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Differences in Milk Yield and Composition of Different Goat Breeds Raised in the Same Environment in South Africa

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Abstract: This study investigated milk yield and composition of four different breeds of goat (Indigenous, British alpine, Toggenburg and Saanen) in South Africa. The experiment was a one way (feeding system) analysis of variance in complete random design where eight replicates were randomly selected from each group. As from kidding up to 8 weeks onwards, a weekly single hand-milking collection was performed on each goat; milk yield and body condition score were recorded while milk samples were analyzed on milk fat percentage, milk lactose and milk proteins concentrations. Data were tested for normal distribution and homogeneous treatment variances. Results showed that milk yield from dairy goats were unsurprisingly higher than that of the indigenous goats during the entire period of study. Milk lactose values (3.9-4.9%) confirmed milk lactose as the most stable constituent of the goat's milk. Milk protein concentration (3.1-4.5%) was significantly higher in the indigenous goats than in dairy breeds, especially on week 1 and from week 4 onwards. Milk fat percentage (3.3-7.7%) values displayed a decline in all goats but from week 3 they showed an increase in indigenous goats and from week 5 onwards, they were significantly higher in indigenous goats than in dairy breeds. The superiority of dairy breeds in milk yield was once more time proved while the indigenous goat merit in milk quality was recognized.

Key words: Dairy goats, milk yield, milk lactose, milk proteins, milk fat percentage, body condition score

INTRODUCTION

Interest in the milking goats has increased considerably during the last 5 years in the world (Ahuya *et al*., 2009). The increased interest in the milking goat has prompted in Africa, the question on the milking ability of the indigenous goat. The rationale behind this question is that local resources used in feeding strategies aimed to support food security and food safety locally are always better than imported products which are often costly, unsustainable and not always adapted to real needs. The aim of this research was to establish which South African available breed is best suited to the rural environment and endeavours to evaluate the merit (if any) that can be attributed to the indigenous goat. In the process, body condition score and milk yield were recorded while milk samples were analyzed on milk lactose, milk fat percentage and milk protein concentration. These parameters are important in the dairy industry because in Africa more specifically, milk is sold as per volume basis whence the relevance of identifying high-milk yielding goats. On the reverse, the industry pays a premium for milk fat and milk proteins concentrations as these technically reflect the milk quality. From the above, it has been deemed reasonable to measure milk yield and constituents as a way to determine the economic merit (if any) attached to each breed of goat discussed in this study.

MATERIALS AND METHODS

This study investigated the milk yield and composition of four different breeds of goats namely the Indigenous (IND), the British Alpine (B. Alp), the Toggenburg (TOG) and the Saanen (SNN) which were all raised in the same environmental conditions. The experiment was a one way (feeding system) analysis of variance where eight goats were randomly selected from each breed for the measurement of Body Condition Score (BCS), milk yield and components. Animal ethics approval was obtained from the Agricultural Research Council (ARC), Animal Ethics Committee (AEC). Twenty four dairy goats (8 B. Alp, 8 TOG and 8 SNN) plus eight IND goats were raised at the ARC-Irene experimental farm nearby Pretoria in South Africa. The goats were all preventive treated with vaccines (pulpy kidney and pasteurellosis), dewormed against wireworms (*Haemonchus contortus)* with 1 mL sub-cutaneous

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moxidectin injection and herded on a kikuyu grazing (*Pennisetum clandestinum*). Drinking water and supplement (maize silage) were provided *ad libitum*. Natural mating took place on breeding season and resulted in a spring kidding from week 1 after lactation and onwards, a provision of ewes and lambs pellets was made available to the goats. During the 8 weeks that lasted lactation in the indigenous goats, BCS as well as milk yield and components were recorded in all does on a weekly basis.

The technique consisted in visual appraisal and palpation for BCS and handmilking all does udders for milk collection after the udder was empty, the does was injected a 1 mL oxytocin Intra Muscular (IM) while all kids were taken away for 4 h. After 4 h, a 2nd milking session was performed in the view of measuring the doe's daily milk yield meanwhile, samples from the 1st (morning) milking were send to the laboratory for analysis (Fig. 1).

Milk samples were sent to Lactolab, a fully accredited laboratory in South Africa where a high capacity milkoscan fully automatic mid-range infrared spectrophotometer was used to analyze lactose, proteins and milk fat concentrations. Analysis of Variance (ANOVA) (SAS, 1999) for unbalanced data was done to test for differences between treatment effects on milk production and composition.

Data was acceptably normal with homogenous treatment variances except for CCN which had to be transformed to $\log_{10}$ to stabilize treatment variances. Testing was done at the 5% level. Treatment means were separated using Fischer's protected t-test Least Significant Difference (LSD) at 5% level of significance (Snedecor and Cochran, 1980).

Fig. 1: On a winter kikuyu grazing, does were fed a winter supplement of maize silage; during lactation (spring), a ration of ewe and lamb pellets was added to the diet

RESULTS AND DISCUSSION

Results on milk yield found in this study are consistent with those from Shamay *et al.* (2000) but lower than those found by Fernandez *et al.* (2008) and higher than those reported by Makun *et al.* (2008). This fluctuation in the results prove that milk yield is subject to much variation within breeds with breeds, age, stage of lactation, parity, season, location and geographic areas. Results in Fig. 2 show that milk yield from dairy goats (SNN, TOG and B. Alp) was higher ($p<0.001$) than the IND goat milk yield during the entire period of study. This superiority of dairy breeds in milk yield was expected. Dairy breeds have long been selected for milk production, their metabolism is entirely under a homeorrhetic control whereby body resources are mobilized at the expenses of other processes for the solely objective to support the ongoing galactopoiesis (Bauman and Currie, 1980). Katanos *et al.* (2005) investigated the partitioning, yield and milk composition of milk in some imported dairy goats and some crosses between them and the local Greek goats. Results showed that daily milk yield was higher in the SNN and the SNN crossed Alpines compared to the SNN crossed local Greek and to the local Greek breeds. They concluded that the SNN and Alpines genotypes had a milk yield superiority. This is conversant with results found in this study (Fig. 2).

As for the indigenous does, their performance in milk yield remained lower ($p<0.001$) but their BCS remained unchanged at 3 (Table 1) in contrast with the B. Alp and more specifically, the SNN whose BCS declined from 3-2 (Fig. 1) suggesting that in dairy breeds, body reserves are actively mobilized in favor of high milk production.

Differences in BCS between the IND and dairy breed goats can be explained by the fact that the IND does are not milk-making machines and their metabolism responds to a central homeostatic control where resource partitioning prioritizes the maintenance of a constant

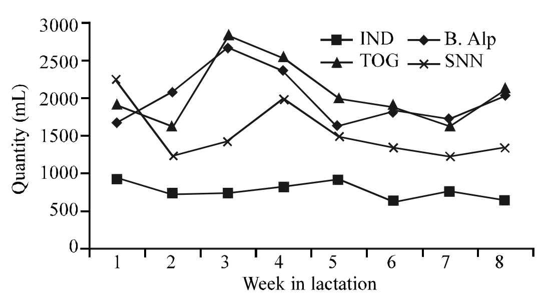

Fig. 2: Indigenous goat (IND) and the dairy breeds of goat (TOG; B. Alp and SNN) milk yield (mL) over 8 week lactation period

Table 1: BCS in all goats during 8 weeks lactation (n = 8)

Weeks/lactation breeds	0	1	2	3	4	5	6	7	8
Indigenous	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Toggenburg	3.0	2.5	2.0	2.5	2.0	2.0	2.5	2.0	2.5
Brit. Alp.	3.0	2.5	2.5	2.0	2.0	2.0	2.0	2.0	2.0
Saanen	2.5	2.0	2.0	1.5	1.5	1.5	2.0	1.5	2.0

internal equilibrium whence the maintenance of stability in BCS at 3 and also the maintenance of stability in its milk yield, contrasting with the erratic performance displayed by the dairy breeds in these two parameters.

In Fig. 2, it is also shown the all-goat decline in milk yield between week 1 and 2. Except from the B. Alp, the other does milk yield declined during this period. The explanation could be that at this period, all goats were on the spring kikuyu grazing (Fig. 1) supplemented by maize silage. The biochemical analysis conducted on these feedstuffs (Department of Animal Science, University of Pretoria) revealed the kikuyu GE value to be 6.8 MJ kg^{-1} while the maize silage GE was 11.8 MJ kg^{-1}. Thus, this diet was inadequate to support the does early lactation increased energy demand whence the all does milk yield decline in week 1, a period (early lactation) where milk yield is expected to be at its highest peak production level. On the reverse during week 2, all the lactating does were additionally fed a commercial ewes and lambs pellet (fat: 250 g kg^{-1}; urea 100 g kg^{-1}) *ad-libitum*, milk yield increased sub-stantially in all breeds. Such an increase was already observed in 1980 by Morand-Fehr and Sauvant who wrote that supplies of concentrates in early lactation could improve milk production. Among other researchers as Min *et al*. (2005) and Zucali *et al*. (2007) supported the opinion that concentrate supply could affect milk yield and composition in lactating goats. Not withstanding the previous, milk production depends on many factors and not solely on feeding (Raynal-Ljutovac *et al*., 2008). In 2007, Morand-Fehr wrote that numerous factors in production and feeding and their interactions could influence milk yield and composition. In this study (Fig. 1, week 1) the B. Alp produced at the onset of lactation, the lowest milk yield of all the dairy breeds. But in week 2 while all does milk yields were at their lowest level, the milk yield of B. Alp was the highest. The B. Alp milking ability did not seem to be affected by the grassland poor nutritional provision. This was observed by Min *et al*. (2005), mentioned that the Alpines dairy goats grazing on forage alone could produce milk inexpensively while other high-producing dairy goats needed moderate levels of concentrate supplementation for economic success. The milk industry buyers pay a premium for milk fat and milk protein percentages because milk quality is greatly determined by its chemical composition in protein, lactose and fat contents (Torii *et al*., 2004; Schmidely *et al*., 2005). In this study,

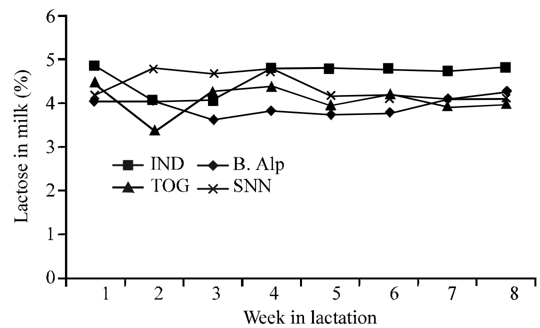

Fig. 3: Lactose concentration (%) in milk of all goats during 8 week lactation period

the milk constituents considered was: lactose, milk fat and milk proteins. Results on milk lactose concentration are showed in Fig. 2.

Milk lactose values found in this study (from 3.9-4.9%) are consistent with the values found by Raynal-Ljutovac *et al*. (2008), Fernandez *et al*. (2008) and Bonanno *et al*. (2007). Lactose is the most stable constituent of the goat's milk (Contreras *et al*., 2009; Fernandez *et al*., 2008; Raynal-Ljutovac *et al*., 2008; Katanos *et al*., 2005) when milk lactose concentration goes down, one should fear infection in the mammary gland (Kifaro *et al*., 2009; Bernacka, 2007; Leitner *et al*., 2004). Inversely, an increased milk lactose concentration may be pointing to a decreased food intake (Min *et al*., 2005; Dahlborn *et al*., 2007) or a severe heat exposure (Sano *et al*., 1985).

Lactose concentration of the IND goats was higher ($p<0.001$) from week 5-8 as compared to the dairy goats (Fig. 3). This has been explained by Chang, Chen and Wu who said in 1996 that low-yielding goats tended to have high blood glucose concentration but a poorer uptake of glucose than the high producing goats; glucose being the only and unique lactose precursor, its high level may be reflected by a high lactose concentration as seen in indigenous does (Fig. 3).

Results of milk proteins (Fig. 4) analysis are comparable and fall into the range of those reported by other researchers (Contreras *et al*., 2009; Fernandez *et al*., 2008; Raynal-Ljutovac *et al*., 2008; Casamassima *et al*., 2007; Rovai *et al*., 2007).

In Fig. 4, it appears that the IND goat's milk protein concentration is higher ($p<0.01$) than in the dairy breeds, especially in week 1 and from week 4-8. In contrast, the

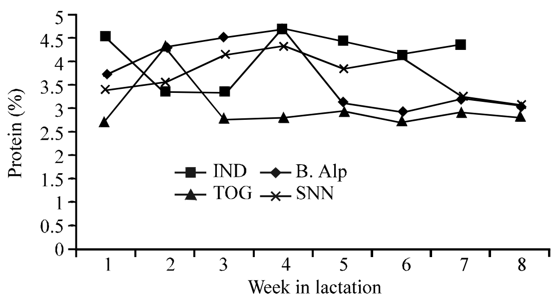

Fig. 4: Milk protein concentration (%) in milk of all goats during 8 week lactation period

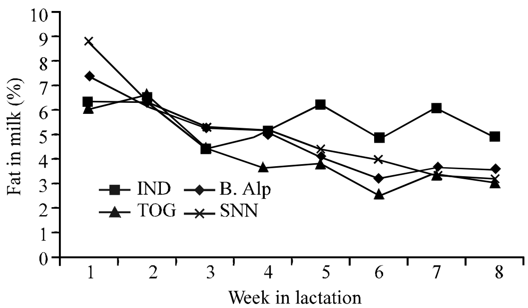

Fig. 5: Milk fat percentage in milk of all goats during 8 week lactation period

TOG who produced the highest milk yield (Fig. 2) are showing the lowest milk proteins concentration (Fig. 4). This result is in accordance with Zumbo and Di Rosa (2007) who showed a negative correlation ($r = -0.18$; $p<0.05$) between quantity and quality of the milk, particularly between daily milk production and protein content Here again, the B. Alp goat's milk protein concentration level seems to be outstanding in week 2 and 3 of lactation. From week 4, the B. Alp goats'milk protein concentration declines drastically probably as a late response to the negative correlation (Zumbo and Di Rosa, 2007) existing between milk yield and milk protein concentration.

Results on milk fat are presented in Fig. 5. These results are within the range of those reported by Bouattour *et al.* (2008) and Fernandez *et al.* (2008). In Fig. 5, the milk fat shows a decline from week 1-8. This decline was also observed by Bouattour *et al.* (2008) who reported that the response of milk fat secretion is usually higher during early lactation because de novo lipogenesis is usually more active after peak lactation than before it. After peak lactation, dietary fatty acids would probably be partitioned more to the adipose tissues synthesis. Earlier findings by Morand-Fehr *et al.* (2007) suggested that milk fat content was stable at the first stage and then decreased under the effect of dilution; this was also the opinion of Chilliard *et al.* (2003) indicated that milk fat content is high after parturition and decreases during the major part of lactation in goat. Chilliard *et al.* (2003) quoting and explained that this decline was related to a decrease in fat mobilization. These explanations are all in agreement with Fernandez *et al.* (2008) said that in general fat and protein content were greater at the beginning than at the end of lactation when milk volume decreased.

As for the IND goats'performance, their milk fat was higher ($p<0.001$) as compared to the dairy breed milk fat (especially from week 5-8). Fernandez *et al.* (2008) suggested that not withstanding the influence of other related factors such as breed, nutrition and climate, milk production level was the factor that influenced milk constituents, especially the percentage of fat. It has indeed been observed that goats with lower milk production level had a higher fat percentage, this negative correlation between milk yield and fat (as well as protein) percentage is known as the Dilution effect (Landau *et al.*, 1993). There is also a certain tendency (Fig. 5) for stability in the indigenous goats milk fat level. This stability was already been observed in this study in the indigenous milk yield (Fig. 2) milk lactose (Fig. 3) and milk protein concentrations (Fig. 4). The stability in the indigenous goat milk quality performance has a reference in the role of the central homeostatic control mechanism.

CONCLUSION

In this study, milk from dairy breed goats was quantitatively higher than the indigenous goats milk yield during the entire period of investigation. Among the dairy breeds, the SNN produced less milk but lost most BCS. On contrast, the TOG and the B. Alp produced more milk but lost less BCS than the SNN. The TOG especially yielded more milk and lost few BCS as compared to the two other dairy goat breeds. As for the B. Alp, the goats displayed better adaptability towards the environment through their productive capacity independency vis a vis the grassland nutritional value. The milk qualitative analysis confirmed milk lactose concentration (3.9-4.9%) as the most stable constituent of does milk. Milk proteins values (3.1-4.5%) found in this study showed that the IND goats milk protein concentration was significantly higher than dairy breeds milk proteins. Results of milk fat (3.3-7.7%) indicated that milk fat content is high in week 1 and decreases during the major part of lactation in goats. The overall results indicated that in a response to the dilution effect, the indigenous goats had higher milk lactose, milk fat and milk proteins than the dairy goat breeds. The indigenous does seemed to be under an homeostatic control mechanism which prioritized stability in parameters like BCS, milk yield and milk components while the dairy goat breeds seemed to be under an homeorhetic metabolic regime which prioritized milk yield at the expense of all body reserves. The dairy goat breeds deserve consideration for their quantitative yield merit. However, a better nutritional plan should be designed for the SNN if this breed is considered for milk exploitation in rural areas. Finally, the premiums paid by the milk industry for milk fat and milk protein percentage suggest that the indigenous goat qualitative merit should be credited, especially with regard to their outstanding capacity to maintain stability irrespective of the feeding environmental supply adequacy.

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REFERENCES

Ahuya, C.O., J.M.K. Ojango, R.O. Mosi, C.P. Peacock and A.M. Okeyo, 2009. Performance of Toggenburg dairy goats in smallholder production systems of the Eastern highliands of Kenya. Small Rumin. Res., 83: 7-13.

Bauman, D.E. and B. Currie, 1980. Partitioning of nutrients during pregnancy and lactation: A review of mechanisms involving homeostasis and homeorhesis. J. Dairy Sci., 63: 1514-1529.

Bernacka, H., 2007. Cytological quality of goat milk on the basis of the Somatic cell count. J. Cent. Eur. Agric., 7: 773-778.

Bonanno, A., A. Di Grigoli, L. Stringi, G. Di Miceli and D. Giambalvo *et al.*, 2007. Intake and milk production of goats grazing Sulla forage under different stocking rates. Ital. J. Anim. Sci., 6: 605-607.

Bouattour, M.A., R. Casals, E. Albanell, X. Such and G. Caja, 2008. Feeding soybean oil to dairy goats increases conjugated linoleic acid in milk. J. Dairy Sci., 91: 2399-2407.

Casamassima, D., M. Palazzo and R. Pizzo, 2007. Evaluation of milk production and some blood parameters in lactating autochthonous goat extensively reared in Molise region. Ital. J. Anim. Sci., 6: 615-617.

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

Contreras, A., M.J. Paape, R.H. Miller, J.C. Corrales, C. Luengo and A. Sanchez, 2009. Effect of bromelain on milk yield, milk composition and mammary health in dairy goats. Trop. Anim. Health Prod., 41: 429-498.

Dahlborn, K., M.O. Nielsen and J. Hossaini-Hilali, 2007. Mechanisms causing decreased milk production in water deprived goats. CIHEAM-Options Mediterraneennes. pp: 199-202. http://ressources.ciheam.org/om/pdf/a34/97606137.pdf.

Fernandez, F.J., H.C. Vazquez, H. Castillo-Juarez, J.A. Saltijeral-Oaxaca, J.R. Gonzalez-Montana and M. Fernandez, 2008. Somatic cell counts and quality of goat milk produced in the central region of Mexico. Res. J. Dairy Sci., 2: 45-50.

Katanos, J., B. Skapetas and V. Laga, 2005. Machine milking ability and milk composition of some imported dairy goat breeds and some crosses in Greece. Czech J. Anim. Sci., 50: 394-401.

Kifaro, G.C., N.G. Moshi and U.M. Minga, 2009. Effect of sub-clinical mastitis on milk yield and composition of dairy goats in Tanzania. Afr. J. Food Agric. Nutr. Dev., 9: 1-10.

Landau, S., J. Vecht and A. Perevolotsky, 1993. Effects of two levels of concentrate supplementation on milk production of dairy goats browsing Mediterranean scrubland. Small Rumin. Res., 11: 227-237.

Leitner, G., U. Merin and N. Silanikove, 2004. Changes in milk composition as affected by subclinical mastitis in goats. J. Dairy Sci., 87: 1719-1726.

Makun, H.J., J.O. Ajanusi, O.W. Ehoche, C.A.M. Lakpini and S.M. Otaru, 2008. Growth rates and milk production potential of sahelian and red sokoto breeds of goats in Northern Guinea Savannah. Pak. J. Biol. Sci., 11: 601-606.

Min, B.R., S.P. Hart, T. Sahlu and L.D. Satter, 2005. The effect of diets on milk production and composition and on lactation curves in pastured dairy goats. J. Dairy Sci., 88: 2604-2615.

Morand-Fehr, P., V. Fedele, M. Decandia and Y. Le Frileux, 2007. Influence of farming and feeding systems on composition and quality of goat and sheep milk. Small Rumin. Res., 68: 20-34.

Raynal-Ljutovac, K., G. Laggrifoul, I. Guillet and Y. Chilliard, 2008. Composition of goat and sheep milk products: An update. Small Rumin. Res., 79: 57-72.

Rovai, M., A. Lock, T. Gipson, A. Goetsch and D. Bauman, 2007. A conjugated linoleic acid supplement containing trans-10, cis-12 CLA reduces milk fat synthesis in lactating goats. J. Dairy Sci., 91: 3291-3299.

SAS, 1999. SAS/STAT User's Guide, Version 9. 1st Edn., SAS Institute Inc, Cary, North Carolina, USA..

Sano, H., K. Ambo and T. Tsuda, 1985. Blood glucose kinetics in whole body and mammary gland of lactating goats exposed to heat. J. Dairy Sci., 8: 2557-2564.

Schmidely, P., P. Morand-Fehr and D. Sauvant, 2005. Influence of extruded soybeans with or without bicarbonate on milk performance and fatty acid composition of goat milk. J. Dairy Sci., 88: 757-765.

Shamay, A., S.J. Mabjeesh, F. Shapiro and N. Silanikove, 2000. Adrenocorticotrophic hormone and dexamethasone failed to affect milk yield in dairy goats: Comparative aspects. Small Rumin. Res., 38: 255-259.

Snedecor, G.W. and W.G. Cochran, 1980. Statistical Methods. 7th Edn., Iowa State University Press, Iowa, USA., ISBN-10: 0-81381560-6, pp: 507.

Torii, M.S., J.C. Damasceno, L.D.R. Ribeiro, E.S. Sakaguti, G.T.D. Santos, M. Matsushita and N.M. Fukumoto, 2004. Physical-chemical characteristics and fatty acids composition in dairy goats milk in response to roughage diet. Braz. Arch. Biol. Technol., 47: 903-909.

Zucali, M., L. Bava, C. Penati and L. Rapetti, 2007. Effect of raw sunflower seeds on goat milk production in different farming systems. Ital. J. Anim. Sci., 6: 633-635.

Zumbo, A. and R. Di Rosa, 2007. Effects of parity and type of kidding on the quantitative and qualitative milk characteristics of the Rossa Mediterranea goats. Ital. J. Anim. Sci., 6: 636-636.