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Milk Production of Three Exotic Dairy Goat Genotypes in Limpopo Province, South Africa

[1]D. Norris, [1]J.W. Ngambi, [2]K. Benyi and [1]C.A. Mbajiorgu
[1]Department of Animal Production, University of Limpopo, Private Bag X1106, Sovenga, 0727, South Africa
[2]Department of Animal Science, University of Venda, Private Bag X5050, Thohoyandou, 0950, South Africa

Corresponding Author: D. Norris, Department of Animal Production, University of Limpopo, Private Bag X1106, Sovenga, 0727, South Africa Tel: +27-726207774

ABSTRACT

The aim of the study was to investigate the milk potential of Saanen, British Alpine and Toggenburg dairy goats does under extensive nutritional management. Saanen produced more milk (1.45 kg day^{-1}) than the two other breeds. Toggenburg produced the least amount of milk (0.56 kg). All breeds produced less than their reported production under improved management regimes. The Toggenburg and the British Alpine least expressed their genetic potential for milk production under extensive nutritional and management scheme. However, the milk yield from these temperate breeds under extensive management system was still much higher than the reported milk production of indigenous goats. Milk from the British Alpine had the highest protein content while the least milk protein content was found in the Toggenburg breed. Fat content was highest in the Toggenburg milk followed by the British Alpine, with the least amount of fat found in the Saanen milk. Milk yield, protein and fat contents were influenced by stage of lactation, season and parity. Milk yield declined with lactation stage.

Key words: Milk yield, milk composition, lactation stage, parity, season

INTRODUCTION

Goats are not a significant source of milk in South Africa (Donkin and Boyazoglu, 2001). Given the high levels of poverty and malnutrition in most rural areas of South Africa, it has become necessary to increase the contribution of dairy goats as potential sources of animal protein to address challenges of poverty and malnutrition. Milk is an important component of the balanced diet for humans and it is known to be more digestible than cows (Thomas and Rollins, 2004). Milk provides energy, proteins, minerals and vitamins and its therapeutic properties including anti-allergic properties have long been recognized (Egwu *et al*., 1995). Since milk provides high quality proteins it contributes to the reduction in malnutrition amongst children and adults, especially pregnant women. However, milk has mostly been harvested from dairy cows in commercial enterprises because of economies of scale. Until of late, dairy research has focused on intensive milk production using highly valued dairy cattle breeds. The emphasis has been on large-scale dairy production systems and the beneficiaries have been the rich and powerful corporations in the society (Mekuria and Moletsane, 1996). Unlike dairy goats, milk production from dairy cattle requires substantial capital investments, including land, labour and technical, financial and managerial skills. All these factors of production are not within the reach of most rural

households who are resource-limited and lack basic skills. Hence, the need for a sustainable source of milk supply for the people of the rural communities. The goat has lower maintenance requirements, compared to the cow and thus makes it an ideal animal for milk production by small scale farmers and rural households (Van der Nest, 1997). Additionally, goat milk production has the advantage that goat enterprises have lower capital investment requirements, concurrent with lower overall risks.

Most rural people depend on indigenous animals for meat and milk but these animals which have traditionally never been selected for meat and milk production (Casey and Van Niekerk, 1988). These animals are usually expected to produce sufficient milk to feed their young and have surplus for human consumption. However, it turns out that because they were never selected for meat and milk production, they are unable to produce adequately for both their young and for satisfaction of human needs. Various dairy goat breeds exist which have been selected for increased milk production but their production under extensive management conditions has not been adequately studied. These breeds may potentially serve as alternative sources of milk production for the rural communities. Excess milk after immediate household use may be sold to generate income for these communities thus improving their livelihoods.

Milk composition and quality are important attributes that determine the nutritive value and consumer acceptability (Zahraddeen *et al*., 2007). A number of studies (Morand-Fehr and Sauvant, 1980; Greyling *et al*., 2004) have looked at the effect of nutrition and management on milk composition but few studies have addressed factors such as stage of lactation, parity, breed and season which have been found to affect milk composition. Some studies (Mioc *et al*., 2008; Zahraddeen *et al*., 2007) have shown that these factors have an influence on milk composition.

The main aim of this study was therefore to determine the potential milk production of established dairy goat breeds under extensive management regime in Limpopo Province, South Africa. Additionally, the study sought to determine factors that affect milk composition.

MATERIALS AND METHODS

The study was carried out at Putukwane, about 100 km Northwest of Polokwane, the provincial capital of Limpopo Province in South Africa. The study was carried out between February, 1996 and January, 2010. The area is mainly a mixed bushveld with vegetation varying from a dense short bushveld to open tree savanna. Trees and shrubs include common Hook-thorn *Acacia caffra*, *Sicklebush dichrostachys cinerea* and various *Grewia* species. Grasses include Fingergrass *Digitaria eriantha*, *Stipagrotis uniplumis* and various *Aristida* and *Eragrostis* species. One hundred and seventy nine multiparous, lactating does were used in the study. These animals belong to the Putukwane goat milk cooperative which is made up of community members from the villages surrounding the study site. The cooperative was formed as part of the district municipality efforts of alleviating poverty in rural communities. The animals were raised under an extensive, natural feeding regime. Supplementary feeding though not regularly available was provided. The University of Limpopo offers support through technical advice and sometimes purchase of feed. Table 1 shows the nutrient composition of the supplementary feed.

Goats were machine milked and milk production was recorded once daily from the first week following parturition for 210 days observation period. Milk samples were kept at 4°C and analyzed for milk fat, protein, carbohydrate, calcium and energy. Total fat content was determined by the Gerber method. Total nitrogen was determined using a Leco TruSpec N and multiplied by

Table 1: Nutrient composition of supplementary feed

Ingredient	Amount
Protein	140 (g kg^{-1})
Fat	25 (g kg^{-1})
Fibre	150 (g kg^{-1})
Calcium	10 (g kg^{-1})
Phosphorus	3 (g kg^{-1})
Urea	10 (g kg^{-1})
Monensin Na	22 (mg kg^{-1})
Zinc bacitracin	50 (mg kg^{-1})

a factor of 6.38 to get total protein content. Carbohydrate content was calculated by difference (100-Water+Protein+Fat+Ash). Calcium content was determined by Atomic Absorption Spectrophotometer (Perkins-Elmer Co.) and the energy value was obtained by multiplying all nutrient contents by their energy conversion factors and added together.

Breed, lactation stage, parity and seasonal effects for the mean daily milk production and milk composition were analyzed using the general linear models procedures of SAS (1991).

RESULTS

Milk production: Saanen breed produced more milk ($p<0.05$) than the other two breeds. The lowest milk production was observed in the Toggenburg breed. Stage of lactation, kidding season and parity had an influence on milk yield. The highest ($p<0.05$) milk yield was observed during early lactation followed by mid lactation, with the lowest milk yield produced during late lactation. Goats kidding in March/April season produced more milk ($p<0.05$) than goats kidding during the months of October and November. Highest milk production was observed in the second parity, followed by third and first parities, respectively (Table 2).

Milk composition: Milk from the British Alpine had more ($p<0.05$) protein content, followed by Saanen and Toggenburg. Milk from the Saanen breed had the least amount ($p<0.05$) of fat while milk from the Toggenburg breed had the highest amount of fat. Milk from the British Alpine and Toggenburg breeds had similar ($p<0.05$) carbohydrate levels (Table 3). The carbohydrate level was higher in the Saanen breed. Energy levels were similar ($p<0.05$) in British and Toggenburg milk. The energy level of the Saanen breed was lower. Similarly, the calcium levels were the same in the British and Toggenburg milk with lower calcium level observed in the Saanen breed milk.

Protein content was highest ($p<0.05$) in late lactation followed by mid and early lactation respectively. There was no significant difference in fat content during early and mid lactation. Higher fat content was observed during late lactation. The amount of carbohydrate was higher in early lactation and no difference was observed during the mid and late lactation. Energy levels were similar during early and mid lactation with a higher milk energy level observed in late lactation. The calcium content was similar across the different stages of lactation.

Seasonal effects had influence on protein, fat and energy levels. Higher levels of protein, fat and energy were observed in the second season. Carbohydrate and calcium amounts were not affected by season. Parity had no effect on carbohydrate, energy and calcium but had influence on protein and fat content. High protein and fat content were observed in the first parity and there were no difference between second and third parities.

Table 2: Means for milk yield by breed, stage of lactation, season and parity

Parameters	Daily milk yield	SE
Breed		
Saanen	1.45[a]	0.27
British Alpine	0.75[b]	0.14
Toggenburg	0.56[c]	0.12
Stage of lactation		
Early	1.15[a]	0.19
Middle	0.96[b]	0.15
Late	0.51[c]	0.12
Season		
1 (March/April)	1.09[a]	0.15
2 (October/November)	0.87[b]	0.13
Parity		
First	0.82[a]	0.11
Second	0.98[b]	0.14
Third	0.93[b]	0.13

Means in the same column sharing a different letter(s) are not significantly different (p>0.05). SE: Standard error

Table 3: Mean milk composition (per 100 g) as influenced by breed, lactation stage, season and parity

Parameters	Protein (g)	Fat (g)	Carbohydrate (g)	Energy (Kj)	Calcium (mg)
Breed					
Saanen	3.56[b]	4.02[a]	4.58[a]	219[a]	130[a]
British Alpine	3.72[a]	4.19[b]	4.36[b]	296[b]	140[b]
Toggenburg	3.37[c]	4.44[c]	4.40[b]	300[b]	137[b]
SE	0.01	0.02	0.02	20	12
Stage of lactation					
Early	3.47[a]	4.16[a]	4.48[a]	263[a]	136
Middle	3.51[b]	4.18[a]	4.40[b]	269[a]	140
Late	3.56[c]	4.23[b]	4.39[b]	286[b]	138
SE	0.01	0.02	0.02	15	10
Season					
1 (March/April)	3.45[a]	4.19[a]	4.45	261[a]	137
2 (October/November)	3.57[b]	4.39[b]	4.47	274[b]	139
SE	0.02	0.03	0.02	14	13
Parity					
First	3.56[a]	4.27[a]	4.41	276	138
Second	3.46[b]	4.17[b]	4.39	264	134
Third	3.48[b]	4.20[b]	4.40	271	136
SE	0.03	0.04	0.03	12	10

Means in the same column sharing a different letter(s) are not significantly different (p>0.05). SE: Standard error

DISCUSSION

Milk production: The milk production recorded for the breeds in this study is far less than the yield observed in other studies (Thomas and Rollins, 2004; Donkin, 1997; Harris and Springer, 1992). Generally, these breeds average between 3 to 4 kg of milk daily (Haenlein, 2004). According to the British Goat Society (http://www.allgoats. com/breeds1.htm, 2004), the British Alpine produces an average daily milk yield of 4.09 kg while the Saanen produces an average daily yield of 5.17 kg. The Toggenburg is reported to produce 4.54 kg milk. These breeds have been selected for milk production in temperate climates and the poor milk production observed in this study is a

clear indication that they can't express their full genetic potential for milk production in tropical climates. However, the milk production observed in this study is still lower than that observed in a few similar studies done in the tropics. In a similar study done in Barbados in the Carribean Islands (Thomas and Rollins, 2004), the average daily milk production for British Alpine, Saanen and Toggenburg was 2.55, 1.73 and 3.46, respectively while in this study the yield was 0.75, 1.45 and 0.56, respectively. It should be noted that the climatic conditions in Barbados are not as harsh as that found in the Limpopo Province of South Africa. In a study done by Donkin (1997), which determined the milk production of Saanen, Indigenous and crossbreds, the Saanen produced 2.45 kg compared to the 1.45 observed in this study. The Indigenous-Saanen crossbred in Donkin's study produced a daily milk average similar to the milk production observed for pure Saanen goats in this study. Apart from the fact that these breeds are not adapted to tropical conditions, the poor milk production observed in this study could be attributed to a less than ideal nutritional environment and poor managerial/technical skills. Milk production is largely affected by a combination of factors, namely, the use of improved breeds selected for milk production, a favorable nutritional environment and improved managerial practices (Devendra and Burns, 1970). As indicated earlier, the breeds were raised under extensive conditions with minimal supplementation. These breeds were not developed for such conditions. Additionally, the technical skills of the farmers are not adequate.

It should be emphasized that although the milk production of the temperate breeds observed in this study is lower than the expected production, the yield is still much higher than the milk production of the indigenous goat. The indigenous goats are known to be poor milkers (Casey and Van Niekerk, 1988) and a study by Donkin *et al.* (1996) showed a milk production level of only 0.25 kg daily milk yield which is 50% less than the least producing breed (Toggenburg) in this study. It seems the use of straight bred dairy goats may still be beneficial for use by small holder farmers. However, it may be advisable to cross these breeds to indigenous goat breeds to improve adaptability of the breeds. Though this was not studied due to poor recording, the kid mortality rate among these goats especially the Toggenburg breed seemed to be abnormally high which could be an indication of poor adaptation. It should be mentioned that farmers should first acquire adequate knowledge on breeding before embarking on crossbreeding since most of the time farmers breed indiscriminately resulting in inbreeding and unsuitable breed gene proportions in the crossbreds.

It is widely known in temperate environments that the Saanen produces more milk than other dairy goat breeds (Peacock, 1996). This study indicates that even under tropical conditions, the Saanen still outperforms other dairy goat breeds. This finding is however contrary to the findings of Thomas and Rollins (2004) which showed the Saanen producing less than both the British Alpine and Toggenburg. There is very little work that has been done in the tropics to compare production levels of these breeds and thus making it difficult to compare this study with other findings in similar environments. The least producing breed in this study was the Toggenburg followed by the British Alpine. However, according to Peacock (1996), these breeds (Toggenburg and British Alpine) are more tolerant to tropical conditions than the Saanen breed. The British Alpine has been found to be hardy and able to thrive in any climate.

Milk yield declined as lactation progressed. This has also been reported in other studies (Prasad *et al.*, 2005; Mioc *et al.*, 2008; Ploumi *et al.*, 1998). Goats kidding during the months of March and April produced more milk than those kidding late in the year. This may be attributed to improved feed resources during the months of March and April. There are usually limited feed resources available during the months of October and November. There was an increasing trend in milk yield as parity increased. This has also been observed by Zahraddeen *et al.* (2009). Increase

in milk yield with increasing parity was also observed by Prasad *et al.* (2005) and Mioc *et al.* (2008). In the Prasad *et al.* (2005) study, milk yield increased to third parity but declined at later parities while in the Mioc study the milk yield increased to fourth parity and started declining after the fourth parity.

Milk composition: Protein, lactose and SNF content determine the value of the milk and milk composition depends largely on the volume of milk produced (Zygoyiannis, 1988). The composition of milk is also a function of several factors including breed, stage of lactation, climatic conditions, diet and season (Merin *et al.*, 1988). The lowest protein content was found in the Toggenburg milk followed by Saanen while the highest protein content was found in the British Alpine. The mean concentration of protein in goat milk is reported to be about 4.5% (Zerfas *et al.*, 1992) and this is higher than the average protein content found in this study. However, the average protein content of the milk recorded for the breeds in this study is higher than the values reported by the British Goat Society. It would seem the protein content is not always influenced by the volume of milk produced since one would have expected the Saanen milk to have the least amount of protein given the higher milk production by the Saanen. However, in Thomas and Rollins study, the highest protein content was associated with least milker and vice-versa. The fat content seems to support the observation that higher levels of milk production are associated with a lower fat content of milk (Zygoyiannis, 1988; Flamant and Morand-Fehr, 1982; Zygoyiannis and Katsaounis, 1986). The fat content was highest in the Toggenburg which was observed to produce the least amount of milk while the lowest fat content was observed in the highest milk producing breed (Saanen). Morand-Fehr and Sauvant (1980) report that the decrease in goat milk fat content is attributed to a decrease in the molar proportion of acetic acid and an increase in the molar proportion of propionic acid in the rumen and generally an increase in milk production is associated with a decrease in milk constituents.

The highest mean milk carbohydrate content was produced by Saanen goats and the least carbohydrate content was observed in the British Alpine. No particular trend is observed in the carbohydrate content in relation to the amount of milk. This is contrary to the observed tendency of carbohydrate content to decline with a decrease in milk production (Singh and Sengar, 1990).

The energy level of milk was similar and higher in British Alpine and Toggenburg breeds than in the Saanen. This could be attributed to the higher fat content in the milk from these two breeds. Similarly, the calcium levels were similar and higher in Toggenburg and British Alpine breeds the Saanen. No studies reporting on energy and calcium levels were found to compare findings.

The influence of lactation stage, kidding season and parity has been reported in other studies. Mioc *et al.* (2008) reported an increase in protein and fat content as milk yield declined. This has been observed in this study. During earlier stages of lactation, milk yield was high and this corresponded with lower protein and fat contents. However, during late lactation when milk yield was low, protein and fat contents were higher. These findings were also observed by Ploumi *et al.* (1998) in Chios ewes. Fat and protein contents were higher in the second season when milk yield was lower further confirming the negative correlation between milk yield and protein and also negative correlation between milk yield and fat. A similar trend was observed with parity. At later parities when milk yield was higher, protein and fat contents were lower. However, parities 2 and 3 had similar protein and fat contents.

Stage of lactation had an influence on carbohydrate content. Carbohydrate amount was higher during mid and late lactation. This has also been observed by Zarahddeen *et al.* (2007) and Prasad *et al.* (2005). Season and parity did not affect the carbohydrate content and this finding is

contrary to studies by Zarahddeen *et al.* (2007) and Prasad *et al.* (2005). However, Prasad *et al.* (2005) study showed no seasonal effect on carbohydrate content. The lack of season and parity influence on carbohydrate content has also been observed by Mioc *et al.* (2008).

Milk energy was influenced by stage of lactation and season. Parity had no influence on milk energy. Prasad *et al.* (2005) found an influence of lactation stage and parity on milk energy but no influence of season. It could be deduced that when the fat level is high, the energy level will also be high. This seems to be the case in this study. During mid and late lactation and during season 2, the fat level was high and this corresponded with high milk energy. However, this does not seem to be the case when one considers parity. Higher fat percentage at first parity did not result in a significantly higher milk energy level. Calcium was only influenced by breed type and all the other factors did not seem to have an effect on calcium content.

CONCLUSION

The extensive rearing conditions inhibited the breeds from expressing their genetic potential for milk production. It is necessary to raise the level of nutrition and management to take reasonable advantage of the breeds' genetic potential for milk production. However, these breeds still manage to produce much higher than the indigenous breed under extensive conditions and this implies that these breeds can provide reasonably adequate milk to the small holder farmers thus improving livelihoods through reduction in malnutrition and increased income that may be accrued through sales of excess milk. Through prudent financial management, the income from excess milk sales could be used to purchase supplementary feed thus improving the milk production of goats with subsequent increase in income from increased milk sales. The Saanen breed seems to be most suitable given its higher milk production. However, it may not be advisable to concretely recommend the use of this breed by small holder farmers. More research will be done to investigate other areas such as mortality levels, lactation lengths and breed maintenance costs/requirements etc.

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