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Comparison Of Milk Component Levels, Processability And Mozzarella Cheese Acceptability From Toggenburg And Their Crosses In Kenya

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ABSTRACT

Comparison of milk component levels, coagulation rate, cheese yield and sensory attributes of mozzarella cheese from Toggenburg and its cross breed with Galla goat was studied through a lactation period of 120 days. The component levels of fat, protein, ash and totals solids from the two genotypes were found to be significantly different at $\alpha = 0.05$. Toggenburg genotype had percent levels of 3.32, 2.85, 0.92 and 10.44 while cross breed had 3.87, 3.51, 0.82 and 11.68 for fat, protein, ash and total solids respectively. Cheese yield differed significantly at 18.66% for Toggenburg compared to 15.23% for cross breed. The correlations (r) between milk component and cheese yield were as follows: cross breed: r = 0.28, 0.42 and 0.65; Toggenburg: r = 0.38, 0.63 and 0.64 for protein, fat and totals solids respectively. A very weak correlation was observed between the fat and protein components of milk from the cross breed and the yield of the mozzarella cheese; Milk coagulation rate showed significant differences at 7.45 minutes for Toggenburg and 8.29 minutes for the crossbreed genotype. Mozzarella cheese made using milk from both genotypes also differed significantly in overall acceptability and scores for flavor, texture, finish and colour. Overall acceptability for Toggenburg cheese on a 5-point hedonic scale was 3.80 with cross breed genotype scoring 3.63. Descriptive sensory analysis for mozzarella cheese using assigned scores for flavour, texture, finish and colour showed differences between the genotypes with toggenburg cheese having higher scores for the sensory attributes. Except milk protein, cheese protein content and coagulation rate, all other components and sensory attributes were significantly influenced by the stage of lactation for both genotypes.

Keywords: cheese yield, goat milk, milk coagulation rate, sensory attributes

INTRODUCTION

In Kenya dairy goat farming has grown significantly through community based dairy goat improvement projects implemented by Farm-Africa (Meru, Kitui, Mwingi) and Heifer Project International in Kwale, Homabay, Nyakach, Rongo, Siaya, Suba and Bomet districts (Ogola *et al.,* 2010). Through these projects pure Toggenburg among other dairy goats breeds were imported and crossbred with indigenous goats (Small East African and the Galla) with the aim of improving milk productivity and growth rate while retaining the beneficial characteristics of the indigenous genotype suitable for tropical climatic conditions. Studies by Ojango *et al* (2010) indicate that milk production has increased from 250 ml by the indigenous goats to 2-3 litres by the three quarter crossbreeds. The herd size of dairy goats in Kenya has also grown significantly and is estimated to be over 200,000 with an annual milk production of 43.8 million litres contributing approximately 1% of the total milk production in the country (MOLD, 2010).

Goats' milk contains bioactive components such as medium chain fatty acids and serum proteins which confer health benefits besides nutrition (Alfrez *et al.,* 2003; Barrionuevo *et al.,* 2003; Haenelein, 2004; Rampilli *et al.,* 2004). These health benefits have been used in Kenya to promote consumption of goats' milk as disease mitigation/intervention measure focusing on child malnutrition and supporting families affected by HIV and AIDS (Ogola *et al.*, 2010). The understanding of the linkage between diet and health and the interest in self-health maintenance has been driving the demand for the goat milk.

For the country to fully exploit the dairy goat industry for economic growth (improved income and overall livelihoods of the rural poor with limited access to livestock asset base) there has been need to expand the market access through value addition and processing of goat milk for the local niche market. Studies in Kenya by Ogola *et al.,(*2010) have shown limited levels of goat milk value addition with most of the milk being marketed raw. Huge opportunities exists in research to innovate new products with the marketing strategy focusing on the use of technical information about goat milk which is its unique selling point.

Among the value addition products is the processing of milk into cheese. Kenyan market for cheese though small is still growing in popularity with a niche among tourists, expatriate residents and local population of middle and upper income. Annually about 10 million litres of milk in Kenya is converted into cheese with cheese production from goats milk being limited and insignificant (Lati, 2007). The slow growth of high value products like cheese among the general populace is partly due to lack of an acquired taste for such products (Maigua P.K unpublished information). Production of specialty goat milk products such as mozzarella would enhance market outlet for the pizza (in which it is an essential ingredient), prolong the shelf life of the milk and provide a concentrated form of nutrients for the consumers interested in self-health maintenance.

The quality of goat milk may be defined as its potential to undergo technological treatment and result in a Product which lives up to the consumer's expectations in terms of nutritional value, safety, and sensory attributes (*Boyazoglu et al., 2001*). Thus, the quality of the milk is closely related to its physico-chemical and biological composition on which its technological capacities are based on (Soryl *et al.*, 2005).

Previous studies in the country have focused more on milk yields from dairy goats and their cross breed with little information provided on the influence of the cross breeding programmes on the component levels and technological capability of the milk from the breeds. Studies by Park *et al* (2007) has shown that milk quality depends on a large number of factors which are related to both the animal (breed, number and stage of lactation, health status) and the conditions of production (region, diet, rearing system) and has a predominant influence on the quality of subsequent goat milk products. Therefore, this study was intended to evaluate the consumer acceptability of Mozzarella cheese and the technological capability (coagulation rate and cheese yield) of milk from Toggenburg and their crosses in Kenya.

MATERIALS AND METHODS

Experimental Does

This study was carried out at Naivasha Sheep and Goat Stattion (NSGS). The experimental does were selected from a flock maintained at the station. The does were balanced for parity, their kidding synchronized and put under similar Management system during the entire experimental period. A total of 10 does were used, 5 Toggenburg and five cross breed ($^3/_4$Toggenburg x $^1/_4$ Galla Goats).

Sampling of Goat milk

The does were milked once a day in the morning on each recorded day. Duplicate milk samples were taken systematically from each breed fortnightly until the end of the experimental period. The samples were assayed for proximate composition of Fat, Protein, Ash and Total Solids following official methods (AOAC 2000). The analysis was replicated 6 times during the experimental period.

Mozzarella Cheese Preparation

Two batches of Mozzarella cheese consisting of milk from each breed was prepared fortnightly up to the 16th week of lactation. 10 kg of milk from each breed was used to prepare cheese following the procedure by Koskowiski (1997). YF – L812 thermophilic culture and Chy – Max Rennet powder both from CHR Hansen was used. Weight of the cheese prepared was determined on the second day. Duplicate samples from each batch were taken for proximate analysis following official methods (AOAC 2000).

Determination of milk coagulation rate

The milk clotting activity was determined following modified procedure by Arima et al. (1970). 10 ml pasteurized milk was added Calcium Chloride (0.01 M) and starter culture and the milk held for 30 minutes in a water bath at 30^{o}c. 0.05 mL of 1% enzymatic solution was added into the milk and the test tube subjected to slight rotation until a layer of film of milk appeared inside the wall of the tube. The time obtained was the mean of three trials.

Analysis of cheese

A representative sample of 100 g of the cheese from each breed was taken for analysis. The sample were analyzed for Moisture (%), Fat (%) and Protein (%) following official methods (AOAC 2000).

Weight of the cheese prepared was determined on the second day after preparation. The actual cheese yield was expressed as kg/kg of goat milk used. Actual yields of the cheeses were expressed as kg of cheese per 100 kg of goat milk.

Because no standard moisture content has been established for goat cheese varieties, the mean moisture content of experimental cheese made in this study was used to determine moisture adjusted cheese yield and hence the cheese yield formulae. The average moisture of the Mozzarella cheese for Toggenburg and its crossbreed used was 56.23%. Cheese yields were predicted using the Van Slyke formulae (1949) as well as the formulae developed in this study. Cheese yield efficiency was expressed as the percentage of the moisture-adjusted cheese yield to the predicted cheese yield.

Sensory evaluation

Descriptive sensory analysis for flavour, appearance, body and texture of mozzarella cheese from the Toggenburg and their crossbreds was performed on the second day after processing by a panel of 5 cheese graders. The procedure by Murray et al (2001) was used. The panelists evaluated cheese samples using the following lexicons for intensities of flavor (Mild flavor - floral, fresh, creamy, sourness and goaty), body and texture (meltability, stretchability, firmness, Stickiness, adhesion to palate and slicing characteristics), finish (smooth and compact) and colour/appearance. Maximum Scores of 45, 30, 15 and 10 points were assigned to flavour, body/texture, finish and appearance/colour parameters respectively. To determine consumer acceptability, a group of 35 potential consumers drawn from Dairy Training Institute were presented with the mozzarella cheese and asked to indicate their liking for the cheese product on a 5 point hedonic scale. The participants were varied in age (19 – 59 years), balanced in gender (Female 18 and Males 17) and having positive altitude (liking) towards cheese. The cheeses were coded with three-digit numbers assigned randomly, and presented in a random order.

Data analysis

The data was analyzed using Analysis of Variance (ANOVA) with the help of the computer Statistical Analytical Systems (SAS 2001) program. The significance of difference between the means was performed using Tukey's Studentized Range Test. For all analysis, statistical significance was accepted at the $P \leq 0.05$ level of probability

RESULTS

The results of analysis of milk and cheese from Toggenburg and the cross between Toggenburg and Galla are given in the tables below.

Table 1: Mean Values for Milk Fat, Protein, Ash and Total Solids according to Genotype and Lactation Stage.

Genotype	Lactation Stage	Fat %	Protein %	Ash %	Total Solids %
Breed	Cross Breed	3.87 a	3.51 a	0.82 b	11.68 a
	Toggenburg	3.32 b	2.85 b	0.93 a	10.44 b
Lactation Stage	Early Lactation	3.70 a	3.24 a	0.89 a	11.40 a
	Mid Lactation	3.59 b	3.15 a	0.89 a	11.18 a
	Late Lactation	3.50 b	3.16 a	0.86 b	10.59 b

Tukey Grouping Means with the same letter are not significantly differently at α = 0.05*

Table 2: Mean values for Cheese Yield, Cheese Moisture, Cheese Protein, Cheese Fat and Milk Coagulation Time.

Genotype	Lactation Stage	Cheese Yield (%)	Cheese Moisture (%)	Cheese Protein (%)	Cheese Fat (%)	Coagulation Time (Min)
Breed	Cross Breed	15.23 b	57.43 a	19.41 b	22.75 b	8.29 a
	Toggenburg	18.66 a	55.02 b	20.28 a	24.44 a	7.45 b
Lactation Stage	Early Lactation	17.65 a	56.75 a	19.88 a	23.84 a	7.90 a
	Mid Lactation	16.98 a	56.34 a	19.83 a	23.60 ab	7.88 a
	Late Lactation	16.20 b	55.59 b	19.82 a	23.35 b	7.84 a

Tukey Grouping Means with the same letter are not significantly differently at α = 0.05*

Table 3: Mean values for Scores of Acceptability, Flavour, Texture, Finish and Colour.

Genotype	Lactation Stage	Overall Acceptability	Flavour Score	Body & Texture Score	Finish Score	Colour Score
Breed	Cross Breed	3.63 b	39.9 b	25.6 b	10.8 b	7.2 b
	Toggenburg	3.80 a	40.7 a	26.1 a	11.0 a	7.3 a
Lactation Stage	Early Lactation	3.70 b	40.0 b	25.4 c	11.1 a	7.4 a
	Mid Lactation	3.60 c	41.1 a	26.3 a	11.1 a	7.1 c
	Late Lactation	3.85 a	39.9 b	25.8 b	10.6 b	7.3 b

Tukey Grouping Means with the same letter are not significantly differently at α = 0.05*

DISCUSSIONS

The component levels of butterfat, protein, ash and total solids from the two goat genotypes was found to be significantly different with cross breed having a higher butterfat content, protein and total solids compared to that of pure Toggenburg. The ash content of Toggenburg was higher than that of the cross breed. Fat content for both genotypes exhibited significant deference between early and both mid and late lactation, however there was no significant difference between the mid and late lactation for both genotypes. Values of total solids and ash were significantly different between late lactation and both early and mid-lactation. Protein content was not significantly different across the lactation stages. The cross breed had superior composition of milk component except for ash which was higher in toggenburg genotype.

The values of fat, protein, ash and totals solids of Toggenburg were slightly different from that reported by Victor H. et al., (2010) of 3.12 +/- 0.27, 3.03 +/- 0.08, 0.96 +/- 0.01 and 10.52 +/- 0.32 respectively. This may be due to differences in nutrition as a result of geographical location. The cross breed with indigenous goats exhibited higher value for butterfat. This is expected as the indigenous African genotypes have been reported to have higher component levels for protein, fat and total solids (Adewumi *et al*., 2009, Zahraddeen *et al*., 2007, Donkin *et al*., 1996).

The values for cheese yields from the Toggenburg were found to be significantly higher than that from its cross breeds. This is in agreement with previous studies on the soft cheese from the same breed. Soryal *et al*., (2004) reported yield of Domiati soft cheese between 12 and 18% while Olizsewki et al, (2002) found 16.5% as the mean yield value of the same.

Even though moisture content of soft cheese depends on the manufacturing technology, the mean moisture content of 57.43 and 55.02 for cross breed and toggenburg are in agreement with previous works that have established moisture content of between 48.7% and 57.1% (ALbenzio *et al*., 2006) and as high as 60% (Gou *et al*., 2004) for Cacioricotta and Domiati soft cheeses respectively. Moisture contents of between 52.0% – 58.0% and fat content of 18% in mozzarella cheese has been found to be suitable for use as pizza topping (Koskowski, 1960).

Research on both commercial and laboratory scales have established relationships between milk components (fat and casein) or cheese composition (moisture, fat, protein) and yield for a variety of cheeses such as Cheddar and Gouda (Lolkema 1993, Brito *et al*., 2002).

Cheese yield from toggenburg was significantly higher than yield from cross breed genotype even though the later had higher values for milk protein and fat. This suggests that most of the fat and protein from cross breed may have been lost during processing. Toggenburg breed exhibited a higher retention values for both protein and fat which indicates that milk from this genotype had better cheese making characteristics.

Together with hygiene and milk composition, milk clotting properties are important technological parameters as they influence later cheese making operations such as draining and ripening. poor clotting properties can lead to yield losses in cheese making as well as poor cheese quality, requiring the adoption of technological modifications for particular type of milk. The toggenburg genotype exhibited better coagulation properties compared to cross breed.

The cheese yield differed significantly between the late and both early and mid-lactation, however there was no significant difference between yield in early and mid-lactation across the breeds. This seems to be in agreement with findings of Sapru *et al*., (1997) in Cheddar cheese, that the relative losses in fat and protein during cheese making are greater for cow milk produced at the end of lactation with respect to milk produced at the beginning of lactation, with consequent minor recovery of substances in the curd.

The correlation between Moisture Adjusted Cheese yield and milk components was determined. The average moisture content was calculated as 56.23 and used to determine moisture adjusted cheese yield since no previous work has been reported on mean moisture content of goat mozzarella. The correlations between milk component and chees yield (r)were as follows: cross breed protein (r = 0.28), fat (r =0.42), total solids (r = 0.65); Toggenburg protein (r = 0.38), fat (r = 0.63), total solids (r = 0.64). There was a very weak correlation between the fat and protein components of milk from the cross breed and the yield of the mozzarella cheese. This could be as a result of technological manipulation of cheese during the manufacture. Certain technological steps in mozzarella cheese making which include immersing curd in hot water at 70^{o}c to enhance plasticity and facilitate stretching are likely to have an effect on retention of some of the milk component and hence yield.

Even though various trials have come up with cheese yield prediction formulas, most of these are based on the milk from cow and to a lesser extent that of buffalo. Van Slyke formula though developed for prediction of cheddar cheese yield is the most widely used for cheese yield predictions. It was based on the finding that 7% of fat and 4% of the casein would be lost in whey. Different cheeses have been found to have different rates of component recovery as a result of different cheese making procedure and hence yield prediction formulae need to be adjusted for a particular cheese procedure. Studies by Barbano, D. M (1996) based on Van Slyke formula has shown retention factors for fat, casein and total solids in mozzarella cheese as 0.85, 0.96 and 1.13 respectively. Retention factors for totals solids has been found to increase with increase in moisture content in cheese and this explains why total solids retention for mozzarella cheese is higher than 1.09 reported for cheddar cheese. Comparing the yield efficiency between the moisture adjusted yield to the predicted yield using Van Slyke formulae a large variation was found from the yield of Toggenburg at 148% efficiency while cross breed had 96% yield efficiency. Such a huge variation indicates that theVan Slyke formulae may not be adequate to predict the yield of mozzarella cheese from goats' milk. Various studies have shown huge differences in milk component recoveries during cheese making using sheep milk where Pirisi A.G., *et al* (2000) reported recoveries of 78 – 81.4% fat and 75.4 – 79.5% protein, Gonzalez J.M *et al*., (1991) recoveries of 65% fat and 65% protein while Economides S.E *et al*., (1987) reported recoveries of 86.9% fat and 78.6% protein. This huge variation in recoveries from sheep milk may probably hold true for goat milk as there are more similarities between sheep and goat milk compared to that of cow and buffalo.

From the results a cheese prediction formula, $Cy = 5.61\ F + {}^{-}1.85\ P$ was proposed for predicting yield of mozzarella cheese based on the results from the two goat genotypes. Where Cy = yield of Mozzarella cheese, F and P are fat and protein contents in milk while 5.61 and $^{-}$1.85 are retention coefficients for fat and protein.

On the sensory attributes, mozzarella cheeses produced using the milk from the two genotypes had significant differences in overall acceptability, flavor, texture, finish and colour scores. Mozzarella from toggenburg had higher mean score of 3.80 on a 5 – point hedonic scale representing 76% acceptability while cross breed had 72.6% acceptability with mean hedonic score of 3.63.

Cheeses from toggenburg and cross breed had total points of 85.1 and 83.5 respectively on scores for flavor, texture, finish and colour. These scores exhibited significant differences between the genotypes in tukey grouping at 95% confidence level.

In cheeses like mozzarella, texture plays an important role in determining consumer acceptance and the flavour cannot be uncoupled from texture when the consumers evaluate cheese (Foegeding *et al*., 2007). Stretchability a texture component is a key quality parameter for mozzarella cheese intended for use as an ingredient in pizza preparation. This desirable characteristic is brought about by action of lactic acid on dicalcium - para- caseinate at ph 5.2 to 5.4 which converts it to mono -calcium para-caseinate which provides the strings and sheen to the cheese (Kosikowski, 1958).

Even though these results show significant differences in sensory scores, acceptability of the mozzarella cheese produced from milk of both genotypes was found to be above average. Texturally, the cheese from toggenburg genotype was characterized by a creamy dense and compact body that may have allowed for the development of bloom in the flavor, resulting in enhanced perception from the cheese graders and the consumers panelists.

The cause of the variation in scoring may be due to the richness of mozzarella cheese from toggenburg as result of high retention values of fat in the cheese. However more studies need to be done on the fatty acid levels of the cheese from the two breeds to determine the actual cause of the difference in cheese sensory scores.

Overall acceptability across the lactation stages was significantly different with mid and late lactation stages across the breeds showing the highest difference of 0.25 in mean acceptability scores. Even though cheese from mid lactation milk across the genotypes had the lowest score in terms of overall acceptability from consumer panel it exhibited very high scores from graders in terms of flavor, texture and finish. This may be due to lack of acquired taste for cheese by the majority of general consumer panelists.

CONCLUSIONS AND RECOMMENDATIONS

Goat breeds significantly influence milk composition. Though milk from cross breed with indigenous goats is richer in important components, slight modification of technological processes need to be adopted to achieve the same cheese yield as milk from pure toggenburg.

As the demand for cheese continue to increase and particularly mozzarella which is an important ingredient in pizza industry, the cheese making properties of milk from dairy goat breeds in Kenya need to start playing an important role in breeding objectives with an aim of maximizing yield while meeting consumer demands for sensory acceptability.

To better understand the key limitations in achieving the same cheese yield from crossbred genotypes as from pure toggenburg, further studies on protein polymorphism need to be undertaken to compare levels of casein variants in milk of toggenburg and crossbreeds which have been known to affect milk yield, milk composition, micelle organization, coagulation characteristics and cheese yield.

Since the type and levels of fatty acids determine the overall acceptability of goat cheese, more studies need to carried out to evaluate the fatty acid profile in the milk from the two goat genotypes. Studies need to be carried out to determine fat and protein recovery values for various cheeses from goat milk and then propose a cheese yield formula that be used to predict cheese yield from goat milk with minimum modifications as is the case with Van Slyke method for cow milk.

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