ANALYSIS OF MILK COMPOSITION AND ACCEPTABILITY OF MOZZARELLA CHEESE FROM KENYAN TOGGENBURG DAIRY GOATS AND THEIR CROSSES WITH GALLA GOATS

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A thesis Submitted to the Graduate School in partial fulfillment for the requirement of the Master of Science Degree in Food Science of Egerton University

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DECLARATION AND RECOMMENDATION

Declaration

I hereby declare that this thesis is entirely my original work except of such references and quotations that have been attributed to their authors or sources. This thesis has never been submitted for any degree of examination here in Egerton or in any other university.

Signature …… Date ……..……..

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KM16/1906/07

Recommendation

This thesis has been submitted for examination with our approval as university supervisors.

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DEDICATION

I dedicate this work to my beloved wife, children, mum and my late father for their support throughout the entire period of my studies.

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ABSTRACT

In Kenya, most studies involving exotic dairy goats and their cross breeds with indigenous goats have majorly focused on milk yield, kidding and growth rates with little information on the technological performance of the milk from cross breeds. In this study milk from the Toggenburg and its cross breed with Galla goat was evaluated fortnightly for composition and its capability for mozzarella cheese making over a three months lactation period. Samples of milk were analyzed for composition using official analytical methods (AOAC, 2000). Milk coagulation time was determined using procedure by Arima and Iwasaki, (1970). Mozzarella cheese was prepared following procedure by Mistry and Koskowski, (1997). The cheese yield was determined on the second day as a percentage of the cheese milk used during and its composition analyzed. Sensory attributes of the cheese were evaluated using procedure by Murray, *et al.,* (2001). Data obtained was analyzed using Statistical Analysis System. Means were separated using Least Significant Differences and for all analysis, statistical significance was accepted at the $P \leq 0.05$ level of probability. Differences were observed in milk composition being 33.32±0.12, 2.85±0.10, 0.93±0.02 and 10.44±0.52 in Toggenburg and 3.87±0.13, 3.51±0.18, 0.82±0.03 and 11.68±0.35 in cross breeds for fat, protein, ash and total solids respectively. Coagulation time was significantly elongated in cross breed milk. Mozzarella cheese yields was higher at 18.66±0.88 for Toggenburg and 15.23±0.98 for the cross breed. Cheese components were higher in Toggenburg at 20.28±0.29 and 24.44±1.21 compared to 19.41±0.19 and 22.75 ±1.51 in cross breed for protein and fat respectively. Weak positive correlation was observed between cheese yield and both protein (0.28) and fat (0.42) in cross breed while Toggenburg had weak correlation value (0.38) for protein. Total solids showed medium positive correlation with cheese yield at 0.65 and 0.64 for cross breed and Toggenburg respectively. Based on a 5-point hedonic scale, cheese acceptability scores were 3.80 for Toggenburg and 3.63 for cross breed while descriptive sensory profiles indicated differences in flavour and texture. Significant effect of the stage of lactation was observed from individual genotypes on the parameters evaluated. From the study, it is concluded that milk from the Toggenburg is superior in terms of Mozzarella cheese making properties and cheese acceptability. The study recommends determination of casein variants and fatty acid profiles in milk from both genotypes as they significantly influence cheese making and acceptability.

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CHAPTER ONE

INTRODUCTION

1.0 Background Information

Goats' milk production is a vital part of national economy in many countries, especially in the Mediterranean and Middle East region where it is well organized and developed (Park and Haenlein, 2006). It is also a dynamic and growing industry that is fundamental to the wellbeing of hundreds of millions of people worldwide (Yangilar, 2013). 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 Toggenburg among other dairy goats' breeds were imported and crossbred with indigenous goats which include the Small East African and the Galla goats with the aim of improving milk productivity and growth rate while retaining the beneficial characteristics of the indigenous genotype suitable for tropical climatic conditions. A study by Ndeke, *et al.,* (2015) reported that Galla and Toggenburg cross were better suited in terms of reproductive performance in semi arid areas of Mwingi. According to Ojango, *et al.,* (2010) milk production from the cross breed has increased from 250 ml by the indigenous goats Galla goats to 2-3 litres by the three quarter crossbreeds between Toggenburg and the Galla. In Kenya, the dairy goat population is estimated at 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).

The demand for goat milk and goat milk products has increased rapidly in the last decade because of the belief that goat milk possesses unique biologically active, therapeutic and health-promoting properties (Liang and Devendra, 2014). These bioactive compounds which confer health benefits besides nutrition include polyamines, nucleotide sugars, amino acids, medium chain fatty acids, polyunsaturated fatty acids and serum proteins (Alfrez, *et al.,* 2003; Barrionuevo, *et al.,* 2003; Haenelein, 2004 and Rampilli, *et al.,* 2004). Goat milk is also more digestible than cow milk, which makes it more suitable for infants, children, and adults who suffer from milk allergies and gastro-intestinal problems (Selvaggi, *et al.,* 2014, Amigo and Fontecha, 2011; El-Agamy, 2011 and Silanikove, *et al.,* 2010). These health benefits have been used in Kenya to promote consumption of goats' milk as disease

mitigation and intervention measure focusing on child malnutrition and supporting families affected by HIV and AIDS (Ogola, *et al.,* 2010). According to Maigua, (2005) the demand for the goat milk and its product is being driven by the growing understanding of the linkage between diet and health and the interest in self-health maintenance.

Studies by Ogola, *et al.,* (2010) further reports that, there are limited levels of goat milk value addition in our country with most of the milk being marketed raw and utilized in its fluid form mostly for household consumption. It is envisaged that as more farmers venture into rearing of dairy goats both exotic and cross breeds due to shrinking land sizes and ease of dairy goats management compared to dairy cows, and the resilience of cross breed dairy goats to harsh climatic conditions and changing weather patterns occasioned by global warming, the production of goat milk is expected to increase significantly. In order to realize higher economic returns, prolong shelf life of milk, and enhance preservation of bioactive compounds for improved food security and nutrition, there is need to diversify and expand the market access of goat milk through value addition and processing of the milk into high value specialty goat milk products. Maigua, (2005) reports that opportunities exists in research to innovate and develop these specialty products with the marketing strategy focusing on the use of technical information on the functional benefits of goat milk which is its unique selling point. One such specialty dairy products is goat milk mozzarella, a pasta pillata cheese whose huge market potential as a key ingredient for the pizza industry remains partly unexploited in our country due to limited information on the technological capability and sensory profiles which significantly influence consumer acceptability of the goat milk. Production of goat mozzarella would enhance market outlet for the pizza, prolong the shelf life of the milk and provide a concentrated form of bioactive compounds to the consumers interested in self-health maintenance.

Maigua, (2005) further contents that the 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 goat's milk being limited and insignificant (Lati, 2007). The slow growth of high value goats' products like cheese among the general populace is partly due to low levels of cheese production and also lack of an acquired taste for such products (Maigua, 2005).

Among the factors that influence technological capability of milk is the genetic variability which significantly influences quality of dairy products and more specifically

cheese yield and composition. Studies by Clark, *et al.,* (2000) has indicated that goat milk with high percent total solids, Solids Nonfat, fat and protein coagulated faster and formed a firmer curd than milk that had lower levels of milk components. Genetic variants of milk proteins associated with the protein composition have a significance influence on the technological properties of milk. The effect of genetic variability is even more pronounced in goats' milk where it further influences consumer acceptability. Caprine breed genotyping has revealed the existence of a wide polymorphism on the αs1-casein locus which leads to reduced proteosynthesis, and a stronger "goaty" flavor in the milk and cheese which affect sensory quality of goat milk and its milk products (Tsartsianidou, *et al.,* 2017). Goat milk is of interest due to variation in milk yield and composition due to breed which affects product yield and quality (Pal and Agnihotri, 1997). Studies by Pal, *et al*., (1997) and Agnihotri, (2002) have shown that characteristic flavour, the most important criterion for selection and consumption of cheeses by the consumers is influenced by milk composition among other factors. Through cross breeding programmes goat milk production in Kenya is from both exotic dairy goats mostly Toggenburg and their cross breeds with Galla goats. However, the information on the influence of this genetic variability on milk composition and technological performance of milk from these two goat genotypes is limited.

1.1 Statement of the problem

A huge potential for specialty dairy goat products such as pasta pillata cheeses exists in the Kenyan market. This potential remains partly unexploited due to limited scientific and technical information on the technological capability and sensory profiles of goat milk products which influence its consumer acceptability. For the Kenyan dairy industry to fully exploit the economic potential from goat milk production there is need to explore avenues that diversify products and open new markets for the goats' milk. One of such specialty dairy products is goat milk mozzarella, a pasta pillata cheese whose market potential as a key ingredient for the pizza industry remains unexploited in our country. Among the factors that influence technological capability of milk is the genetic variability which significantly influences quality of dairy products and more specifically cheese yield and composition. The effect of genetic variability is even more pronounced in goats' milk where it further influences consumer acceptability. However, in Kenya, the information on the influence of the goat breed on cheese making properties and its acceptability is limited. In addition the composition of milk from the Kenyan Toggenburg and its cross breed with Galla goat has not been adequately documented.

1.3 Objectives

1.3.1 General Objective

To evaluate the technological performance of milk from Kenyan Toggenburg and its cross breed with Galla goat through processing of Mozzarella cheese for enhanced food security and nutrition.

1.3.2 Specific Objectives

1. To determine major milk components from Toggenburg dairy goats and its cross breeds with Galla goat.
2. To determine the coagulation rate of milk from Toggenburg dairy goats and its cross breeds with Galla goat.
3. To determine the yield of Mozzarella cheese from Toggenburg dairy goats and its cross breeds with Galla goat.
4. To determine the consumer acceptability of mozzarella cheese from Toggenburg dairy goats and its cross breeds with Galla goat.

1.3.3 Null Hypotheses

1. There is no difference in levels of major milk components from Toggenburg dairy goats and its cross breed with Galla goat.
2. There is no difference in coagulation rate of milk from Toggenburg dairy goats and its cross breeds with Galla goat.
3. There is no difference in yield of Mozzarella cheese from Toggenburg dairy goats and its cross breed with Galla goat.
4. There is no difference in consumer acceptability of mozzarella cheese from Toggenburg dairy goats and its cross breed with Galla goat.

1.4 Justification

Milk in its original form is a highly perishable product and usually has a limited shelf life which can limit its economic returns in the long run. Increase in the uptake of cross breeds between pure dairy goats among them the Toggenburg and the indigenous goats among them the Galla goat has improved the milk production from goats. These volumes are expected to keep on increasing as more famers venture into dairy goat farming due to shrinking land sizes, ease of management compared to dairy cow and resilience of cross breeds to harsh climatic conditions and changing weather patterns due to global warming. With expected increase in milk volumes there is need to venture into value addition with a view to prolong the shelf life of the goat milk and provide a concentrated form of bioactive compounds present. The quality of the dairy products is influenced by the composition of the milk and the ability to undergo technological modification during processing. However, the information on the extent of the technological capability of milk from the cross breeds between Toggenburg and Galla goats in Kenya is limited. Since cross breeding is time consuming and expensive, the study will provide information on the suitability of milk from cross breeds for use in cheese manufacture and consumer acceptability and subsequently inform policy direction on the improvement of indigenous goat breeds for use in commercial dairy subsector sector.

CHAPTER TWO
LITERATURE REVIEW

2.1 Dairy Goat production

Dairy goat production has been gaining popularity in Kenya due to increasing human population leading to increased land pressure. Consequently the smaller land sizes cannot effectively support the dairy cattle, making some farmers turn to rearing of the dairy goats. The promotion of the dairy goat is also aimed at addressing the sustainable development goals of alleviating extreme poverty and hunger. Goats have been found to be a suitable pathway out of poverty for smallholders and contribute to improved nutrition at the household level (Kinuthia, 1997). Rearing of dairy goats have been associated with many advantages which include: superior production capacity compared to that of a cow which is bigger in size and therefore requires more feeds, water, mineral salt and labour; can be reared in an urban and peri-urban set up; is less vulnerable to diseases especially tick borne diseases like anaplasmosis, babesiosis and is not susceptible to East Coast Fever; they are fastidious feeders and as a result they are resilience to harsh tropical climatic conditions and changing weather patterns occasioned by global warming; consume a wide variety of grasses, weeds, small branches of bushes and trees and they also act as scavengers consuming discarded leaves, husks of corn, vegetables and peelings of fruits and other waste plant residues that would otherwise cause pollution (NAFIS, 2017).

Goat population in Kenya is predominantly indigenous Galla and the small East African goats which are reared in arid and semi arid areas (Kinuthia, 1997). Dairy goats in Kenya were introduced in early 1990s through a community based goat improvement programme whose purpose was to improve the productivity of the local goats through better management and development of a more intensive goat milk and meat production system for farmers in areas with small sizes of land (Ahuya, 1997). The national plan of promoting dairy goat production is aimed at addressing the millennium development goal of Alleviating extreme poverty and hunger (Kosgey *et al.,* 2008). Indigenous goats are generally low producers both in terms of milk production and growth rate. Based on past crossbreeding trials and experiences in Kenya, crossbreeding of indigenous goats with exotic breed, the Toggenburg dairy goats gave better general and specific combining results when crossed with Galla goats (Ruvuna, *et al.,* 1989). A study by Ndeke *et al.,* (2015), revealed that in spite of the harsh climatic conditions in Mwingi, the Toggenburg crosses with Galla goat were well adapted and performed better when compared to pure Toggenburg dairy goats.

In the world scene Goat milk is produced in many parts of the world in particular in Southeast Asia mainly in India and Bangladesh; in the Near East countries such as Iraq, Cyprus, Turkey, Syria, Iran; in African countries such as Libya, Morocco, Sudan, Niger and Somalia; in European countries such as Greece, Spain and France (Devendra, 1999). The contribution of goat milk to overall milk production in some individual countries could be considered significant, reaching levels of 44% in Mali, 29% in Somalia, 24% in Iran and 16% in Sudan, In the Caribbean, e.g Haiti and Bahamas, the contribution of goats to milk production is approximately 50% of the total milk produced (Devendra, 1999). However, in each of these countries, goat milk is used for diversified purposes. For instance, in the United States of America, which has plenty of cow milk, goat milk finds a market because of its alleged superiority in nutritional quality or reported value as a source of milk for individuals suffering from allergies to the proteins of cow milk (Jenness, 1980). Therefore, goat milk is used by necessity in some countries, by choice in others and by a combination of the two in still others.

2.2 Functional benefits of goats' milk.

The importance of goats as providers around the world of essential food in meat and dairy products has been discussed and documented in many proceedings (Haenlein and Fahmy, 1999; Boyazoglu and Morand-Fehr, 2001; Haenlein, 2001). In developing countries, production of goat milk has become useful strategy to tackle problems of under nutrition especially among human infants (Haenlein, 2004). The production and marketing of goat milk and its products has become an essential niche in the dairy industry sub sector especially due its functional properties (Hasler, 1998). Goats' milk contains bioactive components like polyamines, nucleotide sugars, amino acids, medium chain fatty acids, polyunsaturated fatty acids and serum proteins (Alferez, *et al.,* 2003; Barrionuevo, *et al.,* 2003; Heinlein, 2004; Rampilli *et al*., 2004). It is also characterized by high bioavailability of proteins, carbohydrates, fats, minerals and vitamins. Further studies by Alferez, *et al.,* (2003) and Barrionuevo, *et al.,* (2003) has also shown increased bioavailability of copper, zinc, selenium and iron from goats milk with these components often being present at levels similar to human milk making it a better alternative for production of infant formulae. The nutrients are contained in fairly good proportions, well balanced and readily available to meet human body requirements (Haenlein, 2004).

According to Hasler, (1998) the availability of proteins is higher than in milk from other dairy animals; provides 8.7 grams of protein (17.4% of the daily value for protein) per

100 gm while same amount of cow milk provides 8.1 grams (16.3% of the daily value for protein); contains 13 percent more calcium, 25 percent more vitamin B-6, 47 percent more vitamin A, 134 percent more potassium; has three times more niacin; contains four times more copper and 27 percent more selenium. Digestibility of goats' milk is highly enhanced by nature of the proteins and the fat molecules. Protein molecules are thinner and fat molecules have more fragile membranes. The increased digestibility of protein is of more importance to infants, invalids and convalescent diets. This is influenced by low curd tension of 10 – 70 g average at 36g, while that of cow range between 15-200g, average 70g. Curd tension is the measure of the hardness or softness of the curd. Goats milk has low curd tension which is attributed to low levels of alpha-S1 casein and higher levels of A_2 beta-casein and hence it is easily digested (Hasler, 1998).

Hydrolysis of casein in the stomach is better at 96% compared to 76-90% of cow milk casein while human casein is completely hydrolyzed (Prosser, 2003). Goat milk will digest in a baby's stomach in 20 minutes, whereas cow's milk takes 2-3 hours (Attaie, *et al.,* 2000). In terms of digestibility and nutrient absorption, it is a better substitute for breast feeding. Goats' milk like the human milk contains oligosaccharides which act as prebiotics. These are important to the infants and also the elderly. Clinical trials by McVeagh and Miller, (1997) have shown that several different oligosaccharides can be used to stimulate bifidobacteria in the GI- tract which include inulin, fructo-oligosaccharides (FOS), galactooligosaccharide and lactulose. The oligosaccharides derived from goats milk have the potential, when included in infant formula, to stimulate host bifidobacteria to grow to levels similar to those in the GI tracts of breast-fed babies (Brand-Miller *et al.,* 1998, McVeagh and Miller, 1997). Milk oligosaccharides are beneficial to the infant with regard to their prebiotic and anti-infective properties. Goats' milk oligosaccharides particularly 6-sialyl lactose constitute the "soluble fibre" which provides nutrients for colonic bacteria. These oligosaccharides provide substrate needed by health enhancing bacteria to multiply in the gut and are anti-inflammatory. Trials by McVeagh and Miller, 1997) have shown that goat milk oligosaccharides inhibit the adhesion of pathogenic bacteria to the epithelial membrane, reduce translocation of harmful bacteria in the epithelial cells, promote the selective growth of lactobacillus and bifidobacteria, and act as pathogen receptors by enabling specific interactions between them and pathogens. These interactions inhibit pathogens such as *Campylobacter jejuni*, *Streptococcus pneumonia*, enteropathogenic *Escherichia coli* and neutralizes effects of *Escherichia coli* toxin (Newburg, *et al.,* 2005).

Goats' milk contains high levels of growth factors similar to those found in human milk making it an essential diet for the infants. The Transforming Growth Factor-a (TGF-a), has a physiological role in maintaining regular functionality of the infant (Playford, *et al.*, 2000). The Transforming Growth Factor-ß (TGF-ß), is involved in numerous processes, such as the development and differentiation of the intestinal epithelium, regulation of the immune response system where it is involved in production and induction of oral tolerance. Neuropeptides, such as neurotensine, Somatostatin, and vasoactive peptide foster immunity response by stimulating T lymphocyte cells and activating macrophages (Goldman, *et al.*, 2000).

2.3 Biochemical characteristics and quality of goats' milk

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 and Morand-Fehr, 2001). Thus, the quality of the milk is closely related to its physico-chemical and biological composition on which its technological capacities are based (Soryal, *et al.*, 2005). Milk quality depends on a large number of factors which are related to both the animal (breed, parity, stage of lactation and health status) and the conditions of production (region, diet, rearing system), and has a predominant influence on the quality of subsequent goat milk products (Park, *et al.*, 2007).

Pizzillo, *et al*, (2005) reported existence of a significant relationship between flavour and milk composition and animal-related factors (age and stage of lactation). Lipase activity and spontaneous lipolysis plays a major role in the development of flavour in goat milk (LE'Quéré, *et al*., 1998)**.** The volatile fatty acids, and particularly branched-chain fatty acids (4-methyloctanoïc and 4-ethyloctanoïc), have been found the most important compounds for the characteristic goat flavour (Goudjil, et al., (2004)). Studies by Goudjil, et al., (2004) have indicated an appreciable amounts of 4- methyloctanoic acid following the action of natural lipase on caprine milk fat.

Morand-Fehr, *et al.*, (2007) reported that cheese quality depended largely on the composition and quality of milk, and quality of these milks can be evaluated by several criteria: sanitary, nutritional, technological, and after cheese – making under aspects of gustative, rheological, gastronomic and hedonic parameters. All these kinds of quality depend on multi-factors and their interaction and they are mainly linked to main components of milk

(fat, protein, lactose) and to their physic-chemical characteristics as well as to micro-compounds present in milk.

2.4 Milk coagulation properties

Milk coagulation properties (MCP) are a feature of the milk to react with a clotting enzyme and form a curd with a suitable firmness in a reasonable time. Milk coagulation process and cheese-making is a process comprising of three overlapping steps as described Figure 1. produced by a milk-coagulation meter (Ikonen, 2000***)***. During the primary step, enzymatic phase (Rennet Coagulation Time- 'RCT' in Figure 1), chymosin, a clotting enzyme, splits k-casein at the Phe_{105}-Met_{106} bond into para-k-casein and a macro peptide. Because of this splitting of k-casein, casein begins to aggregate. The second, non-enzymatic phase of milk coagulation begins before all of the k-casein has been split. During the third step of milk coagulation, aggregated casein micelles form a more or less firm gel structure. Curd-firming time, K_{20}, describes the time needed until the curd is firm enough to be cut (the width of the diagram (Figure 1) is 20 mm), and curd firmness, a_{30}, describes the firmness of the curd 30 minutes after addition of the clotting enzyme. The milk coagulation properties are measured for 30 minutes or more, because in cheese-making for most cheese types, the curd is cut about 30 minutes after addition of the clotting enzyme to the milk (Ikonen, 2000).

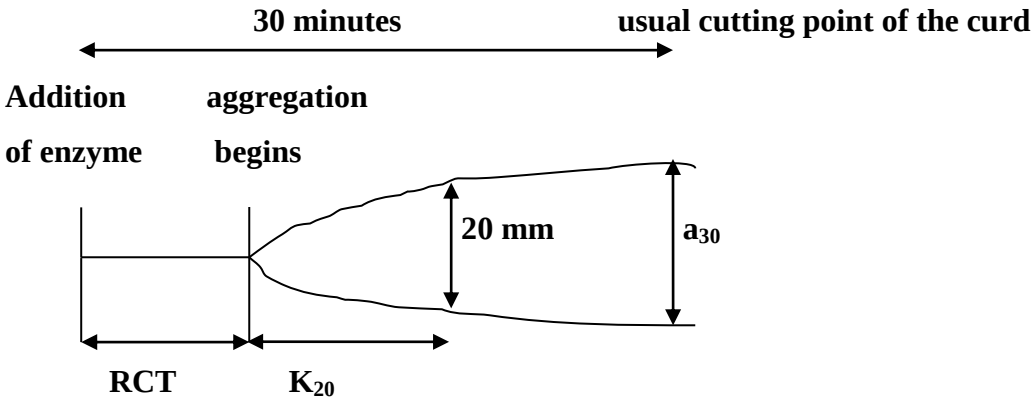

Figure 1: Diagram produced by milk coagulation meter. *Adopted from Ikonen, (2000)*

The milk coagulation properties and composition of milk have a clear effect on cheese making properties. Milk that begins to aggregate soon after addition of the enzyme, and forms a firm curd within a reasonable time is expected to produce higher dry-matter cheese yields compared to milk with poor coagulation properties (Wedholm, *et al*., 2006; Martin, *et al.*, 1997, Ng-Kwai-Hang, *et al.*, 1989). Milk that coagulates quickly is able to entrap more casein and fat into the coagulum before it is cut than one which coagulates slowly. Casein

and fat constitute about 90% of the solids in cheese; hence the amount of casein and fat lost in the cheese whey has a significant effect on the efficiency of cheese making (Lawrence *et al*., 1993; Politis and Ng-Kwai-Hang, 1988,). According to Wedholm, *et al*., (2006), the possibility of varying curd cutting point is limited in large scale cheese production, hence it is important that the curds are firm enough to allow cutting at the usual cutting time.

The ability of casein micelles to stay in solution at natural milk pH (~6.7) relies on the net negative charge and hydrophilic character of the C-terminal end of κ-CN at the micelle surface. There are two approaches to induce micelle aggregation; by enzymatic action or by acidification of milk. The outcome of these reactions is to a large extent determined by amounts and proportions of the various components in milk, with the protein composition contributing significantly in this regard. To determine the coagulation properties of given milk, coagulation time (CT), defined as the time from addition of coagulant until coagulation starts, and curd firmness at a given time after addition of coagulant are measured (Ng-Kwai-Hang, *et al.*, 1989).

Enzymatic coagulation of milk is the modification of casein micelles via limited hydrolysis of casein by rennet, followed by calcium-induced micelle aggregation (Martin, et al., 1997). Rennet is traditionally extracted from calf abomasa and is a mixture of the two gastric proteases chymosin and pepsin. Chymosin is the major and the most active component, specifically cleaving the peptide bond Phe_{105}-Met_{106} of κ-CN. Chymosin-induced coagulation of milk may be described by three phases. During the primary phase the enzymatic hydrolysis of κ-CN into para-κ-CN and caseinomicropeptide takes place, with the hydrophilic caseinomicropeptide part being released into the whey. This causes loss of a negatively charged group and decreased steric stabilisation When approximately 70 % of the κ-CN is hydrolysed colloidal stability of the micelles is reduced enough for the spontaneous, secondary aggregation phase to start. A gel forms as molecular chains connect through hydrophobic bonds to form a three-dimensional network, followed by further solidification through calcium cross-linking. Finally in the third phase whey is expelled from the casein network by syneresis (more contraction through cross-links). Coagulation is enhanced by decreasing pH, increasing calcium concentration and temperature (no aggregation below 20˚C) while syneresis is augmented by increasing temperature, pH and applied pressure, e.g. stirring (Senge, *et al.*, 1997)

In acid induced coagulation of milk, casein micelle properties are altered by a lowering milk pH (Wedholm, *et al*., 2006). This causes colloidal calcium phosphate to dissociate from the micelles and the negative charges in the casein micelles are neutralized, with aggregation occurring as the isoelectric point of the casein micelle (pH 4.6) is approached. A porous network of loosely linked aggregates is formed. Milk used in manufacture of fermented milk products is generally subjected to a quite severe heat treatment (90˚C, 5-10 min), with a marked effect on the end product. Temperatures above 60˚C cause denaturation of whey proteins (mainly β-LG), which via disulphide bonds either associate with κ-CN on the casein micelles or form soluble aggregates. This results in increased curd firmness due to an increased number and strength of bonds of the acid gel, as denatured whey proteins associated with casein micelles interact with each other (Lucey and Singh, 1997). Further, the concentration of protein in the gel network will be increased because of the active participation of denatured whey protein in structure formation. Several ways of monitoring milk coagulation properties exist which are on based on optical, thermal, mechanical, and vibrational methods (O'Callaghan, *et al.*, 2002). These direct methods can produce different results based on the final coagulant activity, type of coagulant and temperature of analysis.

2.4.1 Effect of pH and Temperature on milk coagulation

Decreasing the pH and increasing the temperature increases the coagulation time. Lower pH increases enzyme activity and neutralizes charge repulsion between micelles, and both primary and secondary stages of coagulation proceed more quickly at lower pH (Lucey, 2002). Rennet is more soluble at low pH and, therefore, the amount retained in the curd increases with decreasing pH at draining. At temperature less than 30^{o}C the gel is weak and difficult to cut without excessive yield loss due to fines. At temperatures less than 20^{o}C coagulation does not occur, but the primary stage goes to completion and the milk will then coagulate quickly when warmed (Lucey and Singh, (1997).

2.4.2 Effect of milk components on coagulation properties

Milk composition is among the factors that influence rennet coagulation properties of milk. Milk composition has been found to influence coagulation of milk. Studies by Clark *et al.,* (2000) indicate that goat milk with high percent total solids, Solids Nonfat, fat and protein coagulated faster and formed a firmer curd than milk that had lower levels of milk components.

2.4.3 Effect of breed on milk coagulation

Breed is an important source of variation for milk quality characteristics and coagulation properties. In cows, milk from Holstein Friesian, exhibit a fair milk quality for cheese making, while other breeds produce milk characterized by better milk coagulation Properties (De Marchi, *et al*., 2007). Genetic variants of milk proteins have been shown to be associated with the protein composition and thereby with the technological properties of milk. The best alleles for milk coagulation properties is allele B for β-casein, B for k-casein and B for β-lactoglobulin (Bittante, 2011). Moreover, Tyriseva *et al*., (2004) found candidate genes for non-coagulation of milk and as a consequence, DNA information could be utilized to improve milk coagulation properties through marker assisted selection at early age both for cows and bulls.

2.4.4 Effect of protein polymorphism on coagulation properties of milk

Protein polymorphism associated with a quantitative variability in casein synthesis has a significant effect on coagulation properties, micelle size and mineralization, cheese yield, and sensory attributes (Ramunno, *et al*. 2007). The influence of milk protein variants on coagulation properties of milk is often due to their association with an altered protein composition. The κ-CN B allele has the most favourable properties regarding chymosin-induced coagulation, κ-CN A has longer coagulation times and softer curds, poor milk coagulation properties has been ascribed to the κ-CN E allele and consequently, these effects of the different variants with coagulation properties of milk are also exhibited in cheese yield (Walsh, *et al.*, 1998). The β-CN locus with the B allele has been linked to an improved coagulation compared to the A variants. Higher protein recovery in cheese has been reported for β-CN A^1A^1 compared to A^1A^2 and for β-CN A^2B compared to β-casein A^2A^2 (Ikonen, *et al*, 2004). Although β-LG itself is not involved in the enzymatic process of coagulation of unheated milk, it has been shown that the genetic variants of β-LG may be affecting coagulation properties of raw milk (Ng-Kwai-Hang, *et al.*, 2002). Studies by Lodes, *et al.*, (1996) has shown β-LG B to be associated with a higher cheese yield than β-LG A. This may partly be due to the association of the β-LG genotype with casein content of milk. In acid-induced coagulation association rates for the heat-induced reaction between β-LG and κ-CN have been determined for different genetic variants, where it was more rapid in milk from cows homozygous for the B alleles of both proteins compared to in milk from cows carrying the A alleles.

The differences in as2-casein content in milk are associated with the unique physicochemical characteristics of goat caseins and influence the technological behaviour of goat milk during processing into cheese (Selvaggi and Tufarelli, 2011). According to report by Marletta, *et al., (*2007), goat milk is characterized by favourable alleles results in a higher content of protein, casein and fat, and improved coagulation properties The alpha S_2 casein gene has seven alleles associated with three levels of synthesis where the favourable A, B, C, E, and F alleles are associated with a high level of a_{s2}-casein in milk, and produce 2.5g a_{s2}-casein/litre per allele, the rare defective D allele results in a reduction in a_{s2}-casein content, and allele O results in an absence of a_{s2}-casein in milk (Marletta, *et al.,* 2007). Consequently Marletta, *et al., (*2007) reports that favourable haplotypes for the various caseins, including alpha S_2 casein, have been identified in a number of breeds, with a positive association with milk quality and technological properties.

2.5 Breed effect on cheese yield

Cheese yield is affected by many factors including genetics of the dairy animal (casein variants), milk composition, milk quality, somatic cell count (SCC), curd firmness at cutting, and manufacturing parameters (Fenelon and Guinee, 1999). Breed has frequently been reported as one of the main variables affecting goat milk composition and the proportion of the different casein fractions particularly the αs1-CN content have been shown to influence coagulation properties, cheese yield and protein content (Clark and Sherbon, 2000).

Research has established relationships between milk components (fat and casein) or cheese composition (moisture, fat, protein) and yield of variety of cheeses such as Cheddar and Gouda (Brito *et al*., 2002). Both fat and casein variants are directly related to the breed with casein variant the most dominant factor affecting curd firmness, syneresis rate, moisture retention and ultimately cheese quality and yield (Clark and Sherbon, 2000). Kosikowski, *et al*., (1997) observed a linear relationship between sum of contents of fat and casein content and the yield of cottage cheese. The same showed existence of a linear correlation between increase of yield and increase in the sum of the content of fat and casein which explained over 77% of the fresh cheese. Fat and protein (casein) are the two primary milk components that are recovered in the cheese making process and are directly related to cheese yield. Since casein is the key component in making up the curd matrix that entraps the fat globules, we look at casein relationships with other milk constituents to forecast the potential cheese quality and cheese yield. The Casein/Fat (C/F) ratio is critical in controlling the final Fat in

the Dry Matter (FDM) of the finished cheese. Minimum FDM specifications are established for many of the cheeses with standards of identity. The Casein/True Protein (C/TP) ratio give potential information on the amount of intact casein that is present in the milk to give a good gel structure during curd formation. Typical C/F ratios needed to produce high quality commodity cheeses from cows have been identified for various cheeses: cheddar 0.70; Mozzarella 0.85; Swiss cheese 0.85; Parmesan 0.85; Harvati 0.60 and reduced fat Muenster 1.73 (Wendorff, 2002)

2.6 Cheese yield prediction

Cheese makers using the cows' milk have had cheese yield prediction formulae for over 90 years based on milk composition (Banks, *et al*., 1981). The formulae has been used to predict the potential cheese yield and make adjustments to cheese milk either through milk standardization or by changing of the technological procedures to improve the recovery of milk solids and subsequently increase the yield in the final cheese. The Van Slyke cheese prediction formulae (Slyke, 1909) is the one mostly widely used to determine potential yield of cheddar cheese from cow. This formula has also been adopted for other cheeses with slight modification to predict their yields. The Van Slyke Cheddar Cheese Yield Formula is given as follows:

$$\text{Yield} = [(0.93F + C\text{-}0.1)1.09]/\{100 - W\}$$

Where:

F = fat concentration in the milk, %

C = casein concentration in the milk, %

W = moisture, expressed as Kg water per Kg of cheese

The Van Slyke cheese yield formula was developed for Cheddar cheese based on the premise that about 7% of the fat and about 4% of the casein would be lost in the whey. Other cheeses may have different rates of recovery of milk components in the make procedure and the yield formula may need to be adjusted for that particular cheese making procedure. Such is the case for Mozzarella cheese where Barbano, (1996) revised the Van Slyke formula to effectively predict cheese yield for this commodity cheese as follows:

Yield = [(.85 X % fat) + (% casein – 0.1)1.13 1 – (cheese moisture/100)

Most of the previous formulas were based on cow milk that typically has about 2.5% casein in the milk and may not hold true for goats' milk. With this formula, a cheese maker can incorporate retention factors that are typical for that specific plant and the variety of cheese being produced. Retention factors for Cheddar, Mozzarella and Swiss cheese from cow's milk has also been reported by Barbano, (1996) as follows: Cheddar: 0.93, 0.96, 1.09; Mozzarella:0.85, 0.96, 1.13 and Swiss cheese: 0.77, 0.94, 1.10 for fat, casein and total solids respectively.

Lack of cheese prediction formulae for goats' milk has been a major hindrance for cheese makers to accurately predict yield from goat milk. Due to this limitation a cheese prediction formulae need to be determined for goat cheese and assist the cheese makers to evaluate the efficiency of the cheese making procedures.

2.7 Sensory attributes of goat milk.

Among the characteristics of goat milk, flavour is one quality component of particular importance to the cheese producer. According to Pizzillo, *et al*., (2005), the breed of goats has an effect on the quality of cheese produced particularly on the sensory profile and the fatty acid concentration. Of the fatty acids oleic acid has been found to have a higher concentration in goat cheese (Soryal, *et al*., 2005). Studies by Tayse, et al., (2016) with Saanen and Alpine breeds has shown that the breed has an influence on the pH, fat, moisture, elasticity and sensory profiles of cheeses with the Saanen showing higher pH, fat and moisture while cheese from Alphine milk had higher elasticity.

Although a "goaty" flavour is generally required, the desired intensity of the flavour varies according to the type of product, i.e. strong for ripened soft or hard cheeses, slightly strong for white cheese or fermented milk and slight or nil for pasteurized fluid goat milk (Pizzillo *et al*., 2005). Studies by Ha and Lindsay, (1993) indicate that the formation of the specific flavour of goat milk is closely linked to the nature of the various constituents in the milk, and also to biochemical and enzymatic factors. The latter depend on the technological treatments applied to the milk and result in degradation of its constituents. Lipase activity and spontaneous lipolysis play a major role in the development of flavour in goat milk (Chilliard, et al., 2006) and the effect of the free fatty acids content has been well established (Moioi, *et al.,* 1993). In a study by Moioi, *et al.,* (1993) to identify main neutral volatile compounds responsible for the aroma of fresh milk obtained from the cow, goat, ewe and water buffalo

using gas chromatography-olfactometry techniques, Ethylbutanoate and Ethylhexanoate appeared to be the principal compounds responsible for the odour of goat milk, the latter being differentiated from the milk of ewes and cows by the presence of large amounts of phenylacetaldehyde and benzaldehyde and the absence of phenyl ethanol. Moreover, higher concentrations of indole, 4-methylphenol and 1-octen-3-01 were also found in cow's milk**.** In other studies by LE'Quéré, *et al*., (1998) using gas chromatography, mass spectrometry and olfactometry techniques to identify goat flavour derived from representative extract of cheeses established that branched-chain fatty acids (4-methyloctanoïc and 4-ethyloctanoïc), were the main compounds responsible for the characteristic goat flavour.

Appreciable amounts of 4-methyloctanoïc acid have also been found following the action of natural lipase on caprine milk fat (Ha and Lindsay, *et al*.,1993). Fat present in goat milk is a rich source of Short Chain Fatty Acids (SCFA – C6:0, C8:0, C10:0), which are synthesized *de novo* in the mammary gland (Chilliard, *et al.*, 2006). Chilliard, *et al*., (2006) and San-Sampelayo, *et al*., (2007) indicate that the share of these acids in the pool of fatty acids composing the goat milk fat is more than twice as high as in cow milk (about 18% *vs*. 8%). The SCFA concentration in the milk of goats is important, as it influences the palatability and sensory properties of milk and dairy products (Ekenes, *et al*., 2009; Talpur, *et al*., 2009). A characteristic trait distinguishing goat milk from cow milk is the relation between the lauric (C12:0) and capric (C10:0) acid (0.46 *vs*. 1.16% of sum of acids) (Haenlein and Wendorff, 2006). This is an important indicator, as it may be used to detect falsifications of goat milk with cow milk.

In the fat of goat milk, Saturated Fatty Acids (SFA) are the dominating group and their share in the milk fat ranges from about 67% (Rodriguez-Alcala *et al*. 2009) to about 75% (Žan, *et al.*, 2006). Most fatty acids from acetic (C2:0) to arachidic acid (C20:0), contain an even number of carbon atoms with five fatty acids (C10:0, C14:0, C16:0, C18:0, and C18:1) accounting for >75% of total fatty acids in goat and sheep milk (Žan, *et al.*, 2006). Levels of the metabolically valuable short and medium chain fatty acids; caproic (C6:0 - 2.9%, 2.4%, 1.6%), caprylic (C8:0 - 2.6%, 2.7%, 1.3%), capric (C10:0 - 7.8%, 10.0%, 3.0%), and lauric (C12:0 - 4.4%, 5.0%, 3.1%) are significantly higher in sheep and goat than in cow milk, respectively (Goudjil, *et al*., 2004). These fatty acids are associated with the characteristic flavours of cheeses and can also be used to detect admixtures of milk from different species (Goudjil., *et al*., 2004).

2.8 Effect of genetics on sensory quality of goat cheese

Studies have demonstrated that the preferred "goat" cheese flavor sought by consumers in Northern European cheeses has been attributed to a hereditary feature of goat populations, and such characteristic flavour was also linked to the animal breed and cheeses made with Norwegian breed goats' milk were confirmed to have a stronger "goaty" taste than those made with Saanen goats' (Coulon, *et al.*, 2004). Caprine breed genotyping has revealed the existence of a wide polymorphism on the αs1-casein locus which leads to reduced proteosynthesis, and a stronger "goaty" flavor in the milk and cheese. Genetic polymorphism also has been shown to affect sensory quality of goat and sheep milk, and their products (Tsartsianidou, *et al.*, 2017)

2.9 Stage of lactation on sensory quality of goat cheese

Composition of original milk would significantly affect the composition and organoleptic quality of the manufactured dairy products. In a study on the effect of stage of lactation on the yield of goat milk cheese, Fekadu, *et al*., (2005) found that total solids, fat, and protein contents in hard and semi-hard cheeses were higher at early and late stages of lactation than they were during mid- Lactation which was attributed to the differences in total solid, fat and protein contents of the corresponding milk that were used for manufacture of the hard and semi-hard types of cheeses.

2.10 Effect of feeds on sensory quality of goat cheese

Sensory quality of caprine milk cheeses can be highly influenced by the types of feeds fed to the lactating animals. Off-flavor in goat milk can be attributed to the feeds, weeds, forages, chemicals, building materials, colostrum, estrus, mastitic milk, filthy utensils and strainer, unclean milking equipment, slow cooling, odors from bucks, barn and/or milk room. Feeding odorous feeds at least two hours before milking is not recommended (Moatsou and Park, 2017).

Coulon, *et al*. (2004) postulated that the type of feed given to a lactating animal has an influence on the nutrient input and the main milk components (proteins and fat), which in turn have highly consequential effects on cheese-making performance, sensory characteristics, and texture. The type of pasture fed to lactating goats induces a modification of milk fatty acid composition, which affects cheese texture. Pasture fed diets led to more "animal" and less "bitter" and less "sour" odors (Verdier-Metz, *et al*., 2002).

Some cheese makers have reported differences in the sensory characteristics of cheeses according to the type of forage fed to animals. Differences in sensory characteristics of cheeses have been associated with differences in forage types (hay or pasture). These reports have been proved by scientific studies aimed at analyzing the sensory characteristic diversity of a given type of cheese and paralleling that diversity with the conditions under which the milk and cheeses were produced (Coulon, *et al*., 2004).

CHAPTER THREE
MATERIALS AND METHODS

3.1 Study site

This study was carried out at Naivasha Sheep and Goat Station (NSGS). The station is located 100 km North West of Nairobi at an altitude of 1,829 - 2,330 metres Above Sea Level in agro-ecological zone IV.The area has bimodal annual rainfall between 300 -700 mm with mean of 620 mm. long rains fall in March to May and short rains in October to December. The average day and night temperatures are 28^{o}c and 8^{o}c respectively with relative humidity of 60-75%. The natural vegetation is predominantly star grass (C*ynodon plectostachyus*) with scattered acacia trees (A*cacia xanthophloea*). The soils are volcanic in origin, alkaline (pH 7.4), sodic and deep. The soils are deficient in trace elements requiring fertilization and mineral supplementation (MoLD, 2010).

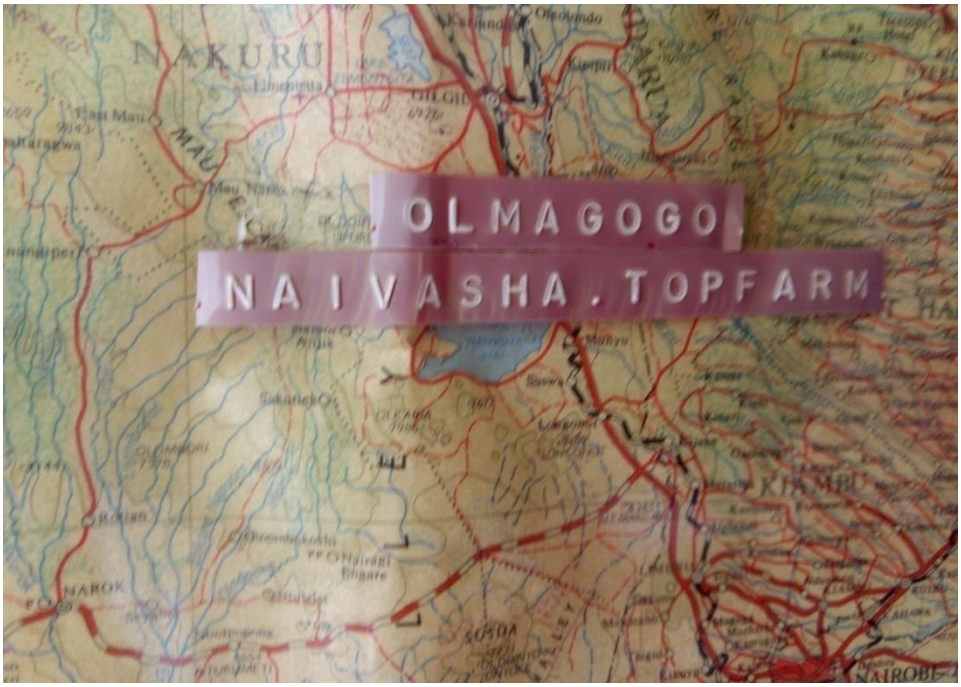

Figure 2: Map of Nakuru showing Naivasha Sheep and Goat station

3.2 Experimental Design

A Completely Randomized Block Design (CRBD) was used in the experiment with the following statistical model:

$$\mathbf{Y_{ij} = \mu + \check{\iota}_i + \beta j + \epsilon ij}$$

Where,

$\mathbf{Y_{ij}}$ = the observation of the depended variable i.e milk components, milk coagulation time, cheese yield, and sensory scores.

$\boldsymbol{\mu}$ = Overall mean

$\boldsymbol{\check{\iota}_i}$ = The effect of genotype

$\boldsymbol{\beta j}$ = The effect due to stage of lactation

$\boldsymbol{\epsilon_{ij}}$ = Random error component.

3.3 Experimental goats.

The study was carried out with five Toggenburg and five cross breed ($^3/_4$Toggenburg x $^1/_4$ Galla goats) does. The experimental does were randomly selected from a flock maintained at the Naivasha Sheep and Goat Station. The selected does were between 3 and $3^1/_2$ years, in their second parity and had kidded within the same week. The goats were put under similar management system during the experimental period.

3.4 Sampling of Goat milk

Milk samples of 200 ml were taken fortnightly from each breed at 7.00 am on each recorded day and immediately taken to the laboratory in an ice box. The samples were analyzed for levels of fat, protein, ash and total solids following official methods (AOAC, 2000). These analysis were replicated 6 times during the experimental period.

3.5 Proximate analysis of milk

3.5.1 Fat Determination

The fat was determined using the soxhlet extraction apparatus. Petroleum ether was added to 5 ml of milk placed in an extraction apparatus. Extraction was carried out for 10 hours, after which the ether was evaporated to dryness. The amount of fat was then obtained from the difference in the weight of the flask before and after drying off the ether.

3.5.2 Crude protein Determination

The protein was determined using the Kjeldahl method. To a 5g milk sample placed in a Kjeldahl flask was added 1g of mixed catalyst (potassium sulfate and copper sulfate) and 5 glass beads. 15 ml of concentrated sulphuric acid were added, rinsing any milk on the neck of flask down into bulb. The flask was placed on a burner so that the neck is inclined at an angle of 45° to the horizontal and flame does not touch the flask above the level of the liquid in bulb. Heating was started slowly by setting low heat so that sample does not foam up neck of Kjeldahl flask. Digestion was done until white fumes appeared in the flask. The flame setting was increased to half way setting and heating continued until the light blue to green colour cleared in the digest. The flame setting was increased to maximum and heating continued for 1 hour. The flask was removed from the flame and the content allowed to cool at room temperature. The sides of the Kjeldah flask were washed with fine jet of distilled water. The flask was placed on the flame and heated for 1 hour. The end of the digestion was indicated by clear digest with no black particles. After cooling, distilled water (20 ml) was added, and the mixture transferred to a 50-ml volumetric flask. A 5 ml portion of the diluted sample was then placed in a microKjeldahl unit and to this 10 ml of 40% sodium hydroxide was added. This was steam distilled, collecting the condensate into a 5 ml solution of 4% boric acid until 10 ml of the condensate was collected. The latter was then titrated with 0.01 M Hydrochloric acid to a red colour. A blank sample was treated in the same manner. The crude protein for milk was then calculated as follows:

$$\% \text{ CP} = \frac{\text{N} \times 14.007 \times (V_s - V_b) \times 6.38 \times 50 \times 100}{\text{W} \times 1000 \times 2}$$

Where,

N = Normality of standard hydrochloric acid

Vs = Volume in ml of standard hydrochloric used to titrate the milk sample.

Vb = Volume in ml of standard hydrochloric acid used to titrate blank.

W = Weight in g, of the milk sample taken.

3.5.3 Total Solids Determination

A 5g sample of milk was placed in a weighed dry flat-bottomed dish. The dish and the sample were then heated in the oven at 100°C±2^{o}c for 2 hours. The dish was then cooled in a desicator and weight taken. The weight of the solids was obtained from the difference in the weight of the dish before and after heating. The percentage weight was the calculated.

3.5.4 Ash determination

5 grams of sample was placed in a crucible which had been kept in the furnace overnight, cooled and weighed prior to putting the sample. The sample was heated over a Bunsen burner with lid half covered until fumes were no longer produced. The crucible with the sample were transferred to the muffle furnace set at 550^{o}c and heated overnight until the sample turned gray. The weight of the ash was there after taken. % Ash was given by dividing the weight of the ash by the weight of the dry sample.

3.5.5 Determination of milk coagulation rate

The milk clotting rate was determined following modified procedure by Arima and Iwasaki, (1970). 10 ml of pasteurized milk was put in a test tube and added 0.01M Calcium Chloride ($CaCl.2H_2O$). The milk was added 1% of prepared solution of thermophilic starter culture, YF – L812 from CHR Hansen and the content were put in a water bath at 37^{0}c, and held for 30 minutes. To this 0.5 ml of 1% enzymatic solution, Chy – Max from CHR Hansen was added and the test tube subjected to slight rotation. The end point was recorded when discrete particles were discernible. The time obtained was the mean of three trials.

3.6 Mozzarella cheese preparation

Mozzarella cheese from milk of each breed was prepared 6 times up to the 12^{th} week of lactation. 10 kg of milk from each breed was used to prepare Mozzarella cheese following the procedure by Mistry and Koskowski, (1997). Whole goat milk was heated to 72^{o}c without holding and then cooled to 42^{o}c. Thermophilic starter culture, YF – L812 from CHR Hansen was added containing *streptococcus thermophilus* and *lactobacillus bulgaricus* strains. The milk was stirred and left undisturbed for 30 minutes. Rennet powder, Chy – Max from CHR Hansen was added to the milk, stirred and left undisturbed for 45 minutes at 42^{o}c. The coagulum was then tested to check if ready and then cut into small pieces of approximately 1cm. The curd was stirred gently for 15 minutes and then let to ferment for 4 hour while maintain the same temperature. The curd was tested for spinning ability by scooping a few curds immersing in boiling water, mounding and then stretching. When the matted curd was ready it was cut into small portions, immersed in a basin of hot water at 85^{o}c and stirred until it looked like dough. The gummy curd was ready for mounding into the required shapes. The cheese was put in cold water for minutes and then placed in 10% brine solution overnight. Weight of the cheese prepared was determined on the second day. Duplicate samples from each batch were taken for proximate analysis using official analytical methods (AOAC,

2000) and sensory evaluation of the mozzarella was carried out to determine consumer acceptability and sensory profiles.

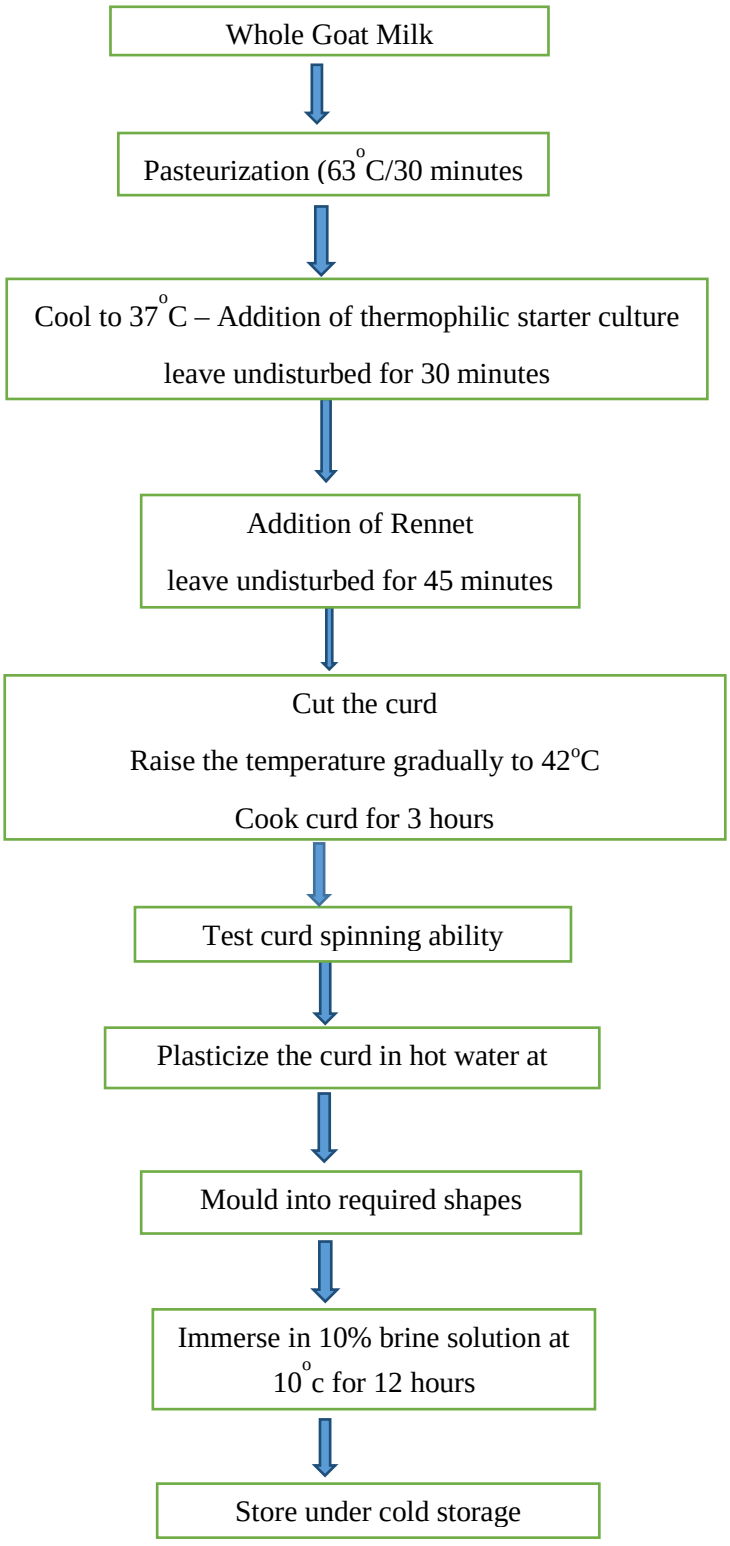

Figure 3: Flow chart for Mozzarella cheese manufacture (*Mistry and Koskowski, 1997)*

3.7 Cheese yield determination

Weight of the cheese prepared was determined on the second day after preparation. The actual cheese yield was recorded as kg/kg of goat milk used and expressed as kg of cheese per 100 kg of goat milk. The actual cheese yields varied markedly in the cheese due to the variations in moisture and therefore, cheese yields were adjusted to standard moisture content. To determine the moisture adjusted cheese yield, a mean moisture content of 56.23% (average moisture of the Mozzarella cheese obtained in this experiment from the two goat genotypes) was used. Adjusted cheese yield was calculated using the formula by Mehaia, (2006) whereby:

$$\text{Moisture adjusted cheese yield \%} = \frac{\{\text{Actual cheese yield \%} \times (100 - \text{Actual cheese moisture \%})\}}{(100 - \text{Average moisture content})}$$

Cheese yield efficiency was expressed as the percentage of the moisture-adjusted cheese yield to the predicted cheese yield using Van Slyke Formulae, (1910).

3.8 Proximate analysis of cheese:

Representative samples (100 g) of each cheese were taken for analysis. The samples were grated and the mass was thoroughly mixed. The samples were analyzed for Moisture, Fat (%) and Protein (%) following official methods (AOAC, 2000).

3.8.1 Cheese fat determination

To determine cheese fat content, 10g of prepared sample was weighed in a 100 ml beaker. 10 ml of concentrated hydrochloric acid was added. The beaker with its contents was heated on a boiling water bath, stirring continuously with a glass rod, until all solid particles were dissolved and the contents turned dark brown. The contents were cooled to room temperature. 10 ml of ethyl alcohol was added to the beaker, mixed well and the contents transferred to the Mojonnier fat extraction flask. 25 ml of ethyl ether was added to the beaker and from the beaker to the Mojonnier flask. The flask was then stoppered and shaken vigorously for one minute. 25 ml of petroleum ether was then added and shaking repeated for another one minute. The flask was centrifuged at 600 rpm. The ether solution was decanted into another flask. The tip and the stopper of the extraction flask was washed with equal parts of the two solvents and the washings added to the flask and extraction of the

liquid remaining in the flask repeated successively using 15ml of each solvent. The solvent was evaporated completely on a water bath without causing sputtering. The fat was dried in an oven at 102 ± 2°C to a constant weight. The cooled flask was weighed. The fat was completely removed from the container with warm petroleum ether and weighed as before.

Fat calculation:

Fat, % (W/W) = $[100(W_1 - W_2)] / W_3$

Where,

W1 = Weight in g of contents in the flask before removal of fat.
W_2 = Weight in g of contents in the flask after removal of fat.
W_3 = Weight in grams of material taken for the test.

3.8.2 Cheese protein determination

The protein content in the mozzarella cheese was determined using the Kjeldahl method. A prepared cheese sample of 5g was placed in a Kjeldahl flask. 1g of mixed catalyst (potassium sulfate and copper sulfate) and 5 glass beads were added. 15 ml of concentrated sulphuric acid were added. The flask was placed on a burner so that the neck was inclined at an angle of 45° to the horizontal and flame does not touch the flask above the level of the liquid in bulb. Heating was started slowly by setting low heat so that sample does not foam up neck of Kjeldahl flask. Digestion was done until white fumes appeared in the flask. The flame setting was increased to half way setting and heating continued until the light blue to green colour cleared in the digest. The flame setting was increased to maximum and heating continued for 1 hour. The flask was removed from the flame and the content allowed to cool at room temperature. The sides of the Kjeldahl flask were washed with fine jet of distilled water. The flask was placed on the flame and heated for 1 hour. The end of the digestion was indicated by clear digest with no black particles. After cooling, distilled water (20 ml) was added, and the mixture transferred to a 50-ml volumetric flask. A 5 ml portion of the diluted sample was then placed in a microKjeldahl unit and to this 10 ml of 40% sodium hydroxide was added. This was steam distilled, collecting the condensate into a 5 ml solution of 4% boric acid until 10 ml of the condensate was collected. The latter was then titrated with 0.01 M Hydrochloric acid to a red colour. A blank sample was treated in the same manner. The crude protein for milk was then calculated using the same formula as in the crude protein determination in milk.

3.8.3 Cheese moisture content

To determine moisture content, a flat bottomed metal dish containing 20 g of prepared sand was heated in hot air oven for about 1 hour. It was allowed to cool in desiccator for 30 minutes. 3 grams of prepared sample was put into the dish containing sand. The sand was saturated with water by carefully adding few drops of distilled water and mixed thoroughly with the cheese sample using a stirring rod to smooth out lumps and spread the moisture over the bottom of the dish. The dish was placed on boiling water for 20 minutes and then transferred to an oven maintained at 102 ± 1^{o}c and heated for 4 hours. The dish was then allowed to cool to room temperature in desicator. The weight of the dish was taken immediately. The uncovered dish was then heated in the oven at 102 ± 1^{o}c for a further 1 hour. The lid was replaced and allowed to cool to room temperature in the desicator and weight taken. This process of drying, cooling and weighing was repeated until the successive weighing did not differ. The total solids were calculated using the following formula:

Moisture % by mass = $M_1 – M_2/ (M_1 –M)$, Where,
M = Mass in g of the empty dish with glass rod,
M_1 = Initial mass in g of the dish, lid, glass rod along with the material taken for analysis,
M_2 = the final mass in g of the dish, lid, glass rod along with the material after drying.

3.9 Sensory evaluation

The cheese blocks were cut into blocks of 2 x 2 x 2 cm blocks and taken for sensory evaluation. Descriptive profile testing for flavour, body/texture, and appearance/colour, of mozzarella cheese from the Toggenburg and its cross breed with Galla goat was performed on the second day after processing. A panel of 5 cheese graders who were conversant with cheese evaluated the mozzarella cheese using procedure by Murray *et al.,* (2001). The panelist were selected based on their sensory ability and trained on the descriptive analysis according to standard profile guidelines on lexicons employed in judging of the mozzarella cheeses. The cheese samples were evaluated using developed lexicons for intensities of flavor, body and texture, and appearance and colour with maximum scores of flavor (45 points), body and texture (30 points) and appearance and color (25 points).

To determine consumer acceptability, Samples of Mozzarella cheese were presented to a non-trained panel of 35 potential volunteer consumers recruited from staff and students of Dairy Training Institute. The panelists were varied in age (19 – 59 years), balanced in gender (Female 18 and Males 17) and having positive attitude towards cheese. The cheeses

were coded with three-digit numbers assigned randomly, and presented in a random order. The panelists were asked to indicate their preference for the cheese on a 5-point hedonic scale. The descriptions used for the hedonic scale were: 5=like extremely, 4 = like slightly, 3 = neither like nor dislike 2 = dislike slightly, 1 = dislike extremely

3.10 Statistical analysis

Data was subjected to analysis using Generalized Linear Model of computer Statistical Analysis System software version 9.1.3 (SAS 2000). For all analysis, statistical significance was accepted at the $P \leq 0.05$ level of probability. Least Significant Difference (LSD) was used to separate means

CHAPTER FOUR
RESULTS AND DISCUSIONS

4.1 Results

4.1.1 Levels of milk components.

The results in Table 1 below show there is a significant difference ($p<0.05$) in levels of protein, fat, ash, total solids and milk coagulation time from milk of the Toggenburg and its cross breed with Galla goat. Cross breed milk showed higher mean values for protein, fat and total solids. However, the mean values for ash content from Toggenburg was higher compared to that from the cross breed.

4.1.2 Milk Coagulation Time (MCT)

Coagulation time of the milk from two genotypes differed significantly at $P<0.05$). Milk from Toggenburg showed a faster coagulation time at 7.45 minutes compared to 8.29 minutes for the cross breed as shown in Table 1 below.

Table 1: Means of milk components and MCT according to genotype.

Genotype	Parameters (%)				
	Fat	Protein	Ash	Total solids	MCT
Cross breed	3.87 ± 0.13^{a}	3.51 ± 0.18^{a}	0.82 ± 0.03^{b}	11.68 ± 0.35^{a}	8.29 ± 0.31^{a}
Toggenburg	3.32 ± 0.12^{b}	2.85 ± 0.10^{b}	0.93 ± 0.02^{a}	10.44 ± 0.52^{b}	7.45 ± 0.24^{b}

Means within columns with different superscripts differ significantly (P<0. 05)

4.1.2.1 Effect of lactation stage on milk components and MCT

The stage of lactation was found to influence the milk composition and coagulation time from individual genotypes as shown in Table 2 below. The milk fat content from cross breed was significantly high during both early and mid lactation compared to late lactation while milk fat content from Toggenburg was high during early lactation but decreased significantly during late lactation. The milk protein content from cross breed did not show significant differences across the lactation stages while milk protein from Toggenburg was significantly higher during early lactation compared to late lactation but did not show significant differences between mid and late lactation. The ash content from cross breed was significantly higher during early lactation compared to late lactation while ash content in milk from Toggenburg did not show significant differences across the lactation stages. Total solids from milk of both genotypes were high during early and mid lactation but decreased

significantly during late lactation. Milk coagulation time for cross breed milk did not show significant difference across the lactation stages while for the Toggenburg milk a significantly faster coagulation was observed during early lactation compared to both mid and late lactation as shown in Table 2.

Table 2: Means of milk components from individual genotypes versus stage of lactation

Genotype	Lactation stage	Parameters			
		Fat	**Protein**	**Ash**	**Total solids**
Cross breed	Early lactation	3.96±0.07^{a}	3.56±0.09^{a}	0.84±0.01^{a}	11.98±0.16^{a}
	Mid lactation	3.86±0.11^{ab}	3.45±0.11^{a}	0.83±0.03^{ab}	11.72±0.26^{a}
	Late Lactation	3.77 ±0.15^{b}	3.52±0.28^{a}	0.80±0.02^{b}	11.33±0.26^{b}
Toggenburg	Early lactation	3.44±0.06^{a}	2.93±0.13^{a}	0.94±0.02^{a}	10.83±0.20^{a}
	Mid lactation	3.30±0.11^{b}	2.84 ±0.05^{ab}	0.94±0.01^{a}	10.64±0.35^{a}
	Late Lactation	3.22±0.07^{b}	2.79±0.06 ^{b}	0.92±0.02^{a}	9.85±0.33^{b}

Means within columns with different superscripts differ significantly (P<0.5)

Table 3: Mean values of MCT for individual genotypes versus stage of lactation

Breed	Lactation stage		
	Early lactation	**Mid lactation**	**Late lactation**
Cross breed	8.43±0.17^{a}	8.33±0.34^{a}	8.13±0.35^{a}
Toggenburg	7.68±0.23^{a}	7.35±0.19^{b}	7.32±0.14^{b}

Means within rows with different superscripts differ significantly (P<0.5).

4.1.3 Cheese yield and composition.

The effect of genotype on cheese yield and composition are presented in Table 4. Mozzarella cheese yield and composition from the two genotypes differed significantly at $p<0.05$. The mozzarella cheese made with milk from the Toggenburg genotype had better quality in terms of yield and cheese composition. The quality of cheese based on yield and cheese composition from the cross breed genotype was lower than the one expected based on the composition of cheese milk.

Table 4: Means of mozzarella cheese yield and composition according to genotype.

Genotype	Parameters (%)			
	Cheese yield	**Cheese moisture**	**Cheese protein**	**Cheese fat**
Cross breed	15.23±0.98[b]	57.43±0.94[a]	19.41±0.19[b]	22.75 ±1.51[b]
Toggenburg	18.66±0.88[a]	55.02±0.77[b]	20.28±0.29[a]	24.44±1.21[a]

Means within columns with different superscripts differ significantly (P<0. 05)

4.1.3.1 Effect of lactation stage on Mozzarella cheese yield and composition.

Results on the parameters of cheese yield and cheese composition from individual genotypes based on stage of lactation are shown in Table 5. Cheese yield from both genotypes was significantly higher during early lactation compared to late lactation stage while cheese fat for both genotypes did not show significant difference across the three stages of lactation. Cheese moisture from Toggenburg was significantly high during early lactation and decreased significantly during late lactation. Moisture content of mozzarella cheese from cross breed did not show differences across the stages of lactation. Cheese protein from cross breed was significantly high during mid lactation compared to late lactation while Toggenburg cheese protein content was significantly high during early lactation compared to both mid and late lactation.

Table 5: Means of cheese components from individual genotypes versus stage of lactation

Genotype	Lactation stage	Cheese parameters (%)			
		Yield	Moisture	Protein	Fat
Cross breed	**Early lactation**	15.88±0.91^{a}	57.87±0.54^{a}	19.38±0.11^{ab}	22.90±1.17^{a}
	Mid lactation	15.40±0.80^{ab}	57.71±0.60^{a}	19.50±0.15^{a}	22.90±1.23^{a}
	Late lactation	14.40±0.65^{b}	56.72±1.19^{a}	18.19±0.30^{b}	22.45±0.85^{a}
Toggenburg	**Early lactation**	19.41±0.72^{a}	55.64±0.34^{a}	21.00±0.41^{a}	24.78±0.59^{a}
	Mid lactation	18.56±0.83^{ab}	54.96±0.78^{ab}	19.58±0.21^{b}	24.31±0.66^{a}
	Late lactation	18.00±0.48^{b}	54.45±0.62^{b}	19.50±0.29^{b}	24.24±1.33^{a}

Means within columns with different superscripts differ significantly (P<0. 05).

4.1.3.2 Correlation between milk components and cheese yield

Correlation values between the milk components and the cheese yield are presented in Table 6 below, Milk fat and total solids from Toggenburg were highly correlated with cheese yield. Significant correlation was also observed between the total solids and cheese yield in cross breed. In both genotypes no significant correlation was observed between milk protein and cheese yield. Weak correlation values between milk components were observed in cross breed compared to those from Toggenburg.

Table 6: Correlation values between milk components and cheese yield

Parameters	Goat Genotype	Parameters		
		Cheese yield	Milk fat	Milk protein
Milk fat	Cross	0.42ns		
	Toggenburg	0.63*		
Milk protein	Cross	0.28ns	0.22ns	
	Toggenburg	0.38ns	0.99*	
Milk total solids	Cross	0.65*	0.99*	0.25ns
	Toggenburg	0.64*	0.88*	0.88*

** Significant at p<0.05; ns = not significant at p<0.05.*

4.1.4 Sensory profiles of Mozzarella cheese.

Mozzarella cheese from Toggenburg showed significantly higher sensory score (3.80± 0.14) on overall acceptability based on a 5- point hedonic scale compared to cross

breed (3.63± 0.09). Descriptive profiles of the mozzarella cheese from Toggenburg showed significantly higher cores for flavour (40.70±0.76), body and texture (26.10±0.52) compared to 39.90±0.59 and 25.60±0.29 respectively for the cross breed. However, there was no significant difference in scores for appearance between the two genotypes as presented in table 7.

Table 7: Means of sensory scores of Mozzarella cheese

Genotype	Sensory parameters			
	Overall Acceptability	**Flavour**	**Body/Texture**	**Appearance**
Cross breed	3.63 ± 0.09^{b}	39.90 ± 0.59^{b}	25.60 ± 0.29^{b}	18.00 ± 1.81^{a}
Toggenburg	3.80 ± 0.14^{a}	40.70 ± 0.76^{a}	26.10 ± 0.52^{a}	18.40 ± 1.72^{a}

Means within columns with different superscripts differ significantly (P<0. 05)

4.1.4.1 Effect of the lactation stage on the sensory properties of mozzarella cheese.

Results on the influence of stage of lactation on sensory scores of mozzarella cheese made with milk from individual goat genotypes are presented in Table 8 below. The overall acceptability of mozzarella cheese from cross breed genotype was significantly high in both early (3.70±0.87) and late lactation (3.70±1.09) compared to mid lactation (3.50±0.82). However, the acceptability of mozzarella cheese from Toggenburg was significantly higher during early (3.70±0.82 and mid (3.70±0.98) lactation compared to late lactation. n. Flavour scores for the cheese were significantly different across the lactation stages for the two genotypes. However, for the cross breed flavour score was high (40.60±1.51) during mid lactation while for the Toggenburg the flavour was high (41.60±1.30) during early lactation. Body and texture score for mozzarella cheese from cross breed was significantly low (25.40±0.89) during early lactation increased significantly in mid lactation (26.00±1.13) and then decreased significantly (25.40±1.48) during late lactation. Scores for the appearance showed no significant differences across the lactation stages for the two genotypes.

Table 8: Means of Mozzarella cheese acceptability according to stage of lactation.

Breed	Lactation stage		
	Early lactation	**Mid lactation**	**Late lactation**
Cross breed	3.70±0.87[a]	3.50±0.82[b]	3.70±1.09[a]
Toggenburg	3.70± 0.82[b]	3.70±0.98[b]	4.00±0.94[a]

Means within rows with different superscripts differ significantly (P<0.5)

Table 9: Means of sensory attributes for individual genotypes according to stage of lactation.

Genotype	Lactation stage	Sensory parameters		
		Flavour	**Body &Texture**	**Appearance**
Cross breed	Early lactation	39.20±1.48[c]	25.40±0.89[b]	18.20±1.52[a]
	Mid lactation	40.60±1.51[a]	26.00 ±1.13[a]	18.00±0.82[a]
	Late lactation	40.00±1.58[b]	25.40±1.48[b]	17.80±1.15[a]
Toggenburg	Early lactation	41.60±1.30[a]	25.40±1.78[c]	18.80±0.84[a]
	Mid lactation	40.80±1.14[b]	26.60±1.00[a]	18.40±0.55[a]
	Late lactation	39.80±1.52[c]	26.20±1.12[b]	18.00±0.71[a]

Means within columns with different superscripts differ significantly (P<0. 05)

4.2 Discussions

4.2.1 Milk components from Toggenburg and its cross breed with Galla goat.

The values of fat (3.32+/-0.12), protein (2.85+/-0.10), ash (0.93+/-0.02) and totals solids (10.44+/-0.52) in Toggenburg milk were slightly different from that reported by Victor, *et al.,* (2010) of 3.12 +/- 0.27, 3.03 +/- 0.08), 0.96 +/- 0.01 and 10.52 +/- 0.32 for fat, protein, ash and total solids respectively. The results for butterfat content seem to be in agreement with results reported by Ferreira, *et al*., (2012), where he observed butterfat content of 3.3%, however, the total solids from the same study of 11.6% is higher than observed in this study. These differences could have been influenced by plane of nutrition and management practices as a result of differences in geographical location.

The obtained mean values of milk fat (3.87+/0.13) and total solids (11.68+/-0.53) from cross breed between Toggenburg and Galla goat are in agreement with finding of Ferreira, et al., 2012, who observed percent mean values of 3.9 and 12.3 for butterfat and totals solids from Toggenburg and Anglo Nubian cross breed. These results also agrees with

finding of Mestawet, *et al*., (2012) who reported milk fat content of 3.7% and total solids of 13.9% from the cross breed between Toggenburg and the Arsi–Bale indigenous goats in Ethiopia.

Higher values of milk fat exhibited by the milk from cross breeds are in line with what was expected, as the indigenous African genotypes have been reported to have higher component levels for protein, fat and total solids (Adewumi and Olorunnisomo, 2009; Zahraddeen, *et al.,* 2007; Donkin, *et al*., 1996). High milk fat values could have been influenced by cross breeding of the Toggenburg with the Galla goat as studies by Devendra and Burns, (1983) reported that indigenous African genotypes have milk fat content which range from 5.32 - 7.78 % and significantly contribution to the genetics in cross breed genotypes.

The fat content obtained in this study agrees with the observation that higher levels of milk production are associated with a lower fat content of milk (Zygoyiannis, 1988). The fat content was higher in the cross breed genotype which has been reported to yield lower volumes of milk compared to Toggenburg genotype. Morand-Fehr and Sauvant, (1980) reported 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. Genetic variability is among several factors which include parity, age, nutrition, lactation stage, and management, that have been identified, to influence the composition of milk in ruminant animals (El-Tarabany and El-Bayoumi, 2015; Mestawet, *et al*., 2012)

The reason for the variations in milk composition from this study as compared to other studies involving the same breed could be due to variations in parity, nutrition and management systems. Generally, the quality of milk produced by livestock is usually determined by the constituents that make up the milk, including fat, protein, lactose, non-solid fat, and density. In this study, the milk constituents from the two goat genotypes were comparable to other reported values. The mean values of milk composition observed in this study from the two genotypes fall within the range of acceptable values of quality milk (Claeys, *et al*, 2014; Yangilar, 2013)

Significance differences was observed in most of the milk components including milk protein, milk fat, ash and total solids among the two different goat genotypes. Since the two

genotypes were put under similar management and in an environment where both genotypes have been well adapted to during the experimental period, the observed difference could be attributable to genetic variation.

Mean values of fat, protein, ash and total solids from the two genotypes were high during the early stage of lactation. This in agreement with studies by Mestawet, *et al*., (2012) who reported that goat milk has significantly high levels of milk components during the early stages of lactation compared to the mid lactation. Even though the study found that the composition of milk components decreased during the mid lactation in both genotypes, the decrease was not significant except for milk fat in Toggenburg.

During the late lactation, values for fat, ash and total solids from the cross breed and fat, protein and total solids from Toggenburg decreased significantly. This is contrary to previous studies by Mestawet, *et al*., (2012) and Ibnelbachyr, *et al*., (2015) which have observed that milk components are significantly high during early and late lactation. The results on milk components in late lactation disagrees with the normal lactation of dairy goats as reported by Agnihotri *et al., (*2007) i.e. the solids content is high in early lactation when milk volumes is low; while milk volumes increases the milk solids decreases; as lactating does enter into late lactation, milk volumes decreases and milk solids increase again. In a study by Agnihotri, *et al.,* (2007) with milk from *Sirohi, Marwari, Kutchi* and *Jakhrana* does in western region of India showed high levels of total solids and fat content during early lactation which declined as lactation advanced followed by a steady increase in late lactation. Generally fat and protein in goats' milk are high in early lactation much lower thereafter until they rise again markedly at the end of lactation, when yields are low.

The results from the two genotypes seems not to agree with the reported findings on behavior of milk components with advance in milk lactation, This could probably be due to short milk production periods witnessed in Naivasha Sheep and Goat Stations as opposed to that experienced in other regions like India and Mediterranean regions where dairy goat farming is advanced and goats are in milk production for a longer period.

4.2.2 Milk coagulation time of milk from Toggenburg and its cross breed with Galla goat.

Together with hygiene and milk composition, milk clotting properties (milk clotting time, curd firming time and curd firmness) are important technological parameters as they influence the 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 a particular type of milk. In this study Toggenburg genotype coagulated faster compared to cross breed. Results showing longer coagulation time by the cross breed genotype was found to agree with findings by Clark, *et al.,* (2000) which indicated that goat milk with high solids, particularly solids non fat and protein, began coagulating later i.e. have long coagulation time, than milk with low solids, suggesting protein delays the onset of coagulation. These results are also supported by Ambrosoli, *et al*., (1988) who found that coagulation began earlier in goat milk with low casein than in goat milk with high casein. It is suggested that the elongation of coagulation time at high protein levels may in part be due to the presence of higher amounts of alpha S_1 casein and alpha S_2 casein in the milk. These two protein fractions may delay curd formation by binding calcium ions, making fewer available for binding after proteolysis of kappa-casein by rennet (Ambrosoli, *et al*., (1988)). The study by Ambrosoli, *et al*., (1988) further observed a positive correlation between coagulation time and curd firmness, with milks that took a long time to begin coagulating forming a firmer curd. However, in this study curd firmness was not investigated.

The findings on coagulation time across the lactation stages also disagrees with the previous studies by Matutinovic, *et al*., (2011) where the report indicated that, in sheep and goat, as the lactation progresses the content of total solids, fat, and protein in milk increase and are positively correlated with milk coagulation time. The findings on similar coagulation time in cross breed milk across the lactation stages could be attributed to the fact that coagulation properties of milk is influenced by the amount of protein and composition of casein variants in the milk. The protein content of the cross breed milk was observed to be similar across lactation stages and it can be postulated that the composition of alpha S_1 casein variant which plays a major role in coagulation time did not change with advance in lactation stages.

Faster coagulation of Toggenburg milk during mid and late lactation could be attributed to depressed levels of alpha S_1 casein variant in the protein which is positively correlated with coagulation time.

4.2.3 Cheese yield and Composition from the two genotypes.

Findings on the mozzarella cheese yield are in agreement with previous studies on the quality of soft cheeses from goat milk where Soryal, *et al*., (2004) reported yield of Domiati soft cheese between 12 and 18% while Oliszewski, *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 respectively 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 cheese 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).

The results of cheese yield (18.66±0.88) disagree with the findings of Victor, *et al.*, (2010) who reported a mean yield of 12.87±0.68 for soft cheeses from Toggenburg milk. However findings on the cheese composition from Toggenburg of cheese moisture (55.02±0.77), cheese fat (24.44±1.21) and cheese protein (20.28±0.29) tend to agree with his findings of 52.79±0.97, 24.43±1.25 and 19.18±0.53 for cheese moisture, cheese fat and cheese protein respectively.

The results from cheese yield and composition from cross breed are also in agreement with findings of Victor, *et al.*, (2010) who reported cheese quality from African biotype, the Anglo-Nubian as follows: cheese yield (17.38±1.87), cheese moisture (53.37±1.35), cheese fat (23.33±0.52), and cheese protein (19.10±0.96).

Results on milk composition showed that cross breed genotype presented the highest content of fat, protein and total solids which contribute significantly to cheese yield and composition. On the contrary, this genotype presented lower values for cheese yield, cheese fat and cheese protein content in mozzarella cheese which implies that a significant portion of these components were lost during processing. On the other hand, a good fat retention was obtained when Toggenburg milk was used which indicate that the cheese technology adopted was suitable for milk from this genotype.

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 (Brito, *et al*. 2002).

The ratio of protein to fat in milk significantly affects cheese yield and the percentage of fat and water retention in cheese. Studies by Guinee, *et al.*, (2007) showed that an increase in the ratio of protein to fat in milk leads to a significant reduction in actual yield of cheese. Reduced cheese yield from cross breed could be explained by a higher ratio of protein to fat in milk at 0.91and 0.85 for cross breed and the Toggenburg respectively.

Results of cheese yield from cross breed indicate that, the linear relationship between the fat and protein content in milk and Mozzarella cheese yield may not hold true beyond a

certain critical value of fat and protein ratio. The higher ratio between fat and protein in cross breed compared to the ratio of fat to protein in Toggenburg could have been responsible for depressed cheese yield. When the milk contains more fat than needed for a particular cheese the whey drains off the curd containing high concentrations of fat which constitutes a significant economic loss due to reduced cheese yield. The negative effect of the high ratio of protein to fat for the cross breed milk on cheese yield signifies the importance of fat standardization before cheese making.

The low cheese yield from the cross breed could have been influenced by the poor clotting ability of its milk. According to studies by Ng-Kwai-Hang, *et al.,* (1989) milk that coagulates faster is able to entrap more casein and fat into the coagulum before it is cut than the one that coagulates slowly a process that influences the cheese yield positively. Casein and fat constitute about 90% of the solids in cheese, so the amount of casein and fat lost in the cheese whey has a substantial effect on the efficiency of cheese-making.

Milk coagulation properties have a linear relationship with cheese yields. Poor coagulation properties of milk from the cross breed resulted to lower cheese yield compared to milk from Toggenburg even though cross breed had higher values for fat and protein, the two major nutrients which determine cheese yield. Poor clotting properties lead to lower retention values for both fat and protein which limits technological capability of the milk to produce high quality cheese.

The milk from Toggenburg aggregated faster after addition of the enzyme and formed a curd within a reasonable time and since faster coagulation produces higher dry-matter cheese yields, this explains partly why the cheese from the Toggenburg had lower moisture content compared to cheese from the cross breed. Because the possibility of varying cutting point in commercial large scale cheese production is limited, it is important that the curds are firm faster enough to allow cutting at the usual cutting time (Ng-Kwai-Hang, *et al.,* 1989)

The results on cheese yield with advance in lactation from the two genotypes disagrees with the findings of Soryal, *et al*., (2005) who reported that soft cheeses made from late lactation milk had higher values for protein, total solids and yield compared to cheese made from mid lactation milk. However, depressed cheese yields in this study may be explained by significantly low values for milk components during late lactation.

The results on cheese yield during late lactation for both genotypes are 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 coefficients between milk components and mozzarella cheese yield obtained from the two genotypes; 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 did not agree with the finding of Zeng, *et al*., (2007) who reported correlation of 0.81, 0.73 and 0.79 for milk fat, protein and total solids in goat milk soft cheeses. The results also disagree with findings of Guo, *et al*., (2004) who observed correlation between milk components and cheese yield as ranging from 0.73 to 0.81.

The weak correlation coefficients between the milk fat and milk protein with mozzarella cheese yield could be as a result of technological manipulation of the 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 fat retention and hence cheese yield.

The weak correlation coefficient could be attributed to poor milk coagulation properties which consequently led to poor retention values for fat and total solid in the Mozzarella cheese.

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.

Retention factors for milk fat and protein in cross breed milk was 0.59 and 0.55 while in the Toggenburg the retention values were 0.74 and 0.71 for fat and protein respectively. These values are lower than that reported by Barbano, (1996) who 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. Even though this study did not determine the amount of casein in milk, it is assumed that it is the principal protein component which is involved in cheese making and contributes considerably to the cheese protein content. Various studies have shown huge differences in milk component recoveries during cheese making using sheep milk where Pirisi, *et al*., (2000) reported recoveries of 78 – 81.4% fat and 75.4 – 79.5% protein, Gonzalez, *et al*., (1991) reported recoveries of 65% fat and 65% protein while

Economides, *et al*., (1987) reported recoveries of 86.9% and 78.6% for fat and protein respectively. 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.

Comparing the yield efficiency between the moisture adjusted yields to the predicted yield using Van Slyke formulae a huge variation was found from the yield of Toggenburg at 148% efficiency while cross breed had 96% yield efficiency. Such a huge variation indicates that the Van Slyke formulae may not be adequate to predict the yield of mozzarella cheese from goats' milk.

In order to accurately predict the yield of the mozzarella cheese from the goat milk, a huge data set across various parities and lactation stages on goat milk composition and cheese yields is required to calculate the retention coefficients for fat and protein.

4.2.4 Sensory evaluation of Mozzarella cheese

Evaluation of sensory attributes of a dairy product helps to determine the perceived profiles and overall acceptability of the product by the consumer. The results from the study show that acceptability of the goat mozzarella cheese was influenced by the goat genotype, with cheese from Toggenburg scoring higher in sensory profiles and overall consumer preference. This is in agreement with findings of Fekudu, *et al*., (2005) who reported that sensory quality of goat cheeses are influenced by a number of factors including animal genetics, production environment and processing technologies.

Low sensory scores for Mozzarella cheese from cross breeds could be partly attributable to an imbalance between fat and casein in cheese as a result of low fat retention. Fat retention in cheese enhances flavour and improves sensory scores (Barbano, 1996). Depressed retention values for fat and total solids and high moisture content in the mozzarella cheese from cross breed is likely to have played a significant role in influencing sensory scores based on flavour and texture lexicons.

High retention values of the milk fat in the cheese made from Toggenburg milk may explain the high sensory scores as result of milk fat contributing to the richness of mozzarella cheese. However, more studies need to be carried out on the fatty profiles and levels in the cheese from the two genotypes to determine the actual cause of the difference in cheese sensory scores.

Higher score on texture lexicons for mozzarella cheese from Toggenburg indicate that cheese from this genotype would be more preferred for use in the pizza industry. 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 consumer's panelists. In cheeses like mozzarella, texture plays an important role in determining consumer acceptance and the flavor cannot be uncoupled from texture when the consumer evaluates cheese (Foegeding and Drake, 2007). Stretchability, a texture component is a key quality parameter for mozzarella cheese intended for use as an ingredient in pizza preparation. According to Atanu, (2001) the specific melting and stretching characteristics is highly appreciated in the manufacture of pizza in which mozzarella is a key ingredient. The desirable characteristic is brought about by action of lactic acid on dicalcium - para-casenate at ph 5.2 to 5.4 which converts it to mono - calcium para-caseinate which provides the strings and sheen to the cheese (Mistry and Kosikowski, 1997).

According to studies by Foegeding and Drake, (2007) if a product is liked, all attributes are positively scored and if the product is disliked, all attributes are negatively scored. Flavor, texture, and visual cues are coupled together in the mind of the consumer to determine product quality and liking.

The results on the appearance of the cheese from the two genotypes did not have differences across the lactation stages. This could be due to the fact that both genotypes were subjected to the same type of pastures which did not have marked compositional variation across the lactation stage. According to Park, *et al*., (2017), the types of pasture fed to dairy animals not only affect the flavors of cheese, but also the color of the products.

Variation in sensory scores of mozzarella cheese from milk of individual goat genotype was found to be in agreement with findings of Soryal, *et al*., (2005), who reported sensory scores of soft cheese (chevre) from Alpine milk as varying throughout the lactation, while those of cheese from Nubian milk were virtually the same regardless of the stage of lactation.

Even though cheese from mid lactation milk across the genotypes had the lowest score in overall acceptability from consumer panelists; it exhibited higher scores from cheese graders in terms of flavor, texture and finish. This may have been due to lack of an acquired taste for the cheese by the general consumer panelists.

CHAPTER FIVE
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

1. There is a wide variability in milk components from the two genotypes with cross breed milk having high levels of fat, protein and total solids which could suggest the advantage of using this genotype milk for fluid milk sale.
2. Toggenburg milk has a favourable condition of reactivity with rennet and hence is better suited to undergo technological manipulation during cheese making process since rennet coagulation time together with curd firming time and curd firmness, are the three parameters which are key in measuring the capability of milk to produce cheese of high quality in terms of yield, composition and sensory profiles.
3. The stage of lactation significantly influence milk components, cheese yield and cheese composition from individual genotypes with a general decline as lactation advances.

5.2 Recommendations:

This study recommends that:

i. Mozzarella cheese makers should preferably use milk from Toggenburg dairy goats or an admixture with milk from its cross breed as opposed to use of cross breed milk only.
ii. Future selection and genetic improvement of dairy goats in our country intended to produce milk for cheese making should take into account the technological capability of the resultant milk.
iii. Studies need to be undertaken to determine levels of casein variants in milk from dairy goats' genotypes as they influence casein micelle organization and subsequently technological capability.
iv. Fatty acid levels and profiles in milk from both genotypes need to be evaluated to determine the cause of variability in sensory scores between the two genotypes.
v. Observations with a large data set and covering several lactation periods are required to determine the retention values for milk components in curd which could assist in predicting goat Mozzarella cheese yield.

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APPENDICES

Appendix 1: Analysis of Variances (ANOVA) across the breeds

Degrees of Freedom (**DF**): Model (**M**) = 3; Error (**E**) = 32; Corrected Total (**C**)= 35									
Parameters	**Sum of squares**			**Mean square**		**F value**	**Pr > F**	**R-Square**	**Mean**
	M	**E**	**C**	**M**	**E**				
Milk Fat	2.99	0.30	3.30	1.00	0.01	104.97	<.0001	0.91	3.59±0.39
Milk Protein	3.95	0.63	4.58	1.32	0.02	66.54	<0.0001	0.86	3.18±0.47
Ash	0.12	0.05	0.135	0.04	0.004	95.48	<0.0001	0.88	0.88±0.08
Total Solids	17.98	2.43	20.42	5.99	0.08	78.82	<0.0001	0.88	11.06±0.88
MCT	6.43	2.63	9.06	2.14	0.08	26.05	<0.0001	0.71	7.87±0.59
Cheese Yield	118.4	16.92	135.29	39.46	0.53	74.60	<0.0001	0.87	16.94±2.43
Cheese Moisture	61.02	16.48	77.51	20.34	0.52	39.49	<0.0001	0.79	56.23±1.70
Cheese Fat	27.31	5.33	32.64	9.10	0.17	54.64	<0.0001	0.84	23.60±0.62
Cheese Protein	6.73	2.08	8.81	2.24	0.07	34.47	<0.0001	0.76	19.84±1.20

MCT = Milk Coagulation Time

Degrees of Freedom (**DF**): Model (**M**) = 4; Error (**E**) = 205; Corrected Total (**C**)= 209									
Parameter	**Sum of squares**			**Mean square**		**F value**	**Pr > F**	**R-Square**	**Mean**
	M	**E**	**C**	**M**	**E**				
Cheese Acceptability	4.40	0.09	4.49	1.10	0.00	2579.68	<0.0001	0.82	3.72±0.12

Degrees of Freedom (**DF**): Model (**M**) = 3; Error (**E**) = 26; Corrected Total (**C**)= 29									
Parameters	**Sum of Squares**			**Mean Square**		**F Value**	**Pr > F**	**R-Square**	**Mean**
	M	**E**	**C**	**M**	**E**				
Cheese Flavour	13.67	4.20	17.87	4.56	0.16	28.20	<0.0001	0.76	40.3±0.57
Cheese Texture	5.70	0.87	6.57	1.90	0.03	57.00	<0.0001	0.87	25.8±0.35
Cheese Appearance	2.20	0.47	2.67	0.73	0.02	40.86	<0.0001	0.83	18.2±0.28

Appendix 2: Analysis of Variances (ANOVA) across the lactation stages

Degrees of freedom: Model (**M**) = 2; Error (**E**) = 15; Corrected Total (**C**)= 17										
Parameters	**Breed**	**Sum of squares**			**Mean square**		**F value**	**Pr > F**	**R-Square**	**Mean**
		M	**E**	**C**	**M**	**E**				
Milk Fat	**TOG**	0.15	0.10	0.25	0.07	0.01	10.82	0.0012	0.59	3.32±0.12
	CRB	0.11	0.20	0.25	0.05	0.01	4.04	0.0394	0.35	3.87±0.13
Milk Protein	**TOG**	0.05	0.11	0.16	0.03	0.01	3.85	0.05	0.34	2.85±0.10
	CRB	0.04	0.50	0.54	0.02	0.03	0.57	0.56	0.70	3.51±0.18
Ash	**TOG**	0.01	0.00	0.01	0.001	0.00	2.12	0.15	0.72	0.93±0.02
	CRB	0.01	0.01	0.02	0.001	0.00	6.02	0.0121	0.69	0.82±0.03
Total Solids	**TOG**	3.20	1.37	4.57	1.60	0.09	17.58	0.0001	0.70	10.44±0.52
	CRB	1.30	0.80	2.11	0.65	0.05	12.18	0.0007	0.62	11.68±0.35

Degrees of freedom: Model (**M**) = 2; Error (**E**) = 15; Corrected Total (**C**)= 17										
Parameters	**Breed**	**Sum of squares**			**Mean square**		**F value**	**Pr > F**	**R-Square**	**Mean**
		M	**E**	**C**	**M**	**E**				
MCT	**TOG**	0.47	0.54	1.02	0.24	0.04	6.54	0.009	0.47	7.45±0.24
	CRB	0.29	1.35	1.64	0.15	0.09	1.62	0.23	0.61	8.29±0.31
Cheese Yield	**TOG**	6.11	7.18	13.29	3.05	0.48	6.38	0.01	0.46	18.66±0.88
	CRB	6.89	9.40	16.29	3.45	0.63	5.50	0.01	0.42	15.23±0.98
Cheese Moisture	**TOG**	4.27	5.71	9.98	2.14	0.38	5.62	0.01	0.43	55.02±0.77
	CRB	4.63	10.29	14.92	2.31	0.69	3.37	0.06	0.63	57.43±0.94
Cheese Fat	**TOG**	1.05	1.97	3.02	0.52	0.13	3.99	0.04	0.55	24.44±1.21
	CRB	0.79	2.99	3.78	0.40	0.20	1.99	0.17	0.52	22.75±1.51
Cheese Protein	**TOG**	8.42	10.01	18.43	4.21	0.67	6.31	0.01	0.55	20.28±0.29
	CRB	6.23	9.49	15.75	3.14	0.63	4.96	0.02	0.59	19.41±0.19

TOG = Toggenburg; **CRB** = Toggenburg and Galla Cross breed;

MCT = Milk Coagulation Time

Degrees of Freedom (**DF**): Model (**M**) = 2; Error (**E**) = 102; Corrected Total (**C**) = 104										
Parameters	**Breed**	**Sum of squares**			**Mean square**		**F value**	**Pr > F**	**R-Square**	**Mean**
		M	**E**	**C**	**M**	**E**				
Cheese Acceptability	**TOG**	2.10	0.0001	2.10	1.05	0.0001	Infinity	<.0001	0.97	3.80±0.14
	CRB	0.93	0.0001	0.93	0.47	0.0001	Infinity	<.0001	0.97	3.63±0.09

Degrees of Freedom (**DF**): Model (**M**) = 2; Error (**E**) = 12; Corrected Total (**C**) = 14										
Parameters	**Breed**	**Sum of squares**			**Mean square**		**F value**	**Pr > F**	**R-Square**	**Mean**
		M	**E**	**C**	**M**	**E**				
Cheese Flavour	**TOG**	8.13	0.0001	8.13	4.07	0.0001	Infinity	<.0001	1.00	40.70±0.76
	CRB	4.93	0.0001	4.93	2.47	0.0001	Infinity	<.0001	1.00	39.90±0.59
Cheese Texture	**TOG**	3.73	0.0000	3.73	1.87	0.0000	Infinity	<.0001	1.00	26.10±0.52
	CRB	1.20	0.0000	1.20	0.60	0.0000	Infinity	<.0001	1.00	25.60±0.29
Cheese Appearance	**TOG**	1.60	40.00	41.60	0.80	3.33	Infinity	<.0001	1.00	18.40±1.72
	CRB	0.40	45.60	46.00	0.20	3.80	Infinity	<.0001	1.00	18.00±1.81

Appendix 3: Gender and Age demographics of consumer panel

	18 -19	**20 – 29**	**30-39**	**40-49**	**50-59**	**Total**
Male	3	13	1	0	0	17
Female	2	12	2	1	1	18
Total	5	25	3	1	1	35

Appendix 4: 5 Point Hedonic scale

Descriptor	**Dislike very much**	**Dislike slightly**	**Neither like nor dislike**	**Like slightly**	**Like very much**
Assigned score	1	2	3	4	5

Appendix 5: Sensory lexicons for Mozzarella cheese

Quality Attribute	**Developed Lexicons**	**Maximum score**	**Awarded score**
Flavour	Fresh, buttery aroma, sourness, goaty flavour.	45	
	Mild flavour, pronounced sourness, goaty flavour	30	
	Bland, uncharacteristic of goat cheese	≤20	
Body and Texture	Soft, stickiness, adhesion to palate, plasticity	30	
	Hard, weak slicing ability, poor plasticizing ability	20	
	Cracking, poor adhesion to the palate	≤10	
Appearance	Smooth, compact, evenly distributed, whitish	25	
	Somehow smooth, slightly compact,	15	
	Not evenly distributed, spotted cheese	≤10	

Appendix 6: Experimental does

Toggenburg and cross breed dairy goats at Naivasha Sheep and Goat Station

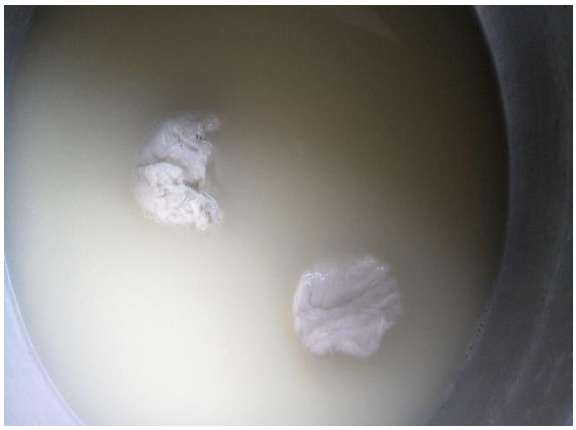
Appendix 7: View of Mozzarella cheese curd

Matted curd ready for plasticizing

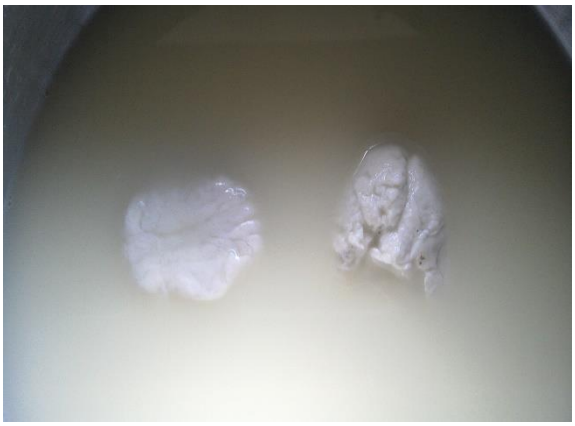
a) Curd from Cross breed milk

b) Curd from Toggenburg milk

Curd immersed in hot water during plasticizing



a) Curd from Cross breed milk



b) Curd from Toggenburg milk

Various Shapes of Goat Mozzarella

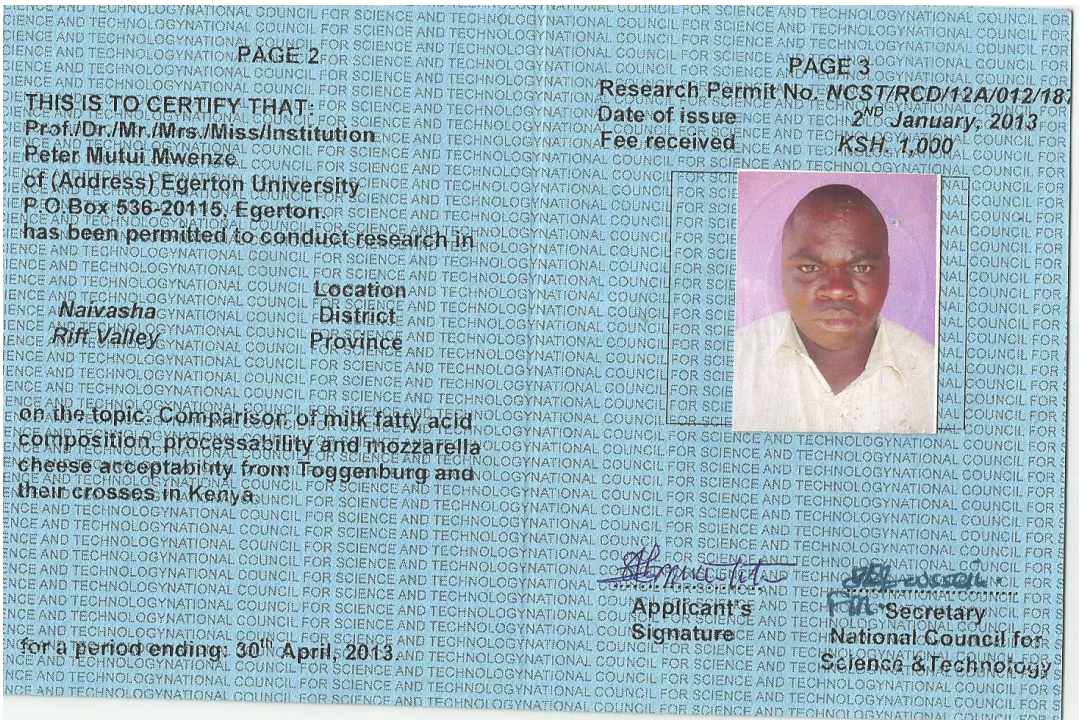
Appendix 8: Publication

Mwenze, P.M., Muliro, P.S., and Matofari, J. W. (2016): Comparison of milk component levels, processability and Mozzarella cheese acceptability from Toggenburg and their crosses in Kenya. *International Journal of Innovative Food, Nutrition, and Sustainable Agriculture.* Vol. 4(4): 7-14. © **SEAHI PUBLICATIONS. Available online at www.seahipaj.org**

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, appearance. 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 and appearance showed differences between the genotypes with Toggenburg cheese having higher scores for the sensory attributes. Individual genotypes showed a significant effect of the stage of lactation on the parameters evaluated. From the study, it is concluded that milk from the Toggenburg is superior in terms of Mozzarella cheese making properties and cheese acceptability. The study recommends determination of casein variants and fatty acid profiles in milk from both genotypes as they have a significant effect on cheese quality and sensory profile.

Appendix 9: Permit and authorization



PAGE 2

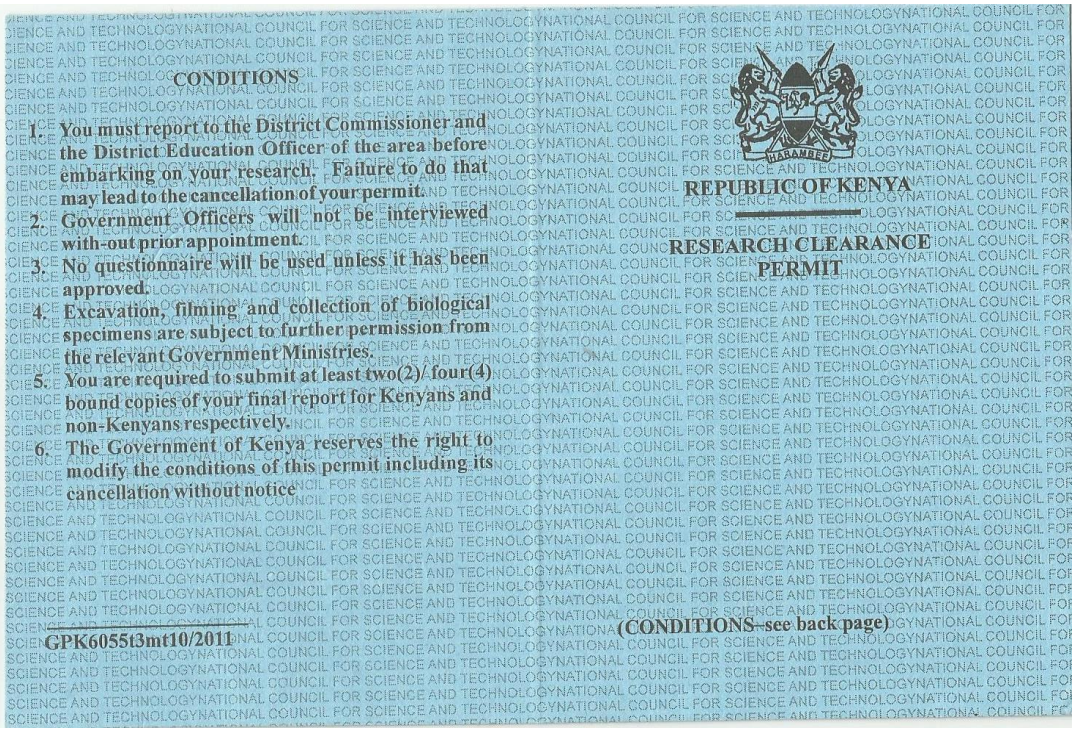
THIS IS TO CERTIFY THAT:
Prof./Dr./Mr./Mrs./Miss/Institution
Peter Mutui Mwenze
of (Address) Egerton University
P.O.Box 536-20115, Egerton
has been permitted to conduct research in
Location Naivasha
District
Province Rift Valley
on the topic: Comparison of milk fatty acid composition, processability and mozzarella cheese acceptability from Toggenburg and their crosses in Kenya
for a period ending: 30th April, 2013

Applicant's Signature

PAGE 3

Research Permit No. NCST/RCD/12A/012/187
Date of issue 2ND January, 2013
Fee received KSH. 1,000

Secretary
National Council for Science & Technology



CONDITIONS

1. You must report to the District Commissioner and the District Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit.
2. Government Officers will not be interviewed with-out prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2)/ four(4) bound copies of your final report for Kenyans and non-Kenyans respectively.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

HARAMBEE

REPUBLIC OF KENYA

RESEARCH CLEARANCE PERMIT

GPK6055t3mt10/2011

(CONDITIONS–see back page)

REPUBLIC OF KENYA

NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY

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secretary@ncst.go.ke

P.O. Box 30623-00100
NAIROBI-KENYA
Website: www.ncst.go.ke

Our Ref: **NCST/RCD/12A/012/187**

Date: **2nd January, 2013**

Peter Mutui Mwenze
Egerton University
P.O.Box 536-20115
Egerton.

RE: RESEARCH AUTHORIZATION

Following your application dated ***14th December, 2012*** for authority to carry out research on "***Comparison of milk fatty acid composition, processability and mozzarella cheese acceptability from Toggenburg and their crosses in Kenya,***" I am pleased to inform you that you have been authorized to undertake research in **Naivasha District** for a period ending **30th April, *2013.***

You are advised to report to **the District Commissioner, the District Education Officer and the District Medical Officer of Health, Naivasha District** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

SAID HUSSEIN
FOR: SECRETARY/CEO

Copy to:

The District Commissioner
The District Education Officer
The District Medical Officer of Health
Naivasha District.

"The National Council for Science and Technology is Committed to the Promotion of Science and Technology for National Development".

REPUBLIC OF KENYA

Ministry of Livestock Development

Fax:-254-050-50169
Telephone: 050-50339 Naivasha
E-mail: mbuzinakondoo@yahoo.com

SHEEP AND GOAT STATION,
P.o. Box 254 – 20117,
NAIVASHA.

All correspondence should be addressed to
"The Officer-in-charge"
Sheep and Goat Station.
When replying please quote

Date: 5TH SEPTEMBER, 2012

Our Ref: **RES/VOL.3/49**

PETER MWENZE
DAIRY TRAINING INSTITUTE
P.O. BOX 449-20117
NAIVASHA

RE: REQUEST TO USE GOATS AT SHEEP AND GOATS STATION

Your letter dated 4th September, 2012 on the above subject refers.
I wish to inform you that your request has been accepted. In line with this, you will have to take care of the welfare of the selected goats and that of the herder. You will also be allocated adequate pens for this group.
I also request that once your report is ready, you will share the findings with the station
The farm manager Top Farm will facilitate the selection exercise.

C.G Wahome
Officer-in-charge

cc. Farm Manager, Top Farm