obtained by Giaccone *et al*. (1995) on "*Derivata di Siria*" goats bred in Sicily, while the protein and fat percentages were higher in the primiparous goats, characterised by a lower milk production. SCC content was significantly lower for the goats of the third and higher parity of kidding.

Table 1 Milk yield and composition (mean values)

Factors		Milk yield	% Fat	% Protein	% Lactose	pH	°SH	Log_{10} SCC
Parity	1	681 A	4.75 A	3.87 A	4.70 a	6.72 A	7.35	5.83 A
	2	852 B	4.26 B	3.63 B	4.63 b	6.65 B	7.25	5.86 A
	≥3	1022 C	4.32 B	3.54 B	4.71 a	6.70 A	7.20	5.54 B
Type of kidding	Single	761 A	4.51	3.65	4.73 A	6.69	7.27	5.63 A
	Multiple	942 B	4.37	3.71	4.63 B	6.69	7.26	5.86 B

Means on the same column followed by different letters differ significantly (A, B, C, = $P < 0.01$; a, b, = $P < 0.05$)

Goats with a multiple kidding, compared to those with single kids showed significant differences ($P < 0.01$) for daily milk yield (942g *vs* 761g), lactose percentage (4.63 *vs*. 4.73) and SCC (log_{10} 5.86 *vs* log_{10} 5.63). The higher milk yield in multiple kidding goats, could be explained by the effect of the greater quantity of placental hormones produced during pregnancy and by the suckling kids in multiple kidding goats. (Bertoni *et al*., 1998). As regards elastometric parameters reported in Table 2, milk from the primiparous goats showed higher values of "r" and " a_{30}" which were highly significant in comparison with those registered for the second and the third and higher parity goats ($P<0.01$).

Table 2 Elastometric parameters (mean values)

Factors		r (min)	k_{20} (min)	a_{30} (mm)
Parity	1	10.06 A	1.84	41A
	2	8.83 B	1.85	35B
	≥3	9.25 B	1.99	33 B
Type of kidding	1	8.88 A	1.85	35 a
	2	9.88 B	1.93	38 b

Means on the same column followed by different letters differ significantly (A, B, = $P < 0.01$; a, b, = $P < 0.05$)

Higher values for clotting time and curd firmness were registered for multiple kidding goats. Neither of the two factors influenced the curd firming time. From correlation analysis, Table 3, a negative correlation of fat and protein percentages with daily milk production ($r = -0.235$ and $r = -0.179$, respectively) was observed in agreement with the studies of Riggert (1980) and Costantinou (1984). For lactose, a positive correlation ($r = 0.245$) between whole milk yield and lactose percentage was obtained, in agreement to that reported by Riggert (1980) and Kala & Prakash (1990).

The correlation between curd firmness (a_{30}) and somatic cell content was negative, but the latter was correlated positively with clotting time, confirming the negative role played by these cells on milk clotting properties. The correlation among protein percentage and r and a_{30} parameters ($r = 0.354$ and $r = 0.478$, respectively) was positive. All elastometric parameters were positively correlated with pH.

Peer-reviewed paper: 8th International Conference on Goats

Table 3 Matrix of correlation coefficients (%)

	Milk yield	Fat	Protein	Lactose	pH	SH	SCC	r	a_{30}	k20
Milk yield	1	-0.235**	-0.179**	0.245**	0,072	0.036	-0.121*	0.151*	0.123*	0,136
Fat		1	0.079	-0.106	0,075	-0.273**	0.235**	0.164**	0.013	0.039
Protein			1	0.304**	0,069	0.496**	-0.146**	0.354**	0.478**	0.040
Lactose				1	0.354**	0.332**	-0.448**	0.209**	0.399**	0.003
PH					1	-0.112*	-0.117*	0.434**	0.216**	0.171**
SH						1	-0.328**	-0.126*	0.318**	-0.103
SCC							1	0,163*	-0.204**	0,106
R								1	0.263**	0.276**
a_{30}									1	-0.081
k_{20}										1

* =P< 0.05; ** =P< 0.01

Conclusions

Information obtained by this research contributed to the knowledge of the value of the *Nebrodi goat* population. In fact milk produced by these goats, even if in small quantity has quality and clotting characteristics that make it better than the milk of specialised milk producing goats. All this underlines the role that the goat race and population could play in the exploitation of the so-called marginal areas in Sicily.

Acknowledgements

Research financed by P.R.A. - 2002 (Prof. Vincenzo Chiofalo)

References

A.S.P.A., 1995. Metodi di analisi del latte delle principali specie di interesse zootecnico. Scientific Association of Animal Production, University of Perugia Press, Perugia, Italy, pp. 152-155.

Bertoni, G., Bernabucci, U., Rosatini, U., 1988. Rapporto fra indice di gemellarità e produzione lattea in pecore di razza Comisana. Atti VIII Convegno SIPAOC. pp.69-75.

Costantinou, A., 1984. Studies on the lactation of Damascus goat and growth of their kids. Anim. Breed. Abstr., 52, 336 (Abstr).

Giaccone, P., Portolano, B., Bonanno, A., Alicata, M.L., Todaro, M., 1995. Aspetti quanti-qualitativi della produzione lattea nella popolazione caprina Derivata di Siria. Zoot. Nutr. Anim., 21, pp.97-109.

Giaccone, P., Todaro, M., Portolano, B., 2001. La capra dei Nebrodi, Eds. Ist. Zootec. Gen., Facoltà di Agraria- Università di Palermo.

Kala, S.N. & Prakash, B., 1990. Genetic and Phenotipic parameters of milk yield and milk composition in two Indian goat breed. Small Rum. Res., 3, 475-484.

Riggert, E.H., 1980. Milk yield of German improved fown goats in lactations, 1-8 Anim. Breed. Abstr., 48, 360 (Abstr).

SAS, 2001. User's Guide: Statistics. Version 8.2,, Cary, NC, USA.

Zumbo, A., Chiofalo, L., Liotta, L., 2000. La Capra Argentata dell'Etna. L'allevatore di ovini e caprini, 1,
1-2.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Evaluation of passive immunity in Saanen goat's kids receiving colostrum at different times and quantities

R. G. Costa [1], S. V. D. Simões [2#], A. L. T. Vilar [3], P. M. Souza [4], A. N. Medeiros [5]

[1] Departamento de Agropecuária, Universidade Federal da Paraíba, Centro de Formação de Tecnólogos, Bananeiras- Paraíba, Brasil

[2] Programa de Pós-graduação em Zootecnia, Centro de Ciências Agrárias, Universidade Federal da Paraíba, Areia- Paraíba, Brasil. CEP 58.397-000

[3] Programa de Pós-graduação em Zootecnia, Centro de Ciências Agrárias, Universidade Federal da Paraíba, Areia- Paraíba, Brasil. CEP 58.397-000

[4] Departamento de Clínicas Veterinárias, Centro de Saúde e Tecnologia Rural, Universidade Federal de Campina Grande, Patos-Paraíba, Brasil. CEP 58.700

[5] Departamento de Zootecnia, Centro de Ciências Agrárias, Universidade Federal da Paraíba, Areia-Paraíba, CEP 58.397.000

Abstract

Utilizing a zinc sulfate turbidity test the levels of passive immunity were evaluated in 56 Saanem goats kids, 30 hours after birth, after submitting them to different systems of colostrum intake. The animals were divided into five experimental groups T1 (n=9) kids were allowed to nurse the dam for 24 hours and ingested colostrum "ad libitum" , T2 (n=11) kids were bottle-fed with 200 ml of colostrum in the first hour of life, T3 (n=12) kids were bottle-fed with 400 ml of colostrum, 200 ml in the first hour and 200 ml eight hours after birth, T4 (n=12) kids were bottle-fed with 400 ml of colostrum, 200 ml in the first hour and 200 ml 14 hours after birth, T5 (n=12) kids were bottle-fed with 600 ml colostrum, 200 ml in the first hour, 200 ml 12 hours after birth and the last intake at 24 hours. A randomized design was utilized. There were differences only in the levels of immunoglobulins in the group that ingested colostrum 2 and 8 hours after birth. All the groups obtained a good transfer of passive immunity because the levels of immunoglobulin were higher than those considered sufficient for calves and lambs, and there were no deaths during the neonatal period.

Keywords: immunoglobulins, kids, goats, colostrum,
[#]Corresponding author; E-mail: saravilar@bol.com.br.

Introduction

Morbidity and mortality of neonatal kids are of significant economic concern to goat production in Northeast Brazil. Kids are born hypogammaglobulinemic and placental barriers in ruminants do not allow the intra-uterine passage of immunoglobulins from dams to neonates. Therefore, consumption of colostrum is required to provide passive immunity until active immunity is established (Tizard, 2000). Kids that fail to achieve passive transfer are predisposed to enteric disease, respiratory tract disease and septicemia. The identification of the best management that provides the optimum passive immunity is critical to kid health.

For approximately 24h after parturition, intestinal epithelial cells absorb macromolecules, such as immunoglobulius (Ig) (Husband *et al*., 1972; Staley & Bush, 1985; Stott *et al*., 1979) which are transported through the cell to the lymphatic system and then to the general circulation. Thereafter, absorption of macromolecules ceases, and opportunity of acquiring passive immunity has passed. If kids do not ingest a sufficient mass of Ig prior to this, increased morbidity and mortality may occur (Nocek, 1984).

In the neonatal ruminant, the level of circulating Ig reflects the extent of the absorption of colostral antibodies and is widely accepted as an indicator of immune status. The determination of plasma immunoglobulin has been used to monitor the disease susceptibility of neonates. The practical difficulty, however, is the need to employ sophisticated laboratory techniques, and has led to an interest in simpler methods of assessing immune status. Measurement of circulating Ig may be estimated by several different methods, including the zinc sulphate turbidity test (Al-salami & Sinclair, 1977).

Peer-reviewed paper: 8th International Conference on Goats

Materials and Methods

This trial was conducted at the Centro de Formação de Tecnólogos, da Universidade Federal da Paraíba located in Bananeiras, Brazil. Goat parturition was supervised to enable pre-suckling samples of 56 Saanen kids, which were submitted to different management regimes in the colostrums intake phase. The animals were divided in five experimental groups: T1 (n=9) kids were allowed to nurse the dam for 24 hours and ingested colostrum "ad libitum"; T2 (n=11) kids were bottle-fed with 200 ml of colostrum in the first hour of life; T3 (n=12) kids were bottle-fed with 400 ml of colostrum, 200 ml in the first hour and 200 ml eight hours after birth, T4 (n=12) kids were bottle-fed with 400 ml of colostrum, 200 ml in the first hour and 200 ml 14 hours after birth; T5 (n=12) kids were bottle-fed with 600 ml colostrum, 200 ml in the first hour, 200 ml 12 hours after birth and the last ingestion of 200 ml at 24 hours. Thirty hours after birth a 4 ml blood sample was collected from the jugular vein into evacuated containers from each kid. The serum was stored at -20^0C until required for analysis. The zinc sulphate test was carried out according to the method of Pfeiffer *et al*. (1977). The samples with higher absorbance were considered with higher levels of immunoglobulins. Utilizing a curve delineated by Feitosa (1998) with fetus serum with know quantities of Ig levels of the immunoglobulin G of the kids were estimated. Data on all the these parameters were analysed by applying ANOVA.

Results and discussion

All groups had a good transfer of passive immunity. Levels of immunoglobulin were higher in kids that ingested colostrum at one and eight hours after parturition. The absorbance and estimate levels of serum Ig G at 30 hours after birth are given in Table 1. The animals with higher absorbance were considered those with higher levels of immunity.

There were differences between the means levels of experimental groups. Statistically group 2 was different from group 3; Kids that received only 200 ml of colostrum had lower levels of gamma globulin. Kids that received 400 ml colostrum at one and eight hour after parturition had the highest level of immunoglobulin. In spite of the lower value obtained in group 2 all the groups obtained a good transfer of passive immunity since Ig levels were higher than those considered adequate for calves and lambs, and there were no deaths during the neonatal period.

The ingestion of colostrum in the first hour is very important because all groups had good levels of serum immunoglobulins in spite of very different intake patterns.

Considering each kid, the zinc sulfate turbidity test detected individual failure of transfer of passive immunity in kids from group 1 (11,11%), 2 (9,09%) and 5 (8,33%). Thus, the management of group 3 and 4 was considered the best for providing adequate passive transfer of immunity in kids.

Table 1 Absorbance and estimate values of IgG kids.

Group and colostrum	Intake (ml)	Means values of absorbance (660 nm)	Estimated values of IgG* (nmg/dl)
T1 - "ad libitum"	*Ad lib*	$0,39^{ab}$	2594,20
T2 - 2 h	200	$0,37^{b}$	2445,50
T3 - 2 & 8h	400	$0,57^{a}$	3787,63
T4 - 2 & 14h	400	$0,38^{ab}$	2549,85
T5 - 2, 12 & 24h	600	$0,37^{ab}$	2353,46

Means within a column not followed by the same superscript differ ($P<0.05$) by Tukey test
* Feitosa (1998)

Conclusions

The zinc sulfate turbidity test, if accurately measured, can give a good indication of the acquisition of passive immunity.

Peer-reviewed paper: 8th International Conference on Goats

The management of group 3 and 4 were considered the best one in providing adequate passive transfer of immunity.

Acknowledgements

The authors thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico,Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and to the Centro de Formação de Tecnólogos for financial support of this project.

References

Al-Salami, M.T.H. & Sinclair, K.B., 1977. Use of the zinc sulphate turbidity test for determining plasma globulin in sheep. Vet. Rec. 100, 93.

Feitosa, F.L.F., 1998. Dinâmica do proteinograma e da atividade da gamaglutamiltransferase no soro sangüíneo de bezerros desde o nascimento até os 365 dias de idade e de vacas, antes e após o parto, da raça holandesa. 219f. Tese (Doutorado em Clinica Médica) - Faculdade de Medicina Veterinária e Zootecnia de São Paulo, São Paulo – Brasil.

Husband, A.J., M.R. Brandon and A. K. Lascelles, 1972. Absorption and endogenous production of immunoglobulins in calves. Aust. J. Exp. Bio. Med. Sci. 50: 491

Nocek, J.E., Braund, D.C. & Warner, R.G., 1984. Influence of neonatal colostrum administration, immunoglobulin, and continued feeding of colostrum on calf gain, health, and serum protein. J. Dairy Sci., 67, (2), 319-333.

Pfeiffer, N.E., McGuire, T.C. & Bendel, R.B. 1977. Quantitation of bovine immunoglobulins: comparison of single radial immunodiffusion, Zinc sulfate turbidity, serum electrophoresis and refractometer methods. Am. J. Vet. Res., 38, (5), 693-98

Staley, T.E. & Bush, L.J., 1985. Receptor mechanisms of the neonatal intestine and relationship to immunoglobulin their absorption and disease. J. Dairy Sci., 68, 184.

Stott, G.H, Marx, D.B., Menefee, B.E. & Nightingale, G.T. 1979. Colostral immunoglobulin transfer in calves. I. Period of absorption. J. Dairy Science, 62, 1632

Peer-reviewed paper: 8th International Conference on Goats

Diseases and mortality of adult goats in a South African milk goat herd

E.F. Donkin[1#] and P.A. Boyazoglu[2]
[1]Department of Animal and Wildlife Sciences, University of Pretoria, Pretoria 0002, South Africa
[2]P.O. Box 52285, Wierda Park, 0149, Pretoria, South Africa

Abstract

Saanen and South African Indigenous goats were crossbred, and all three types were compared in terms of productivity, milk production and diseases between 1988 and 1994. Clinical mastitis occurred in the herd at a moderate level (28 cases of clinical mastitis, including peracute outbreaks, in 251 lactations in six years). Peracute cases resulted in deaths, or loss of an udder half. The main organism identified was *Staphylococcus epidermidis*, infecting 109 of the 1032 udder halves sampled (10.6%). The other bacterial isolations were only 27 of 1032 udder half samples (2.6%), primarily of *Staphylococcus aureus* (23 of 27 colonies: 85%). *Mannheimia haemolytica* (formerly *Pasteurella*) and *Streptococcus sp.* were each identified once, and *Escherichia coli* twice. Somatic Cell Counts (SCC) were an unreliable indication of subclinical mastitis. Abscesses were not a major problem (up to ten cases a year). Dystocia, and the resultant metritis, occurred in only 11 cases in a six year period. Squamous cell carcinoma developed on the udders of half of the 24 pure Saanens from the fourth lactation onwards, and they were culled. No cases were reported in the Crossbred goats. Alterations to the goat pens, which provided adequate shade, resolved the problem. Foot problems occurred when hooves had not been trimmed regularly. Serious eye infections seldom occurred. Six cases of adult goats with pneumonia were recorded. On two occasions, samples were collected from goats that had swollen joints, but tests for caprine arthritis encephalitis (CAEV) were negative; this disease appears not to exist in South Africa. Internal parasites were not a significant problem in adult goats. Lice were the only external parasites in the penned goats. Indigenous goats appeared to be relatively resistant to tick infestation. Mortality increased with age, and as the size of the herd increased. The annual mortality rates of 10% for Saanens and 15% for Crossbreds were high, compared to that for the Indigenous goats of 4%. The most important causes of death were mastitis, ketosis and pneumonia. Pneumonia was diagnosed as the cause of death for five adult goats. Few cases of dystocia were recorded, but some goats were lost as a result of uterine infections and peritonitis. Pregnancy toxaemia occurred with increased demand for energy late in gestation. Plastic bags in the rumen caused deaths of some Indigenous goats in the veld paddocks in later years. Only two cases of heartwater were recorded .

Key words: Milk goats, diseases, mortality.
Corresponding author; E-mail: ned.donkin@up.ac.za

Introduction

The Milch Goat Project was initiated in 1987 to study the factors affecting the establishment of goat milk production for small-scale farmers and households in the developing areas of Southern Africa. Saanen and South African Indigenous goats were crossbred, and kept on a zero grazing system (a total mixed ration diet). In later years, the Indigenous goats were kept in a veld paddock. Some results have been reported previously (Donkin, 1997; Donkin *et al*. 1992; Donkin *et al*. 1996; Donkin *et al*. 2000).

Materials and Methods

Saanen milk goats were purchased from Fairview Estates in Western Cape Province, and South African Indigenous goats were loaned from the Department of Development Aid farm Delftzyl in Limpopo Province. A specific programme was carried out to assess resistance to heartwater (Donkin *et al*. 1992). Breeding, kidding, milk production, diseases and mortality were recorded (Donkin, 1997). Diagnosis was based on clinical signs, lesions, post mortem examination and diagnostic tests. Post mortems were carried out by the Pathology Department of the Faculty of Veterinary Science

Results and discussion

The incidence of diseases in goats that recovered is shown in Table 1. These are in addition to those reported as post mortems (Table 5).

Peer-reviewed paper: 8th International Conference on Goats

Table 1 Goat Diseases Recorded

	Year					
Disease condition	1989	1990	1991	1992	1993	1994
Mastitis	1	7	4	2	2	4
Dystocia	-	2	1	-	1	4
Abscesses	-	7	10	-	1	-
Eye infections	-	-	3	-	-	-
Pneumonia	-	-	1	-	-	-

Clinical mastitis occurred periodically (28 cases in 251lactations of Saanens and Crossbreds) and included occasional peracute outbreaks. The goats were milked by machine, using standard measures for mastitis prevention and control (Kingwill *et al.* 1979). This comprised: washing and drying the udder; stripping foremilk to test for mastitis; teat disinfection after milking; prompt antibiotic treatment of clinical cases; intramammary therapy in the dry period (only for the first three years); and strategic culling of chronically infected animals. Some goats were lost from peracute mastitis (Tables 1 and 4) resulting in deaths, or in the loss of an udder half. One peracute outbreak was caused by a *Pseudomonas* infection apparently transmitted by the milking machine.

In the years 1990/91 milk samples were taken regularly to monitor subclinical infections (Table 2). The incidence of subclinical mastitis as indicated by growth of bacterial colonies was generally low, and infections identified did not often persist. The main organism identified was *Staphylococcus epidermidis*, infecting 109 of the 1032 udder halves sampled (10.6%). This was considered to be an environmental contaminant, and not a true mastitis-causing organism. The other bacteria were few in comparison (27 of 1032 udder half samples: 2.6%), and consisted primarily of *Staphylococcus aureus* (23 of 27 colonies: 85%). *Mannheimia haemolytica* (formerly *Pasteurella)*and *Streptococcus sp.* were each identified once, and *Escherichia coli* twice. As was expected in goats, the Somatic Cell Counts (SCC) were an unreliable indication of subclinical mastitis (Table 3).

Table 2 Subclinical Mastitis Survey: 1990/91: Bacterial growth.

Date	Udder halves sampled	No growth	Growth of bacterial colonies				Percent showing Growth	
			Totals	*Staph. epidermidis*	*Staph. aureus*	Other	*Total*	*Partial**
18/9/90	76	73	3	2	1	0	3.9	1.3
2/10/90	114	106	8	5	2	1	7.0	2.6
16/10/90	140	129	11	10	1	0	7.9	0.7
6/11/90	132	113	19	14	4	1	14.4	3.0
27/11/90	126	106	20	11	9	0	15.9	7.1
5/2/91	118	99	19	17	1	1	16.1	1.7
12/3/91	120	100	20	18	1	1	16.7	1.7
16/4/91	121	98	23	19	4	0	19.0	3.3
14/5/91	85	72	13	13	0	0	15.3	0.0
Totals	1032	896	136	109	23	4	13.2	2.6

[* Excluding *Staph. epidermidis*]

Table 3 Subclinical Mastitis Survey: 1990/91: Somatic Cell Counts (SCC)

(cells x 1000/ml) (mean ± SE)

Date	n	No Growth	Growth
18/9/90	76	1687 ± 2866	1222 ± 1080
2/10/90	114	1042 ± 1712	2334 ± 3989
16/10/90	140	1194 ± 2500	1022 ± 1100
6/11/90	132	508 ± 614	670 ± 696
27/11/90	126	527 ± 1020	1344 ± 2214
5/2/91	118	864 ± 1171	696 ± 525
12/3/91	120	825 ± 1362	671 ± 726
16/4/91	121	831 ± 1242	954 ± 590
14/5/91	85	839 ± 1795	1313 ± 855

Peer-reviewed paper: 8th International Conference on Goats

Abscesses (caseous lymphadenitis) were not experienced as a major problem (up to ten cases per year). Dystocia, and the resultant metritis, occurred in a few goats (11 cases in six years). Some goats died from uterine infections and peritonitis.

Squamous cell carcinoma developed in half of the original herd of 24 pure Saanens on the skin of the udder from the fourth lactation onwards. It was incurable, and these goats were culled. None occurred in Crossbred goats perhaps because of greater skin pigmentation. A new goat shed was constructed which provided more shade, and the problem abated. Foot problems occurred when hooves had not been trimmed regularly. A few goats appeared to have had a genetic weakness, making them susceptible to foot deformities, especially if they became overweight. A few showed laminitis, and spent a proportion of their time kneeling. This may have resulted from the high energy diet fed to the milk goats. Serious eye infections seldom occurred (Table 1). A low incidence of pneumonia occurred (6 cases). (Table 1 and Table 5). On two occasions, samples were collected from goats that had swollen joints, but tests for caprine arthritis encephalitis (CAEV) were negative; this disease appears not to exist in South Africa.

Internal parasites were not a problem in the adult goat herd. Levamisole was given in the dry period. Indigenous goats were dosed with various anthelmintics once or twice a year. Lice occurred on goats in the pens about twice a year, and were controlled with a synthetic pyrethroid. Saanen or Crossbred goats generally were not kept in the veld paddocks because they lost body condition and were at risk of tick-borne diseases. In contrast, Indigenous goats appeared to be relatively resistant to tick infestation. Tick populations on the Indigenous goats were low, under the tail and between the hoof claws, sometimes causing lameness. Only two cases of heartwater were recorded during this period (1988 to 1994), one of which was from a goat kept in the goat pens. The tick could have been transported via guinea fowl that flew in to eat spilled goat feed in the pens, or it could have been carried in by an Indigenous goat that had been in the veld. Because of the risk of heartwater, Saanen and Crossbred goats were seldom sent out to the veld paddocks.

There were few deaths in the early years, but the incidence increased in older animals, and as the size of the herd increased (Table 4). The average annual losses of 10% for Saanens and 15% for Crossbreds were high, compared to those of Indigenous goats (4%). There were too few Three-quarter Saanens to draw conclusions.

Table 4 Mortality of adult female goats: 1988 - 1993

Year	Saanen		Crossbred		3Quarter Saanen		Indigenous	
	No.	Deaths	No.	Deaths	No.	Deaths	No.	Deaths
1988	25	1	-	-	-	-	33	-
1989	24	-	-	-	-	-	3	1
1990	34	5	9	-	-	-	44	6
1991	48	4	21	7	2	-	40	1
1992	41	4	22	2	8	4	48	2
1993	41	9	21	2	9	1	49	1
Averages	35.5	3.8	18.2	2.7	6.3	1.7	41.2	1.8

The most important causes of death identified from post-mortem examinations were mastitis, ketosis and pneumonia (Table 5). Both mastitis and ketosis are management-related diseases. Pneumonia was diagnosed as the cause of death for five adult goats, but this may have been the final complication to other disease problems.

Table 5 Recorded post-mortems of adult goats (n = 32)

Aetiology	No.	Aetiology	No.
mastitis	8	hepatic cirrhosis	2
pregnancy toxaemia (ketosis)	6	heartwater (cowdriosis)	1
pneumonia	5	plastic bags in rumen	1
peritonitis	3	squamous cell carcinoma	1
dystocia, metritis, uterine prolapse	4	nephrosis/ renal calculi	1
Corynebacterium abscesses	1	heart failure	1

[Note: This is a sample of the goats that died, because post mortems were not carried out in all cases.]

Acknowledgements

This research project was carried out in the Department of Animal Health and Production of the Faculty of Veterinary Science at the Medical University of Southern Africa (Medunsa). We gratefully acknowledge the

Peer-reviewed paper: 8th International Conference on Goats

support of Janssen Pharmaceutica in the early years of the Milch Goat Project. Thanks are also due to the many colleagues who assisted with post mortems and laboratory analyses.

References

Donkin, E.F., 1997. Productivity and diseases of Saanen, Indigenous and Crossbred goats on zero grazing. PhD Thesis, Faculty of Veterinary Science, Medical University of Southern Africa. [http://upetd.up.ac.za/thesis/available/etd-07252003-155054/].

Donkin, E.F. & Boyazoglu, P.A., 2000. Milk production from goats for households and small-scale farmers in South Africa. Proc. Seventh International Conf. on Goats, Tours, France, May 2000. 324-326.

Donkin, E.F, Boyazoglu, P.A., Els, H.C., MacGregor, R.G., Ramsay, K.A. & Lubout, P.C., 1996. Productivity of Saanen, South African Indigenous and Crossbred goats fed a complete feed: preliminary results. VI International Conf. on Goats, Beijing, May 1996. Volume 1:132-135.

Donkin, E.F., Stewart, C.G., MacGregor, R.G., Els, H.C. & Boyazoglu, P.A., 1992. Resistance of Indigenous and Crossbred goats to heartwater (*Cowdria ruminantium*). In: Recent Advances in Goat Production, V International Conf. on Goats, New Delhi, March 1992.1716-1719.

Kingwill,R.G., Dodd,F.H. & Neave,F.K., 1979. Machine milking and mastitis. In: Machine Milking; Ed. C.C.Thiel and F.H.Dodd. Technical Bull. No.1, NIRD, Reading, England: 231-285.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Diseases and mortality of goat kids in a South African milk goat herd

E.F. Donkin[1#] and P.A. Boyazoglu[2]
[1]Department of Animal and Wildlife Sciences, University of Pretoria, Pretoria 0002, South Africa
[2]P.O. Box 52285, Wierda Park, 0149, Pretoria, South Africa

Abstract

Small-scale farmers and households in developing areas crossed Saanen milk goats with South African Indigenous goats to evaluate productivity, milk production and disease incidence, and assess their suitability for milk production. Goat kids were separated from their mothers at one week of age, and were kept in groups of ten in pens with slatted floors. They were fed one litre of milk per day in two feeding periods, and had access to a total mixed ration.

A mean annual goat kid mortality of 29% was observed over a period of three years. No effect of breed, gender or of multiple births was apparent. Most goat kid deaths were a result of coccidiosis and pneumonia. Two categories were discerned: kids that died soon after being born; and kids that died from coccidiosis and its complications, at about two to four months of age. In most cases, when pneumonia was diagnosed as the cause of death, it was a complication arising from the debilitating effects of earlier coccidiosis. Other relatively less important disease conditions that affected the goat kids included: rotavirus; orf ; and limb fractures.

Keywords: Goat kids, diseases and mortality.
[#] Corresponding author; E-mail: ned.donkin@up.ac.za

Introduction

The Milch Goat Project in the Department of Animal Health and Production (Medunsa) was initiated in 1987 to study the factors affecting the establishment of goat milk production for small-scale farmers and households in the developing areas of Southern Africa. The goats were kept on a zero grazing system (total mixed ration diet). Some results have been reported (Donkin, 1997; Donkin *et al*. 1992; Donkin *et al*. 1996; Donkin *et al*. 2000).

Materials and Methods

Saanen milk goats were purchased from Fairview Estates in Western Cape Province, and South African Indigenous goats were loaned from the Department of Development Aid farm Delftzyl in Limpopo Province. Crossbred goats were produced and compared to the Saanens and Indigenous goats. Breeding, kidding, milk production, diseases and mortality were recorded (Donkin, 1997). In the first three years, kids were taken from their mothers and kept in groups of up to ten in nursery pens with slatted floors. They were fed 0.5 litres goat milk twice a day, and had free access to a complete feed containing 14% CP in the DM. After weaning they were fed this total mixed ration *ad libitum*. Diagnosis of diseases was based on clinical signs, lesions and specific diagnostic tests. Post mortems were carried out by the Pathology Department of the Faculty of Veterinary Science.

Results and discussion

The mean annual goat kid mortality was unacceptably high at 29%. The overwhelming reasons for the death of goat kids were coccidiosis and pneumonia, usually occurring together. If the diagnosis "enteritis" is also taken to be indicative of coccidiosis, and "cachexia" is the logical consequence before death, then there is no doubt that this was the major problem in the herd. The causative organisms have been studied (Harper & Penzhorn, 1999). Pneumonia also occurred separately from coccidiosis, and this was probably the final reason for death of goat kids that had not received enough colostrum. Many kids were lost in the early days after being born, probably as a result of poor mothering ability, pendulous udders, overcrowding, and lack of close attendance by the staff responsible.

Two distinct groups were discerned (Table 1):

* Kids that died soon after being born. In this group, those that died from pneumonia in the first 35 days after birth, on average at two to three weeks (range: 1 to 33 days).
* Kids that died from coccidiosis and its complications, at about two to four months of age.

Peer-reviewed paper: 8th International Conference on Goats

In most cases, the pneumonia diagnosed after two months was a complication arising from the debilitating effects of earlier coccidiosis. A timely treatment with diclazural (Vecoxan®, Janssen) was usually effective in stopping the diarrhoea, but by then much damage had been done. Affected goat kids usually died, if not from diarrhoea, then from pneumonia. Those that were saved remained stunted. Preventative measures included the addition of an ionophore to the feed, either monensin (Romensin®, Elanco) or lasalocid (Taurotec®, Instavet). Such compounds have a coccidiostatic effect, but this was only partially effective in limiting mortality.

The system of kid rearing that was initially used had to be abandoned because of labour difficulties related to the turbulent political situation in South Africa at that time. The kids were allowed to run with their mothers until about six weeks of age. This system was inefficient, although similar to the method used by farmers in the developing areas. An improvement in hygiene and in careful husbandry of the kids in later years made a great difference in reducing the effects of coccidiosis, but it remained the most important problem in the herd. High kid mortality can occur even with animals kept under extensive management systems (Ndlovu & Sibanda 1991).

Table 1 Age of Goat Kids at Death (days)

Age at death (days)	1988	1989	1990	Totals (Three years) 10d	30d	Percent*
0 to 10	3	8	17	28		
11 to 20	1		4	5		
21 to 30	4			4	37	36.3
31 to 40	2	1	1	4		
41 to 50	5	2		7		
51 to 60		4		4	15	14.7
61 to 70		4		4		
71 to 80		4	4	8		
81 to 90		3	1	4	16	16.7
91 to 100		2	5	7		
101 to 110	1	5	4	10		
111 to 120		3	2	5	22	21.6
121 to 130		2	3	5		
131 to 140		1	1	2		
141 to 150		1	1	2	8	8.8
151 to 160			1	1		
161 to 170			2	2		
171 to 180					3	2.9
Totals	16	40	46	102	102	100

Note: *Percent of animals which died per age group

Breed of goat as well as gender of kid had no effect on mortality. Multiple births did not have a negative effect on mortality. The data in Table 2 might suggest that single goat kids showed a higher mortality than did twins or triplets, but the incidence varied greatly from year to year, and no clear trend was apparent (Donkin 1997).

Table 2 Effect of multiple births on mortality of goat kids

Breed	Singles		Twins and triplets		Totals	
	No.	%	No.	%	No.	%
Saanen	12	32.4	36	31.0	48	31.4
Crossbred	17	30.9	17	19.8	34	24.1
Three-quarter Saanen	11	61.1	6	23.1	17	38.6
South African Indigenous	2	28.6	7	28.0	9	28.1
Totals	42	35.3	66	26.1	108	29.0

Since most goat kids that died did so from diarrhoea / coccidiosis / pneumonia complex of the disease (Table 3), other problems relating to the kids were often not recorded.

Peer-reviewed paper: 8th International Conference on Goats

Table 3 Goat kid mortality from coccidiosis and pneumonia

Reason	No.	Days (mean ± SE)
Coccidiosis	53	86 ± 79
Coccidiosis with pneumonia	14	94 ± 28
Pneumonia (<35 days)	18	13 ± 11
Pneumonia (>35 days)	13	102 ± 30
Pneumonia (> 35 days; incl. coccidiosis)	27	95 ± 31

Some other conditions associated with death are indicated in Table 4. Rotavirus was isolated from the faeces of goat kids in 1990, and reported in 1994 (DaCosta Mendes *et al.*,1994). This was believed to be the first report of rotavirus in goats in southern Africa. Further attempts to isolate the virus in other years were unsuccessful, and it cannot be assumed to be the cause of subsequent mortality.

In the early years, limb fractures were a problem with young kids; but the incidence was generally low. Exact statistics were not recorded, but were of the order of two to four kids a year (approximately 1% to 4%). Initially, orf was not apparent in the herd. However, in later years outbreaks occurred sporadically in kids of about three months of age. The lesions contributed to mortality, by making the drinking of milk or eating of other food difficult. Generally the orf cleared up after a few weeks, and was not considered to be a major problem.

Table 4 Goat kid post-mortems: 1988 to 1994

Reason for death	Number of kids
pneumonia	54
coccidiosis	53
enteritis/diarrhoea	9
cachexia	15
puerperal infections*	15
neonatal mortality **	10
miscellaneous***	9
Total	150

Notes: * Includes: septicaemia (8), *E.coli* (3), myocarditis (1), pericarditis (1) arthritis (1), pyogenic bacterial embolism (1).
** Includes: stillborn (4), born weak (5), hypothermia (1)
*** Includes: cerebrocortical necrosis (1), vitamin E/selenium deficiency (1), ataxia (1), renal dysplasia (1), *Monezia* (1), asphyxiation (stuck in feed bin) (2), 'concentrate overload' (2).

Conclusions

The high kid mortality was the most significant syndrome affecting the goats. The main losses occurred in the first three months of life. The main reasons were coccidiosis (presumably resulting from overcrowding and poor hygiene), and pneumonia associated with the coccidiosis, but related to poor mothering ability, pendulous udders, overcrowding, and lack of close attendance by the staff responsible. This was a management problem related to the political turmoil at that time.

Acknowledgements

This research was carried out in the Department of Animal Health and Production of the Faculty of Veterinary Science at the Medical University of Southern Africa (Medunsa). We gratefully acknowledge the support of Janssen Pharmaceutica in the early years of the Milch Goat Project. Thanks are also due to the many colleagues who assisted with post mortems and laboratory analyses.

References

Da Costa Mendes,V.M., De Beer,M.C., Els, H.J., Goosen,G.H., Theron,J. & Steele,A.D., 1994. Rotavirus in Saanen goats. *J. S. Afr. Vet. Ass.* 65(3), 132-133.

Donkin, E.F., 1997. Productivity and diseases of Saanen, Indigenous and Crossbred goats on zero grazing. PhD Thesis, Faculty of Veterinary Science, Medical University of Southern Africa. [http://upetd.up.ac.za/thesis/available/etd-07252003-155054/].

Donkin, E.F. & Boyazoglu, P.A. (2000). Milk production from goats for households and small-scale farmers in

Peer-reviewed paper: 8th International Conference on Goats

South Africa. Proc. Seventh International Conf. on Goats, Tours, France, May 2000. 324-326.

Donkin, E.F, Boyazoglu, P.A., Els, H.C., MacGregor, R.G., Ramsay, K.A. & Lubout, P.C., 1996. Productivity of Saanen, South African Indigenous and Crossbred goats fed a complete feed: preliminary results. VI International Conf. on Goats, Beijing, May 1996. Volume 1:132-135.

Donkin, E.F., Stewart, C.G., MacGregor, R.G., Els, H.C. & Boyazoglu, P.A. ,1992. Resistance of Indigenous and Crossbred goats to heartwater (*Cowdria ruminantium*). In: Recent Advances in Goat Production, V International Conf. on Goats, New Delhi, March 1992.1716-1719.

Harper, C.K. & Penzhorn, B.L., 1999. Occurrence and diversity of coccidia in indigenous, Saanen and crossbred goats in South Africa. *Veterinary Parasitology* 82, 1-9.

Ndlovu,L.R. & Sibanda,L.M., 1991. Productivity of indigenous goats in communal areas of Nyanga North and Gwanda South: Performance of kids from birth to weaning and implications for management and extension. In: Goat development in Zimbabwe: Prospects and Constraints. Proc. Workshop, Matopos Research Station, November 1991. Ed:L.Ndlovu: 97-105.

Antibiotic residue withdrawal periods in milk of Saanen dairy goats and udder tissue irritation: Preliminary results

J. Karzis[#1], E.F. Donkin[2] and I.M. Petzer[1]
[1]Department of Production Animal Studies, Faculty of Veterinary Science,
University of Pretoria, Private Bag X04, Onderstepoort, 0110,South Africa
[2]Department of Animal & Wildlife Sciences, Faculty of Nastural and Agricultural Sciences,
University of Pretoria 0002, South Africa

Abstract

In Trial 1, eight goats were treated with Curaclox LC and six goats were untreated controls. All goats were in early lactation except for 9/2. Withdrawal periods of Curaclox LC calculated according to TRIS were shorter than withdrawal periods corresponding to the disappearance of the blue dye in the milk. SCC of treatment and control groups peaked after treatment and returned to baseline. SCC of non-infected goats was slightly lower than those of infected goats. In Trial 2, seven goats were treated with Spectrazol and seven goats were untreated controls. All goats were in mid to late lactation. Withdrawal periods calculated according to TRIS results in Trial 2 were longer than those of Trial 1. SCC of treatment and control group and of infected and non-infected goats remained unstable in Trial 2, due to late lactation and stress.

Keywords: goat milk, antibiotic withdrawal
[#]Corresponding author; E-mail: joanne.karzis@op.up.ac.za

Introduction

Dairy goats rather than cows are often more appropriate for subsistence milk production (Devendra & Burns, 1983; Donkin, 1997). Mastitis can be a major disease in dairy goat production (Fisberg, *et al* 2000); (Higgs, & Bramley, 1980); (Jackson, 1980). Limited research has shown that withdrawal times for antibiotic residues are longer in goat milk than in milk from cows (Al-Bassan, & Hasso, 1996); (Debackere, 1995). Antibiotic residues in goat milk may cause anaphylactic and allergic reactions in humans consuming the milk, cause the development of resistant strains of bacteria and affect the cheese making process (Stabenfeldt, & Spencer, 1965); (Youzhang, 1996).

Materials and methods

A semi-synthetic penicillin-based intramammary preparation (Curaclox LC, containing 75mg sodium ampicillin and 200mg sodium cloxacillin per dose plus blue dye) was administered into both udder halves of eight goats. Six similar goats were used as untreated controls.

Milk production of each goat was measured 12 hourly. Foremilk samples were taken and tested for conductivity and CMCT. Results of the first three samplings were used to determine a baseline. On the fourth sampling, the goats were given antibiotic for three treatments at 12 hourly intervals. Milk samples were analyzed until there were no antibiotic residues present, as indicated by the results of the Thermo-Resistant Inhibitory Substances (TRIS) test and when the Somatic Cell Counts (SCC; Fossomatic 90) had returned to that of the baseline. Culturing onto BTA plates identified bacteria. The trial was repeated using a cefuroxime 250mg based intramammary product (Spectrazol Milking Cow, Schering-Plough). Seven goats were treated and the remaining seven goats were used as controls.

Two clinical mastitis cases have been obtained so far from a nearby farmer. One of these cases was treated with Spectrazol and the other one was treated with Curaclox LC. The same dairy and laboratory procedures as above were followed.

Results

Figure 1 and Figure 2 illustrate the results of Trial 1,in which all the goats were in early lactation, except for goat number 9/2, which was in late lactation. Both Figures 1 and 2 illustrate a sudden increase in cell counts the first evening the goats were sampled, probably due to the stress of the change in the usual milking routine. However by the next morning, the SCC had dropped to baseline. The goats were treated with Curaclox LC on the evening of the first treatment. Subsequent treatments were given on the morning and evening of the following day. The SCC peaked after all 3 antibiotic treatments had been administered.

Four days later SCC had returned to baseline, indicating the end of udder irritation caused by antibiotics administered to the udder.

Figure 1

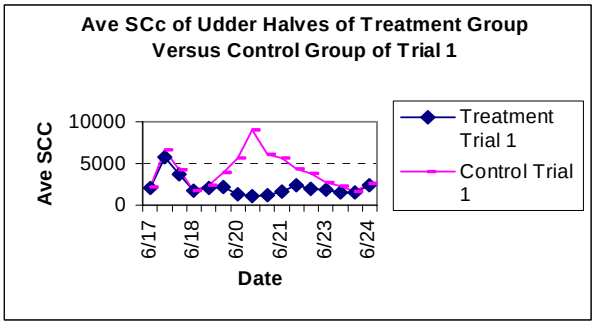


Figure 2

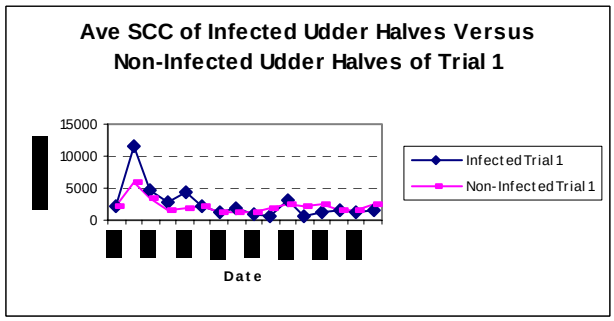


Figure 3

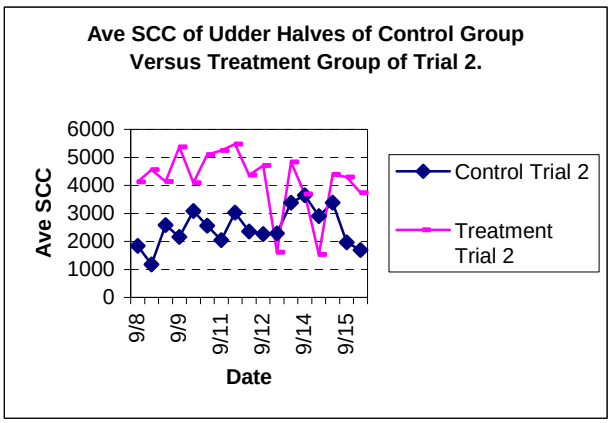


Figure 4

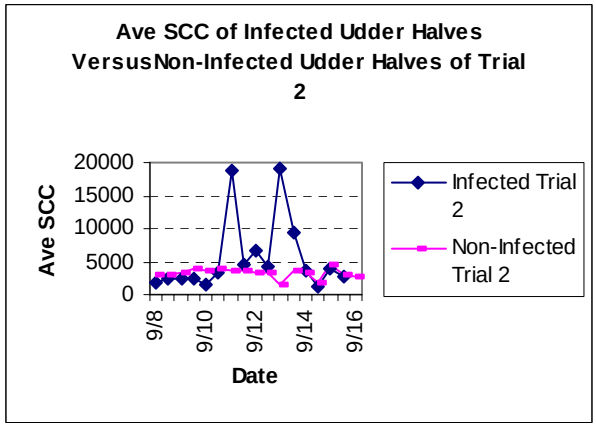


Table 1 Withdrawal Periods of Trial 1 using Curaclox LC

Goat Number	Udder half	Antibiotic Withdrawal Period (h)	Withdrawal period of Dye (h)
9/2	R	72	84
9/2	L	72	96
983	R	72	132
983	L	96	132
W6	R	72	120
W6	L	72	120
1/9	R	72	96
1/9	L	84	96
A74	R	84	132
A74	L	84	132
A79	R	72	132
A79	L	72	132
1/12	R	108	108
1/12	L	72	108
W21	R	108	108
W21	L	108	108

Table 2 Withdrawal Periods of Trial 2 using Spectrazol

Goat Number	Udder Half	Antibiotic Withdrawal Period (h)
1) 9	R	84
1) 9	L	84
A79	R	96
A79	L	84
W6	R	108
W6	L	96
W10	R	108
W10	L	108
W2	R	132
W2	L	108
99041	R	120
99041	L	84
W18	R	120
W18	L	96

SCC of infected and non-infected udder halves remained within the same range after the initial rise in SCC on the first evening, which dropped to baseline by the next morning. Figure 3 and Figure 4 illustrate the results of Trial 2 seen previously when all the goats used were in mid to late lactation. SCC of the treatment group began higher than that of the control group and remained higher throughout the trial except for dropping to below that of the control group on two days (Fig.3). The SCC of the control group remained

unstable throughout the trial. The rise and fall of the SCC of Figure 3 did not correspond to the administration of Spectrazol.

The SCC of the non-infected udder halves started at a higher point than the SCC of the infected udder halves (Fig.4). SCC of Infected udder halves remained unstable throughout the trial and did not correspond to administration of Spectrazol treatments. Withdrawal periods for Trial 1(Curaclox LC) calculated according to the TRIS results ranged from 3days(72h) to 4.5days(108h). The withdrawal periods for Trial 1 calculated according to the disappearance of the blue dye ranged from 3.5days(84h) to 5.5days(132h). Withdrawal periods for Trial 2(Spectrazol) calculated according to the TRIS results ranged from 3.5days(84h) to 5.5days(132h).

Discussion

The fluctuation of results in Trial 2 as illustrated in Figure 3 and Figure 4, could have been due to the late lactation cycle of the goats or due to stress. During this trial the dairy experienced fluctuations in the electricity supply causing the milking machine to stop and start irregularly during milking, thus increasing udder-irritation and stress and resulting in increased and irregular SCC.

In Trial 1 using Curaclox LC, the withdrawal periods calculated according to TRIS test (showing no inhibition from antibiotic residues) were shorter than the withdrawal periods indicated by the disappearing of the blue dye in the milk. Thus according to this trial this product may be successfully used for treatment of mastitis in goats, since the withdrawal times of the antibiotic residues were shorter than the indication of the dye. In Trial 1 all the goats were in early lactation except for goat number 9/2.

In Trial 2 Spectrazol was used and all the goats used were in mid to late lactation. The withdrawal periods for Spectrazol were longer than those for Curaclox LC. However, this could also have been caused by the later stage of lactation and the stress on the goats and not be a true indicator that Spectrazol had a longer withdrawal period of antibiotic residues than Curaclox LC.

Conclusion

Withdrawal periods according to dye disappearance indicated that Curaclox LC may be used on goats and that the milk was safe for human consumption when the dye had disappeared. Withdrawal periods as indicated by TRIS were longer for Spectrazol than for Curaclox LC. Withdrawal periods of Spectrazol (60h) and Curaclox LC (72h) on the directions for use in cattle were shorter than the maximum withdrawal period required for goats as a result of this experiment. This was a preliminary study and more data has to be collected in order for statistically viable results to be obtained to substantiate the above statements.

References

Bassan, L.S & Hasso., 1996.S.A.Mastitis in goats caused by *Nocardia asteroids.* Proceedings from 6th International conference on goats, Beijing, China.6-11May 1996,Volume 2,758

Debackere, M., 1995.Pharmacokinetics and Pharmacodynamics of Antimicrobials in Relation to their Residues in Milk. Proceedings of Symposium on Residues of Antimicrobial Drugs and other inhibitors in Milk.Kiel, Germany.28-31 August 1995,41

Devendra, C & Burns. M., 1983.Goat production in the Tropics. Commonwealth agricultural bureaux, Slough, England.

Fisberg, M., Ferreira, A.M.A., Nogueira, M. & Fisberg, R.M., 2000. Acceptance and tolerability of goat milk in preschool children. Proceedings of 7th International Conference on Goats, Tours, France. 15-18 May 2000,881

Higgs, T.M. & Bramley, A.J., 1980. Laboratory techniques for the examination of milk samples. Mastitis Control and Herd Management. Technical Bulletin 4.Proceedings of a course organized by the National Institute for Research in Dairying on 22,23 and 24 September 1980,for the British Cattle Veterinary Association. pp. 95

Jackson, E.R., 1980. The role of the veterinary practitioner in mastitis control. Mastitis Control and Herd Management. Technical Bulletin 4. Proceedings of a course organized by the National Institute for Research in Dairying on 22,23 and 24 September 1980,for the British Cattle Veterinary Association.pp.253

Stabenfeldt, G. H., & Spencer, G R., 1965. Pathol. Vet. 2, 585.

Youzang, Z., 1996. Goat Industry and its Significance in Chinese Economy Proceedings from 6th International conference on goats, Beijing, China.6-11May 1996, Volume 1,1.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Effects of CAEV infection on the performance of Hungarian goat breeds

S. Kukovics[1#], A. Molnár[1], M. Ábrahám[1], Z. Dani[1], Sz. Kusza[2], Gy. Fülöp[3], Zs. Bösze[4], and A. Jávor[2]

[1]Research Institute for Animal Breeding and Nutrition, Gesztenyés u. 1. H-2053 Herceghalom, Hungary; [2]University of Debrecen, Centre of Agriculture, Böszörményi u. 138. H-4015 Debrecen, Hungary; [3]Hungarian Goat Breeders' Association, Gesztenyés u. 1. H-2053 Herceghalom, Hungary
[4] Agricultural Biotechnical Centre, P.O. Box 411., H-2100 Gödöllő, Hungary

Abstract

CAEV (caprine arthritis encephalitis virus) infection was discovered some years ego in Hungarian goat sector after livestock importation from the Netherland (Saanen), Germany (Boer) and France (Alpine). In order to determine the level of infection 83 goat farms were investigated, and 5,077 animals were sampled. The selection was made based on the size of the farm (1-10, 11-30, 31-50, 51-100, 101-150, 151-200, above 200 does), the breed (purebred and crossbred Saanen-, Alpine- and Boer, Hungarian Milking Brown-, White- and Multicolour, and Hungarian native), as well as the areas of the country. Blood samples were examined at the Central Veterinary Institute using ELISA and AGID test.

Based on the results, milk samples from both sero-positive and sero-negative animals (about 1,000 each) were taken in order to determine milk components (fat-, protein and lactose %, somatic cell count-SCC). The milk samples were examined at the official raw milk laboratory of the Animal Breeding Performance Examination Ltd (Gödöllő). Litter size of the does was also studied. SPSS for Windows and Microsoft Excel programmes were used for processing the data.

The results suggest that the level of infection varied from county to county within the country, and increased with an increase in the size of the herd. The level of infection was different in various breeds, with the highest in Saanens, and the smallest in Hungarian Milking Goats. According to the preliminary results the effect of CAEV infection on the milk yield and milk composition traits differed between breeds. Sero-negative animals were uniformly at an advantage for SCC, and litter size.

Keywords: CAEV, goats, performance, Hungary
[#]Corresponding author; E-mail: sandor.kukovics@atk.hu

Introduction

Caprine Arthritis Encephalitis (CAE) is an infectious disease caused by a slow virus, that produces infection in the brain and the spinal cord (2-4 months of age) as well as in the joints of goats (3-5 years of age). A high percentage of kids and adult goats affected by the CAEV succumb. According to various authors reviewed by Kukovics (2001) this disease may be found in the goat herds of almost every country that imported breeding goats. The highest incidence of the disease is found in Switzerland and France, but the Netherlands also has a high incidence.

During the last decade breeding goats were imported into Hungary from France, the Netherlands and Germany and the CAE infections appeared in more and more farms. A study was started by the Research Institute for Animal Breeding and Nutrition in a co-operation with the Hungarian Goat Breeders' Association supported by the Biotechnology Award 2001 of the Ministry of Education to assess the extent of the problem.

The aim of the study was to establish

- the CAEV infection rate of the domestic goat population, the breed distribution, and , the origin of infection,
- whether difference could be demonstrated in the susceptibility of the goats by means of DNA tests,
- whether the expected differences could be used in the control of the disease,
- the effects of CAEV on production traits.

The first part of the research programme dealt with the assessment of the infection, and its effect on the production traits.

Materials and Methods

Several aspects were taken into consideration in the selection of the farms surveyed. The most important factors were the size (number of does), the breed, and the place (every county of the country). The

Peer-reviewed paper: 8th International Conference on Goats

goat sector is characterised by small farms (about 80% of the farms have less than 30 heads), therefore farms were selected from representatives: <10 (15 farms, 92 head), 11-30 (22 farms, 460 heads), 31-50 (13 farms, 544 head), 51-100 (21 farms, 1545 head), 101-200 (9 farms, 1528 head) and above 200 goats (3 farms, 928 head) – altogether 83 farms and 5077 goats. The selected farms represented all breeds and every county of the country.

Blood samples were taken from every animal and the samples were examined in the National Animal Health Institute using ELISA and AGID methods (Kukovics *et al*. 2003. a. and b.). Based on these results milk samples were taken 5 times during the lactation, 4 weeks apart, from sero-positive and sero-negative animals (about equal numbers on each farm) in order to determine milk composition (Table 1). The milk samples were examined by the official raw milk laboratory of the Animal Breeding Performance Examination Ltd (Gödöllő). Litter sizes of the does were also studied. Microsoft Excel and SPSS for Windows 6.5 software were used in the processing of the data.

Table 1 Breeds and numbers in the performance study

Breed		CAEV status	
		Negative (-)	Positive (+)
Alpine	(A)	72	18
Alpine crossbred	(AC)	6	12
Hungarian native	(H)	38	45
Saanen	(S)	84	31
Saanen crossbred	(SC)	17	5
Hungarian Milking Brown	(HMB)	240	51
Hungarian Milking White	(HMW)	178	46
Hungarian Milking Multicolour	(HMM)	131	41

Results and Discussion

We collected proper samples from 16 out of the total of 19 counties, and there were significant differences among them. In some counties we found no infected animals, while in several others the infection rate was quite high with as much as 30% of the animals testing positive. There was an apparent positive relationship between inflation rate and farm size (from 10 to 80%)

The CAEV infection rate amongst the various breeds was differed. The highest rate was observed in purebred and crossbred Saanen goats, while in Alpine and Boer populations it also exceeded expectation. In the Hungarian goats the infection rate varied between 8-15% (Kukovics *et al*. 2003. a and b). The herds with positive serological results had direct or indirect relationships with livestock importation from the abovementioned countries. Four Saanen, three Boer and two Alpine livestock imports carried out during the last 15 years were thought to be the origin of the infection. Several farms purchased the progeny of these animals to improve the production traits of their original goats, and the infection then appeared in many herds.

There were interesting differences among breeds. The length of milking period (Table 2.) was significantly longer in positive goats than negative ones in half of the breeds, and most of these were significant. The effect of CAEV infection on milk yield was also different from breed to breed. In three breeds (AC, H, SC) the positive goats produced more milk than the negative ones, but the advantage was significant only in one (H) breed. In other breeds, most of the differences were significant and the negative goats had the advantage.

Most of the differences between negative and positive goats on the daily milk yield were significant, and the positive ones had advantage only in three cases (H, SC, HMM). The negative goats had much higher daily milk yield in the other breeds. Differences were changed between 0.3 and 1.6 litres ($P<0.001$ in the case of A, AC, S and HMM breeds, while $P< 0.01$ in HMB, and $P< 0.05$ in HMW breed).

With one exception (HMM) in all breeds the negative animals had bigger litter size than the positive ones, however, the advantage was significant in only two breeds (S, HMW).

Our findings indicated that the CAEV infection did not have a consistent effect on milk components (Table 3.). In most of the breeds the positive animals had higher fat % in their milk, except breed (S) where the negative goats had a significant advantage ($P<0.01$). Quite small differences were observed between positive and negative goats in all studied breeds, except one (HMM), where the advantage of the positive

Peer-reviewed paper: 8th International Conference on Goats

ones was highly significant. In general, the lactose content was higher in the milk of negative animals, however, in the case of two breeds (SC, HMB) data of positive animals were higher.

The somatic cell count (SCC) data was very high in the milk of positive animals in every breed. The advantage of negative animals was general, but the difference was highly significant in only two cases (HMW, HMM).

Table 2 Milking performance and litter size related to CEAV infection

Breed / sero quality	Milking days		Milk yield (litre)		Daily milk yield (litre)		Litter size	
	–	+	–	+	–	+	–	+
A	167.2	157.7	482.9	202.2***	2.93	1.31***	1.80	1.72
AC	146.5	236.0***	438.6	464.6	3.10	1.90***	1.57	1.53
H	175.9	202.0**	320.7	413.9**	1.79	1.99+	1.76	1.67
S	160.0	189.6*	365.9	306.6	2.10	1.50***	1.85	1.55*
SC	180.4	196.4	423.6	451.8	2.26	2.28	2.00	1.80
HMB	180.2	162.9**	389.5	291.6***	2.14	1.76**	1.68	1.63
HMW	173.9	162.8	363.0	297.8*	2.04	1.77*	1.77	1.50**
HMM	181.4	168.9+	335.8	328.6	1.81	1.99***	1.57	1.58

+P<0.1; * P<0.05; **P<0.01; ***P<0.001

Table 3 Effect of breed and CAEV status on milk componentes

Breed / CAEV status	Fat %		Protein %		Lactose %		SCC (x 1000)	
	–	+	–	+	–	+	–	+
A	3.42	3.36	3.17	3.44*	4.62	4.60	1 915	3 460+
AC	3.94	3.50	3.32	3.30	4.59	4.42	683	1 291
H	3.04	2.97	3.40	3.33	4.71	4.56***	552	1 289+
S	4.25	3.12***	3.30	3.29	4.57	4.33*	1 956	2 418
SC	2.94	3.17	3.53	3.51	4.60	4.64	870	1 003
HMB	3.79	3.85	3.37	3.38	4.51	4.52	2 029	2 264
HMW	3.54	3.81*	3.39	3.47	4.56	4.51*	1 815	3 379***
HMM	3.69	4.12*	3.33	3.54***	4.56	4.44***	1 583	2 992***

+P<0.1; * P<0.05; **P<0.01; ***P<0.001

Conclusions

The following conclusions may be drawn from these preliminary results:

- 30% of the investigated population proved to be CAE-positive supporting the importance of the study, the level of infection varied county to county. The proportion of infected animals increases with the size of the herd. Some breeds (like Saanen) are much more affected, than others (like Hungarian Milking Goats) This indicates the necessity to examining the whole Hungarian goat population during the next year.
- The milk yield data were not equally effected by the infection, in some cases the positive animals had better results.
- The positive animals had a smaller litter size, in general, than the negative ones.
- The milk-composition of positive and negative animals was different. It was not possible to establish a clear trend, except the somatic cell count. In the case of fat, protein and lactose the advantage of positive or negative animals were varied from breed to breed.

References

Kukovics, S., 2001. A kecske és a CAE vírus /The goat and the CAEV/. In: Magyar Juhászat + Kecsketenyésztés /Hungarian Sheep-Farming + Goat Breeding/ (Hungary), 10 (9), 4-5.

Kukovics, S., Molnár, A., Ábrahám, M., Dani, Z., Kusza, Sz. & Fülöp, Gy., 2003a. Presence of CAEV infection in Hungarian goat industry as an effect of livestock import. In: Book of Abstracts; 54th Annual Meeting of EAAP, Rome, Italy, 31 August -03 September, 2003, No. 9. 320. pp.

Kukovics, S., Molnár, A., Ábrahám, M., Dani, Z., Kusza, Sz. & Fülöp, Gy., 2003b. Presence of CAEV infection in the Hungarian goat industry as an effect of livestock import. In: Buletinul, Universitatii de Stiinte Agricole Si medicina Veterinara, Seria Zootechnie si Biotechnologii, (Romania) ISSN 1454-2382, Volumul 59, 42-48. pp.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

The acaricidal effect of the essential oil of *Ageratum houstonianum* Mill. flowers on ticks (*Rhipicephalus lunulatus*) in Cameroon

Pamo T. E[1]., F. Tendonkeng[1], J.R. Kana[1], G. Tenekeu[2]., L. A. Tapondjou[2] and V. Khan Payne[3]

1-Animal Nutrition Laboratory, Department of Animal Production, FASA, University of Dschang. P.O. Box.: 222 Dschang, Cameroon.

2-University of Dschang, Faculty of Sciences, Department of Chemistry, P.O. Box 67 Dschang, Cameroon.

3- University of Dschang, Faculty of Sciences, Department of Animal Biology P.O. Box 67 Dschang, Cameroon

Abstract

The acaricidal effect of essential oil of the flowers of *Ageratum houstonianum* on *Rhipicephalus lunulatus* was tested in the Laboratory of Parasitology of the University of Dschang in the Western Highlands zone of Cameroon. Five doses of the essential oil (0.00, 0.016, 0.031, 0.062 and 0.125µl/cm^2) in four replicates were used. Each replicate consisted of ten ticks in a Petri dish with filter paper on the base of the dish uniformly impregnated with the product. The results of this study indicate that essential oil of the flowers is toxic to *lunulatus* ticks. The mortality after six days of exposure in the control group was 10% while the tested doses had exterminated the ticks. The LD_{50} was 0.06653µl/cm^2 at the end of the first day indicating a potentially high efficiency of this product on this parasite.

Keywords: *Rhipicephalus lunulatus*, *Ageratum houstonianum*, acaricide, essential oil, flowers, LD_{50}, West African Dwarf goat.

[#]Corresponding author; E-mail: pamo_te@yahoo.fr / pamo-te@excite.com

Introduction

Ruminant husbandry constitutes one of the farming principal activities in most African countries in general and in Cameroon in particularly. Unfortunately, these animals depend essentially on natural pasture for their diet and are exposed to numerous constraints including disease, which affect growth (Lhoste *et al*., 1993; Pamo *et al*., 2003). Amongst these diseases, parasitic infestations are very common in the tropics where the environment provides favourable conditions for their development (Ukoli, 1984; Pamo *et al*., 2000). External parasites such as arthropods especially ticks feed on blood and transmit many diseases (IEMVT, 1989) which are complex to diagnose.

The control of ticks under commercial production systems is through the use of acaricides while small holder farmers generally remove the ticks manually or use medicinal plants. Some tick populations have developed resistance to most acaricides (Barnett, 1961; Wharton, 1976; Hall, 1982; Ukoli, 1984).

The large-scale use of synthetic insecticides has resulted in serious negative effects on man, animals and the vegetation (Knipling, 1952; Fivaz *et al*., 1992) with enormous consequences on the agricultural environment. The effects of the parasites on animal hinders the development of cost-effective animal production in environments where they occur can severely affect profitability. Losses due to ticks in both tropical and temperate environments have been estimated to amount to several hundred million dollars per year (Soulsby, 1982). It is therefore necessary to look for alternative measures which are adaptable and less expensive especially for the subsistence farmers with limited capital and who constitute the majority of animal rearers in Cameroon as well as in most of the sub-Saharan region.

The bark, fruits, roots and flowers of many plants contain therapeutic substances such as tannins and alkaloids (Lhoste *et al*., 1993). Essential oils have various biological activities including healing, antiseptic, anti-inflammatory, antipyretic, antispasmodic, insecticidal, bactericidal and fungicidal (Kuiate, 1993; Pamo *et al*., 2003). Herbal medicine is a cheap form of therapy and many plant products have been reported to be very effective (Lhoste *et al*., 1993). In view of this, a research programme in the University of Dschang, Cameroon, was therefore set up to study the possible acaricidal effects of some local plants.

Peer-reviewed paper: 8th International Conference on Goats

The results which are reported here arise from an investigation into the effects of essential oils from *A. houstonianum* flowers on ticks (*Rhipicephalus lunulatus*) of West African Dwarf goats.

Materials and Methods

Previous works carried out at the University of Dschang indicated that the essential oils of flowers of *A. houstonianum* was toxic to insects of crops in storage such as *Tribolium confusum* and *Collosobruchus maculatus* (Pidjou, 1999). In addition, the bark of this plant is traditionally used to cure several diseases. In view of these facts, it was therefore thought necessary to test the essential oil on West African Dwarf goat ticks.

The work was carried out in Dschang which has an altitude of about 1420m, 5°26 N and 10°26 E. The climate is typically equatorial with a long wet season (mid March -to mid November) and a short dry season (mid November to mid -March). The flowers of *A. houstonianum* were collected in the University of Dschang Campus and its surroundings. They were transported to the analytical chemistry laboratory for extraction.

The flowers of *A. houstonianum* were put into a 2 litre water flask containing distilled water. Hydrodistillation was carried out for 10 hours using a modified Clevenger apparatus. The essential oil collected was dehydrated with anhydrous sodium tetrasulphate and the resulting clear yellowish product with a strong and persistent odour was preserved at room temperature in the dark. The principal constituents of the essential oil were identified by GC-MS using a HP 5890 II gaseous phase chromatograph coupled with a HP 5972 mass selective spectrophotometer and a DBwax capillary column (60m x 0.25mm). The furnace was regulated at temperatures from 60° to 220°C at a speed of 5°C per minute. Helium was the gas vector, the rate of flow was 0.9ml per minute, the injection temperature 230°C and that of the interphase 240°C.

The different volatile components were identified by comparing their mass spectra and/or their retention rate to the standard reference of the Institut Für Getreide Verarbeitung Gmbh of Berlin, Germany. The quantification of each component was determined by integrating its peak on the spectrum of the gaseous phase chromatograph.

Ticks of the genus *Rhipicephalus*, which infest ruminants in the Western Highlands of Cameroon, were carefully collected from the goats in the University of Dschang Experimental Farm and the surroundings. The ticks collected were approximately 4.09mm in length, flat, and had not gorged. They were fixed with ethyl acetate and identification was carried out as described by Walker *et al*. (2002).

After several preliminary tests, 4 doses were adopted for use and prepared by diluting in 1ml of acetone 1, 2, 4 and 8µl of the product. Each dose was uniformly spread with the aid of a micropipette on a round Whatman filter paper (63.62cm^2). After complete evaporation of the solvent after 20 minutes: 0.016, 0.031, 0.062 and 0.125µl/ cm^2 doses were obtained on each filter paper. Filter papers impregnated with solvent (acetone) were used as control.

Each treatment dose consisted of 4 replicates, each made up of 10 non-sexed ticks selected randomly and introduced into a Petri dish. The toxic effect of the essential oil on the ticks was evaluated in the laboratory at 24°C and 70% relative humidity. Daily mortality rates for 8 days were calculated using the Abbott formula (Abbott, 1952).

$$M_c = \frac{M_o - M_t}{100 - M_t} \times 100$$

M_c = Corrected mortality rate
M_o = Mortality rate in treated dishes
M_t = Mortality rate in control dish (natural mortality)

Analysis of variance (McClave and Dietrich II, 1979) was carried out on the data and difference between treatment when significant separated using Duncan Multiple Range test. The logarithmic regression of the doses and the probit were used to determine the LD_{50} of the product.

Results and Discussion

The extraction yield of the essential oil was 0.2% and the principal chemical components are presented in Table I. Precocen I (48.01%) and Precocen II (36.55%) are the major substances in the oil. Figure 1 summarises the corrected cumulative mortality of *Rhipicephalus lunulatus* for the different doses during the experimental period. The mortality increased with increased doses and also

Peer-reviewed paper: 8th International Conference on Goats

in the course of time (day), reaching a maximum of 100% on the fifth day with the group on the highest dose (0.125µl/ cm^2) and sixth day with the group with the lowest dose (0.016µl/ cm^2).

Table I: Principal chemicals constituents of the essential oil in *Ageratum houstonianum.*

Name of components	Percentage (%)
Demethoxy ageratochromene (Precocen I)	48.01
Ageratochromene (Precocen II)	36.55
β-caryophyllen	8.37
Germacrene D	2.34
Acetate of bornyl	2.29
β-cubebene	1.22
β-farnesene	0.66

The essential oil of *A. houstonianum* flowers was toxic to *lunulatus.* On the fifth day of exposure, the highest doses had killed all the ticks, producing a significantly ($P<0.05$) different result between the group with the highest dose (0.125µl/ cm^2) and the other treatment group. There was no significant ($P>0.05$) difference in the mortality observed between the groups on 0.016µl/ cm^2 and 0.031µl/ cm^2 doses. The same result was recorded between the mortality recorded with doses 0.031 and 0.061µl/ cm^2. Irrespective of the dose used, the mortality observed among the treatment groups on the fifth day was significantly ($P<0.01$) higher than that of the control group.

The transformation in the profit of mortality rates after the first day of exposure were determined and the regression of the data obtained based on the logarithm of the doses gave the following equation:

$Y = 1.1641x + 6.3701$ ($R^2 = 0.9752$) and the LD_{50} calculated was 0.06653µl/ cm^2.

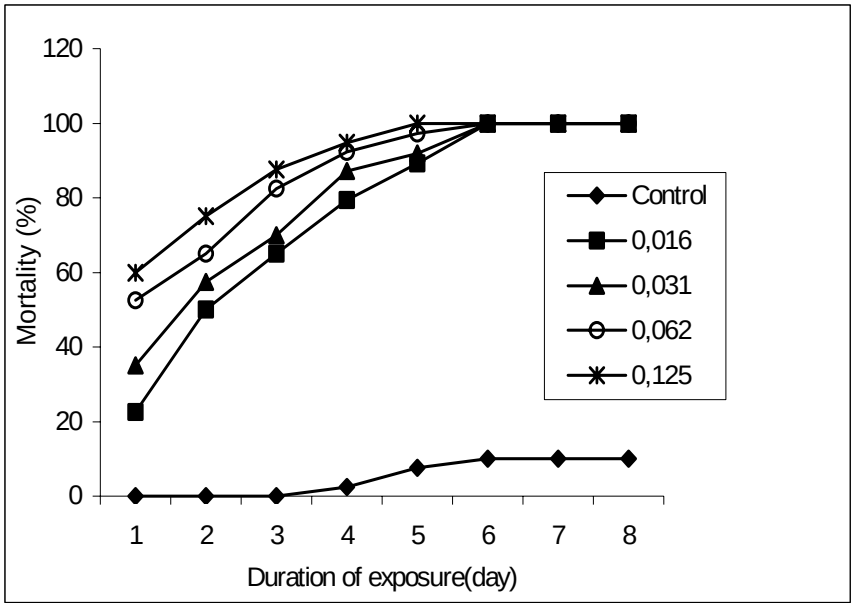


Figure 1: Effect of essential oil (µl/cm^2) of A. *houstonianum* on *R. lunulatus.*

Following chemical analysis (Table I) Precocens I and II are the most important components of the essential oil. The toxicity of the oil to *lunulatus* may be attributed to these 2 substances or to a synergistic interaction between these components and the other constituents of the essential oil. These results are in agreement with those of Pamo *et al.* (2003) working with the leaves of the same plant. Bowers *et al*. (1976) noticed that adult insects coming into contact with the Precocens became sterile while there is early metamorphosis among the immature insects and immediate death of the premature adults. It is possible that these compounds have similar actions on the ticks. The metabolism of insects

activates the Precocens leading to production of epoxyde which reacts with the proteins of "corpora allata" destroying them. The Precocens are highly specific chemical substances, which attack certains areas of the insect endocrine system causing not only toxic effects but also disturbing the development process and reproduction.

Conclusion

It appears that the essential oil from *A. houstonianum* flowers has a toxic effect on ticks of the genus *Rhipicephalus*. The mortality rate increases with dose and time. Irrespective of the treatment there was 100% mortality after six day of exposure. The LD_{50} calculated was 0.06653µl/ cm^2 on the first day of exposure.

References

Abbott, W. S., 1952. A method for computing the effectiveness of an insecticide. *J. Econ. Entomol*. 18, 265-267.

Barnett, S. M., 1961. The control of ticks on livestock. FAO Agricultural studies, n° 54, 106p.

Bowers, W. S., Ohta, T., Cleere, J. S. and Marsella, P. A., 1976. Discovery of insect anti-juvenile hormone in plants. *Science*, 193, 542-547.

Fivaz, B. H., De Waal, D. T. and Lander, K., 1992. Indigenous and crossbred cattle. A comparison of resistance to ticks and implication for their strategic control in Zimbabwe, *Trop. Anim. Health & Prod*. 24, 81-89.

IEMVT (Institut d'élevage et de Médecine Vétérinaire des Pays Tropicaux)., 1989. Elevage du mouton en zone tropicale humide. Ministère de la Coopération et du Développement. Paris, France.

Hall, H. T. B., 1982. Diseases and parasites of livestock in the tropics, 2nd ed. Longman Scientific & Technical Intermediate Tropical Agriculture series. 328p.

Knipling, E. F., 1952. Ticks, lice, sheep kids, mites. *In* : Insect. The yearbook of agriculture, United States Government Printing Office. Pp 662-666.

Kuiate, J. R., 1993. Détermination des teneurs, des proprétés chimiques et des activités antimicrobiens des huiles essentielles de quelques Astéracées utilisées en médecine traditionnelle au Cameroun. Thèse de Doctorat de 3e cycle, Université de Yaoundé I. 217p.

Lhoste, P., Dolle, V., Rousseau, J. et Soltner, D., 1993. Manuel de zootechnie des régions chaudes. Les systemes d'élevage; Collection précis d'élevage, Ministère de la Coopération. Pp 18-218.

Mc Clave, J. T., and Dietrich II, F. H., 1979. Statistics. Dellen Publishing Compagny, San Francisco, California. 681p.

Pamo, T.E., Mpoame, M. et Sonchieu, J., 2000. Infestations parasitaires gastro-intestinales précoces chez la Chèvre Naine de Guinée (*Capra reversa)* à Dschang dans l'Ouest-Cameroun. Revue. *Elev.Méd.vét Pays trop*. 53 (4), 333-336.

Pamo, T.E., Tapondjou, L., Tendonkeng, F., Nzogang, J.F., Djoukeng, J., Ngandeu, F. et Kana, J.R., 2003. Effet des huiles essentielles des feuilles et des extremites fleuries de *Cupressus lusitanica* sur la tique *Rhipicephalus lunulatus* à l'Ouest-Cameroun. *Revue de l'Academie des Sciences du Cameroun*, 3 (3), 169-175.

Pidjou, T. L. B., 1999. Composition chimique et effet insecticides des extraits de tiges de *Ageratum houstonianum.* Mémoire de Maîtrise de chimie, Université de Dschang, Cameroun. 35p.

Soulsby, E. J. L., 1982. Helminths, Arthropods and Protozoa of domesticated animals. Baillière Tindall, London. 809p.

Ukoli, F. M. A., 1984. Introduction to parasitology in tropical Africa. John Wiley and sons LTD, Chichester, New york, Brisbane, Toronto, Singapore. 464p.

Wharton, R. H., 1976. Les maladies du bétail transmises par les tiques et leurs vecteurs. Résistance aux acaricides. *Revue Mondiale de Zootechnie*, FAO. 20, 8-15.

Walker J. B., Keirans J. E. and Horak I. G., 2002. The genus Rhipicephalus (Acari, Ixodidae): A guide to the brown ticks of the world. Cambridge University Press. 655p.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Effects of feeding sericea lespedeza hay to goats infected with *Haemonchus contortus*

S.A. Shaik[1], T.H. Terrill[1#], J.E. Miller[2], B. Kouakou[1], G. Kannan[1], R.K. Kallu[1] and J.A. Mosjidis[3]
[1]Fort Valley State University, Fort Valley, GA 31030, USA
[2]Louisiana State University, Baton Rouge, LA 70803, USA
[3]Auburn University, Auburn, AL 36849, USA

Abstract

Infection with gastrointestinal nematodes (GIN) is a primary constraint to economic goat production in the southern USA. Anthelmintic resistance is highly prevalent in goat nematodes in this region, and non-chemical control methods are needed. Grazing of forages containing condensed tannins (CT), or feeding purified CT as part of the diet has shown potential for reducing parasite egg counts in feces of sheep and goats, but little information is available on feeding hay from CT-containing forages. The anthelmintic potential of sericea lespedeza [*Lespedeza cuneata* (Dum-Cours.) G. Don] hay was evaluated in an 8-week feeding trial with goats. Twenty yearling Spanish-cross does were given a single challenge of 10,000 *Haemonchus contortus* infective (L3) larvae to boost their naturally acquired parasite load. After 3 weeks grazing, the does were moved to pens (5 animals per pen) and fed either ground sericea or bermudagrass [*Cynodon dactylon* (L.) Pers.] hay diets (treatment n = 10) balanced for crude protein and energy with a small amount of supplement. All 20 does were fed the bermudagrass diet for a 1-week adjustment period, after which 2 pens of animals were switched to the sericea diet for 4 weeks (trial period). All the does were then fed the bermudagrass diet for an additional 3 weeks. Throughout the experiment, worm egg counts (FEC; fecal egg count) were done weekly for each doe. Egg shedding was similar between the two groups prior to feeding the treatment diets, significantly lower ($P < 0.05$) in sericea-fed goats during the 4-week trial period, and again similar during the 3-week post-trial period. Feeding sericea lespedeza hay to goats reduced nematode egg shedding and may have potential to reduce pasture contamination from GIN larvae.

Keywords: *Haemonchus contortus*, sericea lespedeza, goats, condensed tannins.
[#]Corresponding Author; Email: terrillt@fvsu.edu.

Introduction

In the southern USA, goat production for meat or milk is an attractive alternative enterprise for farmers because of the comparatively low cost of breeding stock, high reproductive rate of goats, and their ability to thrive on native pastures or brushland that is unsuitable for cropping (Glimp *et al*., 1986). In addition, the high ethnic demand for goat meat and milk products, particularly in large metropolitan areas in the USA, is exceeding current production levels. Despite the increasing demand, growth of the goat industry in the southern USA has been slow. The major hindrance to economic goat production in this region is infection with GIN, particularly *Haemonchus contortus*. The conventional method of GIN control by farmers in the Southeast is regular use of anthelmintics, sometimes monthly or more often during the warm season. Overuse and/or misuse of anthelmintics has led to increased anthelmintic resistance in GIN of goats, sheep, and cattle in many parts of the world (Prichard, 1994), and recent reports from Virginia (Zajac & Gipson, 2000) and Georgia (Mortensen *et al*., 2003) indicate that anthelmintic resistance in goats has become highly prevalent in the southern USA.

In many parts of the world the use of plants with anthelmintic properties is being considered as an alternative to anthelmintic drugs. Grazing forages high in tannins or adding purified CT to the diet has been shown to reduce numbers of parasite eggs in sheep and goat feces in a number of studies (Niezen *et al*., 1998; Athanasiadou *et al*., 2000; Min & Hart, 2003; Paolini *et al*., 2003a). However, there have been very few reports on anthelmintic effects of feeding hay from CT-containing forages, although Paolini et al (2003b) reported lower egg counts in feces of goats fed sainfoin (*Onobrychis viciifolia* Scop.) hay, compared with grass hay. The purpose of the current study was to test for potential anthelmintic effects of feeding sericea lespedeza hay to goats.

Peer-reviewed paper: 8th International Conference on Goats

Materials and Methods

A study was completed at the Fort Valley State University Agricultural Research Station, Fort Valley, GA., USA, from October-December, 2003. Twenty yearling Spanish x Boer x Kiko cross does were randomly assigned to two treatment groups of 10 goats each based on FEC. One group was fed a diet of coarse-ground sericea lespedeza hay and the other with bermudagrass hay in an 8-week confinement study. The diets were balanced for protein and energy with a small amount of supplement (ground corn, soybean meal poultry fat, trace mineral salt and vitamin premix). The diets comprised approximately 80 % hay and 20 % supplement by weight. Prior to starting the trial, the does acquired a low-level natural GIN infection (< 200 FEC; 97 % *H. contortus*) by grazing native pasture for approximately 6 months. Three weeks before moving the does to the pens (2 pens of 5 animals each for each treatment), the infection levels of the does were boosted by a single drench of 10,000 *H. contortus* larvae per animal.

Upon entry into feeding pens, all the goats were fed ground bermudagrass hay during a 7-day adjustment period, after which two pens of goats were switched to the sericea hay ration. After four weeks on the experimental rations, all of the goats were again given the bermudagrass ration for an additional 3 weeks. The goats were given a small amount of concentrate (as required to balance the two rations for crude protein and energy) daily throughout the trial, with *ad libitum* access to hay and water. The concentrate feeding was held constant, while the hay ration for each pen was adjusted daily to allow 10 % uneaten feed. Throughout the 8-week experiment, FEC was monitored in all does on a weekly basis.

Fecal egg count data was analyzed by repeated measures analysis (SAS, 1992). The pre-trial (sampling dates 1-3), trial (sampling dates 4-8), and post-trial (sampling dates 9-11) periods were analyzed separately.

Results

Haemonchus egg counts were similar between the two groups during a 3-week pre-trial period (Table 1). During the 4-week trial period, treatment, time, and treatment x time effects were all significant ($P < 0.05$). FECs were lower ($P < 0.05$) in the *sericea*-fed group, with the difference increasing in size over time. After the sericea-fed goats were switched back to bermudagrass, there were no significant differences in FECs during weeks 9-11, although they were numerically lower in animals previously fed sericea.

Table 1 Worm egg counts in naturally infected goats given an artificial booster infection of *H. contortus* larvae and fed diets of ground sericea lespedeza or bermudagrass hay and a small amount of concentrates.

	Sampling times (weeks after parasite challenge)[1]									
	Pre-trial Period[2]			Trial Period[3]					Post-trial Period[4]	
Diet	1	2	3	4	5	6	7	8	9	11
	Parasite eggs per gram of feces									
Bermudagrass hay + concentrates	300	179	321	179	357	221	436[a]	5150[a]	1314	514
Sericea lespedeza hay + concentrates	238	263	88	207	107	64	36[b]	729[b]	233	0
Standard error	139	106	185	49	182	57	85	1239	530	337
Prob for TRT main effect	0.76	0.59	0.40	0.69	0.35	0.08	0.01	0.03	0.20	0.32

[1]A separate statistical analysis was completed for each period.
[2]Goats grazed on pasture for three weeks, moved into pens after week 3, fed bermudagrass diets for 1 week.

Peer-reviewed paper: 8th International Conference on Goats

[3]Half the animals switched to sericea diet after week 4, through week 8.
[4]After week 8, all animals switched back to bermudagrass diets through week 11.
[a,b]Column means with unlike superscripts differ significantly ($P < 0.05$).

Discussion

Grazing of tannin-containing forages has been suggested as an alternative to chemical anthelmintics for controlling gastrointestinal nematodes in both sheep and goats (Niezen *et al*., 1998; Min & Hart, 2003). There are limitations to this approach, however, particularly the lack of suitable pasture forages that contain considerable levels of CT. Based on the results of the current study, feeding hay of CT-containing forages to control parasitic nematodes appears to be a viable alternative to grazing CT forages for goats. Feeding hay may also allow these benefits to be realized with other species, such as cattle, sheep, or horses, although this remains to be tested. Cattle and sheep do not like to graze sericea lespedeza, but readily consume it as hay (Terrill *et al*., 1989).

Although goats fed the sericea hay had lower FECs than those fed bermudagrass hay, these differences were not significant after sericea feeding had stopped, suggesting a greater effect on worm fecundity than on worm numbers. This is supported by the work of Min & Hart (2003), who reported reduced FEC in goats grazing sericea lespedeza, but that was quickly lost when the animals were switched to tall fescue (*Festuca arundinacea* Schreb.) pastures. In contrast, Paolini *et al* (2003b) reported that FEC remained lower in goats fed hay from sainfoin, compared with grass hay for two weeks after sainfoin hay feeding had been stopped. These authors suggested a possible effect on worm numbers. The animals used in the current study were from our breeding herd and could not be slaughtered for worm counts. Reduced fecundity could have a large effect on reducing pasture contamination, however. Potential anthelmintic properties of sericea lespedeza hay in goats needs to be tested when fed as a supplement to naturally-infected animals under grazing conditions.

Conclusions

Feeding hay of sericea lespedeza to goats reduced gastrointestinal parasite egg counts, compared with FECs of goats fed bermudagrass hay, and may be an effective means of reducing egg shedding on pasture. Evaluation of the anthelmintic potential of feeding hay of CT-containing forage to grazing goats is needed.

References

Athanasiadou, S., Dyriazakis, I., Jackson, F., & Coop, R.L., 2000. Consequences of long-term feeding with condensed tannins on sheep parasitized with *T. colubriformis*. Int. J. Parasitol. 30, 1025-1033.

Glimp, H.A., Ospina, E., & Yazman, J., 1986. Strategies for expanding goat meat production, processing, and marketing in the southeastern US. Winrock International. Morrilton, AR.

Min, B.R., & Hart, S.P., 2003. Tannins for suppression of internal parasites. J. Anim. Sci. 81(E. Suppl. 2), E102-E109.

Mortensen, L.L., Williamson, L.H., Terrill, T.H., Kircher, R.A., Larsen, M., & Kaplan, R.M., 2003. Evaluation of prevalence and clinical implications of anthelmintic resistance in gastrointestinal nematodes in goats. JAVMA 223, 495-500.

Niezen, J.H., Roberson, H.A., Waghorn, G.C., & Charleston, W.A.G., 1998. Production, faecal egg counts and worm burdens of ewe lambs which grazed six contrasting forages. Vet. Parasitol. 80, 15-27.

Paolini, V., Bergeaud, J.P., Grisez, C., Prevot, F., Dorchies, P., & Hoste, H., 2003a. Effects of condensed tannins on goats experimentally infected with *Haemonchus contortus*. Vet. Parasitol. 113, 253-261.

Paolini, V., Dorchies, P., & Hoste, H., 2003b. Effects of sainfoin hay on gastrointestinal nematode infections in goats. Vet. Record 152, 600-601.

Peer-reviewed paper: 8th International Conference on Goats

Prichard, R., 1994. Anthelmintic resistance. Vet. Parasitol. 54, 259-268.

SAS Institute, 1992. SAS/STAT Software: Changes and enhancements, Release 6.07, SAS Technical Report, SAS Institute Inc., Cary, N.C.

Terrill, T.H., Windham, W.R., Evans, J.J., & Amos, H.E., 1989. Forage preservation method influences on tannin concentration, intake, and digestibility of sericea lespedeza by sheep. Agron. J. 81, 435-439.

Zajac, A, & Gipson, T.A., 2000. Multiple anthelmintic resistance in a goat herd. Vet. Parasitol. 87, 163-172.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

The effects of five anthelmintic treatment regimes on milk production in goats naturally infected by gastrointestinal nematodes

V. Veneziano[1] , R. Rubino[2], V. Fedele[2], L. Rinaldi[1], M. Santaniello[1], M. Schioppi[1], C. Cascone[1], M. Pizzillo[2] and G. Cringoli[1#]

[1]Dipartimento di Patologia e Sanità Animale, Facoltà di Medicina Veterinaria, Università degli Studi di Napoli "Federico II" - *CREMOPAR*, Regione Campania, Napoli, Italy;
[2]Istituto Sperimentale per la Zootecnia, Bella Scalo, Potenza, Italy.

Abstract

A study was carried out in Southern Italy on 90 Siriana breed goats with naturally occurring infections of gastrointestinal nematodes. Six similar groups of 15 goats were formed, one untreated control group and five groups treated once with ivermectin (I treatment) and once with netobimin (II treatment) at different times. Daily milk volume (ml) was recorded fortnightly for each animal for the whole lactation period. All the treated groups showed a total milk production that was statistically higher than that of the control group, and four of these groups showed at least one fortnightly measurement in which differences from the corresponding values of the control group were statistically significant ($P<0.05$). The best treatment timing seemed to be October-May, followed by February-June, December-May, and February-May.

Keywords: Goat-helminths; nematode control; milk production; dosing programme
[#]Corresponding author; E-mail: cringoli@unina.it.

Introduction

Gastrointestinal nematodes (GIN) are the most serious problem affecting goat production worldwide (Pugh et al., 1998). The assessment of losses caused by GIN in a given region, is imperative for the establishment of sustainable control methods. In dairy goats GIN infection is strongly associated to grazing management and the intensity of faecal egg excretion is negatively correlated to milk production, live weight gain and general farm productivity (Chartier *et al.*, 2000; Faizal *et al.*, 2002). Hence GIN control is of particular economic importance in goat production systems worldwide.

The present study was conducted over a period of a year to compare the benefit of 5 different timings of anthelmintic treatments on milk production of Siriana goats with natural GIN infection.

Materials and Methods

Study farm and flock parasitological status - A native herbaceous pasture in a Basilicata valley, Southern Italy (40°21' N and 15°30'25'' E) at 360 m above sea level was used for this study at the Istituto Sperimentale per la Zootecnia - Bella, located in Potenza province. With about 70 % of the annual rainfall of 450 - 700 mm falling in winter and temperature ranges of -6 to 8 °C in winter and 32 °C in summer, the botanical composition changes considerably from one season to another. Grasses (particularly *Lolium perenne, Dactylis glomerata* and *Bromus* spp.) predominate in winter and autumn, these species and legumes (*Medicago polimorpha*, *Trifolium repens*, and *Vicia* spp.) in spring, and forbs (*Ranunculus bulbosus*, *Asperula odorosa*, *Daucus carota*, *Geranium molle*, etc.) especially during summer. The goats grazed for eight hours/day and were supplemented with concentrate (15% CP, 42% NDF), corresponding to 50% of energy requirements. The most dominant GIN observed in the goats of this farm were *Teladorsagia circumcincta*, *Haemonchus contortus*, *Trichostrongylus colubriformis* and *Oesophagostomum venulosum* (Cringoli *et al.*, 2004).

(*Study animals and treatments*) - The study was carried out on a total of 90 female Siriana goats, from 2 to 4 years old and 40-50 kg body weight; all goats kidded towards the end of February and the beginning of March, 2003.

Six similar groups were formed for age, milk production, weight, and positive GIN faecal egg counts and randomly assigned to six groups of 15 animals, one untreated control group and five groups treated once with ivermectin (Oramec™, Merial - I treatment) and once with netobimin

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

(Hapadex™ 5%, Shering-Plough - II treatment) as follows: Oct-May (treated in October and May); Dec-May (December and May); Feb-May (February and May); Feb-Jun (February and June) and Feb-Jul (February and July). The dates of treatments in 2002 were 29 October and 13 December, and in 2003, 11 February; 27 May; 26 June; and 26 July.

As suggested by Chartier & Hoste (1997) and Silvestre *et al*. (2002), ivermectin and netobimim were administred per os at the dose rate of 0.4 mg/Kg body weight and 15 mg/Kg body weight, respectively, i.e. twice the therapentic dosages recommended for sheep. The goats of the control group were subjected to the same handling procedures as were those that were treated. A paddock pasture with similar characteristics was used for each group. From the end of November to the end of February the goats were housed because of the adverse climatic conditions, even though they were let out onto pasture on some days towards the end of December.

(Coprological examinations) - Faecal egg counts were performed on each study animal at the start of the trial (October) and fortnightly from February to the end of the study (summarised to monthly averages in the figure below). The counts were done using a modified McMaster technique (M.A.F.F., 1986) and with a sucrose flotation medium (specific gravity = 1.250), at a sensitivity of 10 eggs per gram (epg) of faeces.

(Milk production) - Daily milk volume (ml) was recorded for each animal and the mean per group calculated for each fortnight for the lactation period (May 2003-October 2003) after the kids.

(Data analysis) – While geometric mean value were calculated per group, per sampling day for epg counts after these had been transformed to natural logarithms (ln (x+1), arithmetic means were used for statistical comparisons of milk yields (ml).

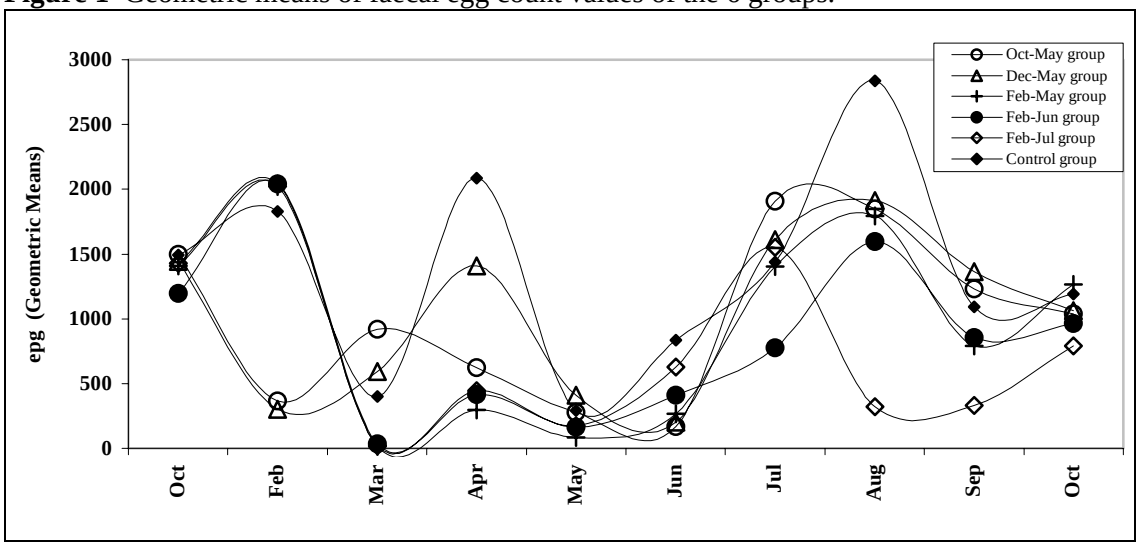
As an indication of the best timing of anthelmintic treatment for maximum milk production, milk values of trial groups were tested for significant differences ($P<0.05$) by analysis of variance, using the following model in the GLM procedure (General Linear Model) of SPSS (SPSS 11, 2000):

Milk production model: $Y_1 = I_1 + Cm + Cp + Gn$, where: I_1 = Intercept; Cm = Covariate milk production in 12/05/03; Cp = Covariate epg value in 29/10/02 ; Gn = Groups (n = 1…6). Covariates were used in order to balance initial differences among groups.

Results and Discussion

The results of the faecal egg counts are summarized in Fig.1.

Figure 1 Geometric means of faecal egg count values of the 6 groups.



Both ivermectin and netobimin treatments were effective against GIN at the dose rates used.

The results of the fortnightly milk production of each of the 6 groups over the study are shown in Table1.

South African Journal of Animal Science 2004, 34 (Supplement 1)

Peer-reviewed paper: 8th International Conference on Goats

Table 1 – Arithmetic means of fortnightly milk production (ml) of the 6 study groups.

Groups	May 12	May 27	Jun 11	Jun 26	Jul 11	Jul 26	Aug 10	Aug 25	Sep 10	Sep 24	Total milk production
Oct-May	1411	765	945*	965*	802*	505	432	400*	395	381	7001*
Dec-May	944	554	612	692	639*	434	360	500*	475	433	5643*
Feb-May	1467	700	928	864	550	518	417	454*	435	360	6693*
Feb-Jun	1451	898	982	914	839*	786*	636	518*	450	467	7941*
Feb-Jul	1491	859	856	787	646	424	412	450	400	290	6615*
Control	909	479	387	393	288	320	320	250	240	225	3811

*P<0.05

Although all the treated groups showed a total milk production higher than the control group (P< 0.05), only a few of the differences between fortnightly values of the various groups were statistically significant. Among the five treated groups, the Oct-May group showed the greatest number (n. = 4) of milk production values that were significantly higher (P<0.05) than the corresponding ones of the control group. Similarly, there were three such cases in the Feb-Jun group. For both the above groups the significant differences commenced shortly after the second treatment. Only a few random differences between treated and control group values occured in the case of the Dec-May and Feb-May groups and none for the Feb-Jul group.

Conclusions

In the present study of goats naturally infected with GIN, each of the five trial groups receiving two anthelmintic treatments produced significantly more milk than the untreated groups, and in four of these groups at least one of the fortnightly sets of measurements was significantly higher than the corresponding value of the control group. The best timing of treatment seemed October - May, followed by February – June, December-May, and February - May. The second treatment performed either in May or June, which is the common lactating period of goats in southern Italy, as well as in many other zones, seemed imperative. For these reasons, the availability of anthelmintics with negligible milk residues for goats during the lactating stage would be of great assistance to dairy goat farmers.

References

Chartier, C. & Hoste, H., 1997. La thérapeutique anthelminthique chez les caprins. Point Vet., 28, 1907-1914.

Chartier, C., Etter, E., Hoste, H., Pors. I., Mallereau., M.P., Broqua, C., Mallet, S., Koch, C., Masse, A., 2000. Effects of the initial level of milk production and of the dietary protein intake on the course of natural nematode infection in dairy goats. Vet. Parasitol. 92, 1-13.

Cringoli, G., Rinaldi, L., Veneziano, V., Capelli, G., Rubino, R., 2004. Effectiveness of eprinomectin pour-on against gastrointestinal nematodes of naturally infected goats. Small Rum. Res., paper accepted for publication.

Faizal, A.M.C., Rajapaksha, W.R.A.K.J.S., Rajapakse, R.P.V.J., 2002. Benefit of the control of gastrointestinal nematode infection in goats in the dry zone of Sri Lanka. J. Vet. Med. 49, 115-119.

M.A.F.F., 1986. Manual of veterinary parasitological laboratory techniques, Ministry of Agriculture, Fisheries and Food, Reference book 418, H.M.S.O., London, 5 and 36 pp.

Pugh, D.G., Mobini, S.M., Hilton, C.D., 1998. Control programs for gastrointestinal nematodes in sheep and goats. Comp. Cont. Ed. Pract. Vet. 20, S112-S123.

Silvestre, A., Leignel, V., Berrag, B., Gasnier, N., Humbert, J.F., Chartier, C., Cabaret, J., 2002. Sheep and goat nematode resistance to anthelmintics: pro and cons among breeding management factors. Vet. Res. 33, 465-480.