Quality of Milk from Norwegian Dairy Goats Bred and raised in Mgeta Division, Morogoro Region, Tanzania

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Abstract

Milk from goats has uplifted the nutritional standards of many poor households in rural communities in developing countries. In Tanzania, consumption of milk in these communities has increased since introduction of dairy goats in 1960s. Nutritional composition including carbohydrate, protein, fat, minerals, and associated and quality attributes are important factors of milk for human consumption. Also, milk should be obtained from health animals in order to safeguard the health of consumers. These parameters are affected by many factors including management, production level, breed, parity and stage of lactation, as well as processing and handling conditions. We carried out this study to evaluate the composition of milk from the most famous dairy goats namely Norwegian Landrace (NL), mainly crosses with indigenous Small East African (SEA) goats which are bred and managed in Mgeta division, Morogoro region, Eastern Tanzania. We collected 75 milk samples considering various factors. These samples were analysed for somatic cell count (SCC), crude protein (CP), butterfat (BF), lactose, total solids (TS), solids-not-fat (SNF), Chloride (Cl) as well as milk density. We obtained averages of each parameter for each factor and made statistical decision using the general linear model procedures of the statistical analysis system. Averages for milk yield (MY), SSC, CP, BF, lactose, Cl, TS, SNF and milk density were 1.32 litres/day, 1.48x105 cells/ml, 3.65%, 4.34%, 4.20%, 0.15%, 12.29%, 7.95% and 27.98 respectively. Conclusively, values of parameters are within the recommended ranges and milk from NL goats is good for consumption.

Keywords: Cross breeding, Dairy goats, Milk yield, Nutrition, Small East African goats, Udder health

Introduction

Since the 1960s dairy goats have been imported in Tanzania to uplift the nutritional and economic standards of the poor households mainly in rural communities (Mtenga and Kifaro, 1992; Das and Sendalo, 1990). The consumption of milk in these communities has increased following introduction of dairy goats. The economic and nutrition benefits of dairy goats in the country are increasingly reported (Eik *et al.,* 2008; Krogh *et al.,* 2007; Chenyambuga *et al.,* 2014). Mgeta division in Morogoro region is one example of the rural communities in the country which had high level of animal protein insecurity. For this reasons, the Sokoine University of Agriculture (SUA) also in Morogoro region, Eastern Tanzania, selected Mgeta as a centre for testing and breeding of Norwegian Landrace (NL) goats in late 1980s (Mtenga and Kifaro, 1992). Crossbreeding with the indigenous Small East African (SEA) goats was the main option of producing these goats to enable good survival rates. The NL is currently the major breed among dairy goats and is found in Morogoro and Manyara regions (Kifaro *et al.,* 2007; Msalya *et al.,* 2017). The conducive climate has enabled the thriving of NL goats in Mgeta making it a hub of breeding in the country while increasing milk consumption from zero in 1980s to 1.6 litres per household per day in recent years (Kifaro *et al.,* 2012). Since introduction of dairy goats, there have been fewer efforts to evaluate quality of milk from dairy goats. Published reports are few

and include one study by Ryoba and Hansen (1988) on SEA goats milk quality and another by Kiango (1996) mainly on growth and milk production in NL goats. Elsewhere goat milk quality has been studied extensively including as old as 30 years e.g. Rasic and Kurmann (1978). Therefore the objective of this study was to determine the quality of goat milk in NL goats with particular interests on the nutritional components and udder health.

Composition and quality are important attributes of milk for human consumption. The composition refers to contents of the various nutrients present in milk whereas quality is related to health, nutritional value, hygiene and sensory attributes which satisfy the expectations of the consumers. Milk quality and composition can be affected by many factors including parity, breed, stage and length of lactation of the animals as well as management factors such as feeding (Goetsch *et al.,* 2011; Salari *et al.,* 2016; Ying and Hsu, 2004). In addition, these milk characteristics can be compromised by actors in different nodes of the production or supply chains for various reasons (Lie *et al.,* 2012). It is of no doubt that milk composition and quality can vary or compromised at different nodes of milk value chain due differences in factors such as sanitation and hygiene in milk handling as well as storage conditions which often times poor resulting into high bacterial counts. Furthermore, milk quality might be deteriorated in the cause of transportation and processing due to time lag since milking and handling at the processing centre or adulteration made by farmers in order increase volumes and aimed at getting more income from sales. Moreover, other factors including diseases such as mastitis have been reported to negatively affect composition and quality of goat milk (Kifaro *et al.,* 2009). Thus we determined the composition/quality factors of milk from dairy goats based on various factors.

Materials and Methods

Study area, animals and collection of milk samples

This study was conducted in Mgeta division found at 1,550 and 1,750 metres above sea level on the western slopes of the Uluguru Mountains, about 50 kms from Morogoro municipality. The climate in Mgeta is fairly temperate with temperature ranges from 11 to 23°C and high precipitation, which favours production of dairy goats. Milk samples were collected from 50 lactating does kept by the farming households (one sample per animal per household) in Mgeta. The farming households were participating in a dairy goat up-scaling project conducted by researchers from SUA and their participation was voluntary. The farmers are spread in five villages in division (Nyandira, Tchenzema, Mwarazi, Ndugutu and Kibagala) and only 10 households per village were involved in the study. Twenty (20) samples were picked from milk bulked at two collection centres (10 samples per collection centre) while and five (5) others were processed milk (either pasteurized milk or yoghurt) from the processing centre at Nyandira. From the goats, milk was obtained directly from the doe after complete milking and measuring milk yield (MY) at morning milking (between 7 and 10 am). At the collection centres the sampling was between 10 to 11 am when all farmers have bulked the milk and samples were obtained from the containers. At the processing centre the samples were obtained on one day after sampling in the villages. Each sample was about 100 mls in sterile falcon tubes. A cool box with ice blocks (about 4°C) was used in packing the samples which were transported to SUA within Morogoro municipality on the same day. Care was taken not to contaminate the milk during sampling and delays were avoided. Preservation was done with potassium dichromate pellets and sampling was extended for two weeks. The collection and processing centres are owned by the association of these farmers known as TWAWOSE.

Analysis of somatic cell counts (SCC)

Somatic Cell Count (SCC) was determined as described by Dhakal (2006). Briefly, milk film on slides was fixed in methanol for about five minutes, dried and held in Newman Lampert stain for two minutes and dried at room temperature. Finally the film was washed with tap water three times as well as two times with distilled water before a final drying at room temperature was done. The SCC was obtained

using an electron microscope with oil immersion and was calculated as the possible number of such fields counted in cm2 (4,000). Milk volume represented by each field was 1/100×1/4,000 = 1/400,000, hence, the microscopic field (MF) was 400,000 milk volume/field; Total number of fields counted was 50. The working factor (WF) was calculated as 400,000/50=8,000. Finally, SCC/ml was obtained by multiplying the WF 8,000×number of cells counted.

Analysis of milk composition

All samples were analysed for milk density, total solids (TS), solids not fat (SNF), crude protein (CP), butter fat (BF), lactose, and chlorine (Cl). Milk density and pH were determined by using lactometer and pH meter respectively whereas TS was analysed by direct oven drying (AOAC, 1990). Total protein content was analysed by the standard Kjeldahl method as described by AOAC (1990). The CP content was obtained after multiplying Nitrogen (N) content by a factor of 6.38. The BF was determined by the standard Gerber method (Van den Berg, 1998). The determination of lactose content was done according to IDF method for determination of lactose in milk as directed by the International Standards No. 28 of 1974 (cited by Luguru, 2008). The Cl content was determined by titration using the standard silver nitrate (0.1M) solution as described by Harold *et al.* (1981). The MY was included in the study as one of the factor affecting the composition and was measured using a measuring cylinder in the households.

Data analyses

Raw data were edited and processed using spreadsheet before analyses. The General Linear Model (GLM) procedure of the statistical analysis system (SAS, 2004) was used in the analyses of data. The linear model involved stage of lactation (L), parity (P), and blood level (B) as fixed effects and SCC, MY, lactose, BF, CP, TS, SNF and chloride as dependent variables and is shown here. Comparisons were done by t-test and decisions were based on 5% level of significance or 95% of confidence.

$Yijk = \mu + Li + Pj + Bk + Eijk$

Yijk = Dependent variables

μ = Overall mean

Li = Effect of the ith stage of lactation (1 – 2, 3 – 4 and 5 – 6 months)

Pj = Effect of the jth parity (1 to 5)

Bk = Effect of the kth blood level (50%, 75% and >75%)

Eijk = Random residual error

Results and Discussion

Milk yield (MY)

The MY was recorded in 50 lactating does during sampling. The animals were grouped according parity levels 1 to 5, stage of lactation (early, mid or late), and NL blood levels (crossbreeding level between SEA and NL goats e.g. 50, 75% or higher). The overall MY was 1.32±0.06 litres/day (l/d) and ranged from 1.26±0.09 l/d in animals in the fifth parity to 1.41±0.08 l/d in those which were in the first parity. No significant difference was obtained in MY between parities. With respect to stage of lactation, more milk was recorded for does in the late stage of lactation compared to those in early and mid stages. The different was not significant among the stages. Concerning the blood levels, more milk was produced when the blood levels increased from 50% to higher NL blood. Fifty percent crosses produced 0.74 l/d whereas 75% and higher animals were able to solicit up to 1.07 l/d. The difference was significant ($P<0.001$). Detailed results are summarized in Table 1.

Somatic cell counts (SCC)

In the present study, the overall mean for SCC was 1.48±0.06x105 cells/ml. Also, the SCC values were compared in milk obtained for different parities, stage of lactation and in blood levels of the goats involved in the study (Table 2). There was significant variation in SCC values between parities ($P>0.05$) although there was a slight increase in SCC with advancing stage of lactation. Significant difference ($P<0.05$) was also obtained between early and mid stages or early and late stages when these were considered independently. As for the varying blood levels of NL goats, there was no significant variation with respect to SCC values although the values were lower in 75% animals compared to those of 50% or above 75%.

Table 1: Milk yield (MY) in the Mgeta Norwegian dairy goats based on parity, stage of lactation and blood level (Mean±Standard error, Abb. SE)

Source of Variation		n	MY (litres/day)	Remarks
Overall		**50**	**1.32±0.06**	
Parity	1	8	1.41±0.08	NS
	2	12	1.26±0.06	
	3	12	1.34±0.06	
	4	15	1.33±0.05	
	5	3	1.26±0.09	
Stage of lactation	1 – 2 months	31	1.25±0.02	NS
	3 – 4 months	12	1.29±0.08	
	5 – 6 months	7	1.34±0.09	
Blood level	50%	30	0.87±0.03b	***
	75%	9	1.06±0.06b	
	>75%	11	1.71±0.08a	

MY: Milk yield; NS: Not significant P>0.05

Table 2: Somatic cell count (SCC) in fresh goat milk based on parity, stage of lactation and blood level (Mean±SE)

Source of Variation		N	SCCx105 cells/ml	Remarks
Overall		**50**	**1.48±0.06**	
Parity	1	8	1.19±0.08	NS
	2	12	1.29±0.06	
	3	12	1.28±0.06	
	4	15	1.28±0.06	
	5	3	1.22±0.15	
Stage of lactation	1 – 2 months	31	0.85±0.09b	*
	3 – 4 months	12	1.29±0.06a	
	5 – 6 months	7	1.60±0.14a	
Blood level	50%	30	1.25±0.02	NS
	75%	9	0.69±0.07	
	>75%	11	1.21±0.04	

SCC: Somatic cell counts; NS: Not significant P>0.05

Composition parameters in fresh goat milk

Furthermore, the components of milk quality were quantified including milk density, TS, SNF, CP, lactose, BF, as well as Cl and are presented in Table 3. Overall milk density was 27.98±0.09 and ranged from 26.73±1.18 in the fifth parity to 28.94±0.49 in animals on second parity and differed significantly from the first to the fifth parity. With regard to stage of lactation and blood levels the difference was not significant. The overall TS was 12.29±0.08. Blood level had a significant (P>0.05) effect on TS content but other factors did not influence the parameter. In the present study the overall CP was 3.65±0.05%. Both stage of lactation and parity had significant influence (P>0.01) on CP content. There was a slight decrease in CP with advancement of stage of lactation. Concerning lactose content the overall mean was 4.20±0.06 percent and none of the factors in the model showed significant influence on it. As a general note, lactose content was fairly stable

Table 3. Composition of the important nutritional elements in goat milk (Mean±SE)

Variation	N	Milk density	TS (%)	SNF (%)	CP (%)	Lactose (%)	BF (%)	Cl (%)
Overall	**50**	**27.98±0.09**	**12.29±0.08**	**7.95±0.09**	**3.65±0.05**	**4.20±0.06**	**4.34±0.04**	**0.15±0.04**
Parity		*	NS	NS	**	NS	NS	NS
1	8	27.43±0.62b	12.04±0.16	7.79±0.15	3.63±0.08	4.27±0.13	4.24±0.17	0.15±0.01
2	12	28.94±0.49a	12.38±0.13	8.16±0.12	3.68±0.06	4.14±0.11	4.22±0.12	0.16±0.01
3	12	27.01±0.49b	11.95±0.13	7.69±0.13	3.69±0.06	4.31±0.10	4.27±0.14	0.15±0.01
4	15	28.09±0.50a	12.23±0.13	7.96±0.12	3.47±0.07	4.01±0.11	4.27±0.06	0.15±0.02
5	3	26.73±1.18c	12.08±0.31	7.66±0.29	3.17±0.15	4.19±0.25	4.42±0.17	0.04±0.01
Lactation		NS	NS	NS	**	NS	NS	NS
1-2 months	31	27.15±0.84	12.14±0.16	7.83±0.15	3.75±0.09	4.17±0.16	4.36±0.19	0.15±0.01
3-4 months	12	28.76±0.46	12.13±0.23	7.08±0.22	3.53±0.06	4.19±0.11	4.21±0.16	0.15±0.01
5-6 months	7	28.62±0.51	12.12±0.18	8.12±0.14	3.29±0.14	4.15±0.03	4.29±0.12	0.14±0.03
Blood level		NS	*	NS	NS	NS	*	NS
50%	30	27.35±0.53	12.79±0.14a	7.91±0.13	3.47±0.07	4.19±0.11	4.89±0.16a	0.15±0.01
75%	9	27.87±0.62	11.81±0.16b	7.82±0.15	3.55±0.11	4.19±0.13	3.57±0.17b	0.15±0.01
>75%	11	28.61±0.71	12.63±0.19a	8.04±0.17	3.49±0.13	4.14±0.19	3.38±0.12b	0.14±0.02

*SCC: Somatic cell counts; TS: Total solids; SNF: Solids not fat, CP: Crude protein; CF: Crude fibre; Cl: Chloride; Milk density (Lactometer reading); *: Statistical significance P<0.05; **: Statistical significance P<0.01; NS: Not significant P>0.05*

throughout the lactation period (no significant changes among parity, lactation stages or blood levels). As for the BF, a significant decrease (P<0.05) in content with increased NL blood level was observed. No other factor significantly influenced the BF content. The range was from 3.38±0.12% in milk from animals above 75% to 4.42±0.17% in the fifth parity. The Cl was also evaluated and it was found to range from 0.14±0.02 to 0.16±0.01% in this study. Its overall mean was 0.15±0.004%. There was no statistical significance in the amount of Cl in all factors included in the model.

Composition parameters in bulked goat milk

Farmers bulk milk in one or two containers at a collection centre (two collection centres, Nyandira and Tchenzema were operational during our study). Samples obtained from milk bulked at the centres had the overall values of 0.94×105 cells/ml, 27.79, as well as 12.79, 8.63, 3.56, 4.17, 4.30, and 0.15 percentages for mean SCC, milk density as well as TS, SNF, CP, BF, Lactose, and Cl respectively. Detailed information is presented in Table 4.

Quality and composition parameters in processed goat milk

The association of dairy goats' farmers process pasteurized milk and yoghurt at a processing centre in Nyandira. The same parameters as was in the fresh milk as well as pH were measured. The values of these elements are presented Table 5 and only pH differed significantly between the two forms. For pasteurized milk the pH was 6.2±1.01 and 4.81±0.82 in yoghurt. The milk density was 27.87± 0.63 in pasteurized milk and 28.01±0.31 in yoghurt.

Discussion

Among the dairy goats involved in crossbreeding programmes in Tanzania the NL is the major breed and NL animals are found almost everywhere in the country (Msalya *et al.,* 2016). The potential and benefits of dairy goats are now evident and increasingly report (Chenyambuga *et al.,* 2014; Eik *et al.,* 2008). Until 1988 there were no dairy animals in the highlands areas of Mgeta, Morogoro and milk consumption was zero. Since a previous evaluation in these goats in 1996 (Kiango, 1996)

Table 4: Values of quality and nutritional elements in bulked milk

Factor	Nyandira (N = 10)	Tchenzema (N = 10)	Overall
SCC (cells/ml)	1.02 ± 0.12×105	0.89±0.09×105	0.94×105
Milk density	28.05±0.71	27.72±0.60	27.95
TS	12.97±0.24	12.67±0.21	12.79
SNF	8.72±0.18	8.56±0.16	8.63
CP	3.59±0.09	3.55±0.08	3.56
CF	4.25±0.11	4.12±0.09	4.17
Lactose	4.24±0.13	4.34±0.11	4.30
Cl	0.15±0.01	0.15±0.01	0.15

SCC: Somatic cell counts; TS: Total solids; SNF: Solids not fat, CP: Crude protein; CF: Crude fibre; Cl: Chloride; Milk density (Lactometer reading); Means were not significantly different (P>0.05)

Table 5. Composition goat milk products (pasteurized milk and yoghurt)

Product (N = 5)	pH	BF	CP	Lactose	Cl	Milk density	SNF	TS
Pasteurized	6.2±1.01	4.31± 1.25	3.50±0.64	4.27±0.05	0.15±0.09	27.87±0.63	7.83±0.41	12.14±0.50
Yoghurt	4.81±0.82	3.90 ± 0.60	3.81±0.30	4.12± 0.04	0.16±0.10	28.01±0.31	8.20±0.32	12.71±0.47
	*	NS	NS	NS	NS	NS	NS	NS

**: P<0.05; NS: Not significant (P>0.05)*

MY has increased from 1.03 to 1.4 litres per animal per day while consumption has reached 1.6 litres per household per day in recent years (Kifaro *et al.,* 2012). Although quality is of primary priority in any food production system, previous research in dairy goats in Tanzania has concentrated on animal management to improve breeding and milk production. As such quality of goat milk is under studied. Thus our objective was to determine the quality of goat milk in the study sites. We included MY as one aspect of the study because of its relationship with milk quality.

The SCC is a widely used parameter in the evaluation of milk quality and is an indication of udder health in dairy animals including goats (Raynal-Ljutovac *et al.,* 2007). In our samples, this was in the normal ranges in goat milk and slightly lower than the values reported earlier by Luguru (2008) in the same area (1.8±0.48x105 cells/ml). Greater number of SCC has been associated to mastitis and intramammary infection in goats and sheep. In Cyprus, the level of SCC in mastitic ewes was estimated to be 2.0x106 cells/ml (Mavrogenis *et al.,* 1995). The lactometer readings (milk density) were in the range of 27 to 28.9, within the ranges for goat milk but a little lower to those of cows and buffalos milk (Kanwal *et al.,* 2004). This may also indicate lack of adulteration in the milk we collected. Concerning TS the mean values were within the recommended levels and are closer to the values reported by various authors including for example 12 to 16% in Damascus goats (Frederick and Harris, 2003) and 10.98 to 13.01% in Alpine goats (Hadjpanayiotou, 1995).

The SNF is one indicator of protein content in milk and the overall mean of 7.95±0.09 was obtained. This is closer to normal values in goat milk about 8 in most literature including Kanwal et al. (2004) and Kapadiya *et al.* (2016). We also obtained values for CP within the most ranges in literature (3.52 to 4.10%) as reported by various workers including Mgeta (Luguru, 2008) and elsewhere (Frederick and Harris, 2003; Harold, 1999).

Lactose is a principal sugar in milk and in goat it has been pretty above 4% in conformity with our findings (4.20±0.06%). In literature, BF in goat milk is highly variable and ranges from 3.0 to 6.0% (Frederick and Harris, 2003). In Kenya, milk from the Galla goats was shown to have overall BF of 3.5±0.16% (Okeyo and Ahuya, 1998) slightly lower than the values we obtained in this study (4.34±0.04). Galla are meat specialized goats (Ngila *et al.,* 2016) and therefore lower BF value may be expected. The Cl was also evaluated as one of the minerals in milk and it was found to range from 0.14±0.02 to 0.16±0.01%t in conformity with values reported in the literature for goat milk (between 0.15 and 0.17% with mean value of 0.16%) as for example in Kapadiya *et al.* (2016). Also, Luguru, (2008) reported 0.15±0.005% for BF in the same study area. Currently there are only two collection centres in the project site and our results show comparable values for the determined parameters. Overall our results were in good ranges and thus milk and milk products from our animals were nutritionally of acceptable composition and from health udders. We encourage the farmers in Mgeta to maintain this spirit of managing the animals following good management practices as it was during the period of this study.

Conclusions

Dairy goats are becoming popular in Tanzania and they have played a significant role in milk production in places where it is difficult to keep dairy cattle. It is of great important to monitor the yield, composition and nutritional quality of milk from goats for informed management decisions for both animals and milk values chains. Based on the findings of the present study, we conclude that milk production from the NL goats in Mgeta division has been increasing since the past decade. The increase may be a factor of improved management such as feeding, housing and disease control among others. Over the years the farmers in the study areas have been constantly followed in training on improved goat husbandry practices by the dairy goats' project implementing team at SUA. With respect to quality, the milk is shown to possess recommended quality values for goat milk and good for consumption. No significant variation in composition with relation to aspects such as parity, stage of lactation and NL blood levels.

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Conflict of Interest

We declare that no conflict of interest exist for this article.

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