EVALUATION OF KENYA ALPINE DAIRY GOAT (C*apra aegagrus hircus*) MILK YIELD, AND ITS NUTRITIONAL AND CHEMICAL COMPOSITION FOR PRODUCT DEVELOPMENT, IN NYERI COUNTY

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DECLARATION

This is my original work and has not previously been submitted to any other university either in whole or in part for the award of any degree, fellowship or any other similar awards whatsoever.

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DEDICATION

I wish to dedicate this research work to my family especially my loving husband - Johnnie, our eight children - Jose, Leah, Mike, Immaculate, Triza, Joseph, Nancy and Seraphine; and my dear parents – for their love, inspiration, prayers and moral support. May the Sacred Heart of Jesus and the Immaculate Heart of Mary reign forever.

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ABBREVIATIONS AND ACRONYMS

ASAL – Arid and Semi arid Lands

CTA - Technical Centre for Agricultural and Rural Cooperation ACP-EU

DGAK – Dairy Goat Association of Kenya

EU – European Union

FAO – Food Agriculture Organization

FAOSTAT - FAO statistical database

GDP – Gross Domestic Product

GNP – Gross National Product

GOK – Government of Kenya

HIV/AIDS - Human immunodeficiency virus infection / acquired immunodeficiency syndrome

HPIK – Heifer Project International –Kenya

KDB – Kenya Dairy Board

KSB – Kenya Stud Book

MDG – Millennium Development goals

MoLD – Ministry of Livestock Development

MT – Metric Tones

NEMA - National Environment Management Authority

NGO – Non Governmental Organization

ABSTRACT

In Kenya use of exotic dairy goats in breeding programmes for smallholder production systems has become popular, but information on the milk production and nutritional quality is scarce. This research project was done to investigate the milk yield and its nutritional composition of Kenya Alpine dairy goat, *Capra aegagrus hircus*, for value addition. The initial work constituted assessing the dairy goat feeding practices in the study areas of Mukurweini, Kieni East and Kieni West, where it was found that all the households involved in the study relied on natural pastures as a source of feed for dairy goats. The dairy goats in Kieni East and Kieni West were fed with concentrates and mineral supplementation during milking, while Mukurweini farmers used less concentrates and no mineral supplements. The Appendix grade in Kieni East gave the highest amount of milk per day, while the foundation grade in Mukurweini produced the least. There was significant increase in daily milk production with crossbreeding in Kieni West, from the original to pedigree grade. Consequently, there was no improvement in daily milk production with the crossbred goats in the Kieni East and Mukurweini. The dairy goats start to produce milk at the age of 2.0 to 2.9 years in the three regions, with milk yield showing significant variation in different age groups. There was a significant increase in milk production for the pedigree grade at the age of 5.0 and 5.9 years. Variations were noted in milk chemical composition for dairy goats in semi arid and high potential areas under the study. Mukurweini dairy goat milk had higher amount of ash, fat and protein as compared to the other two regions of the semi arid area. The mineral composition differed clearly among the three regions with Mukurweini giving significantly higher amounts of calcium, magnesium, iron, zinc, sodium and potassium In the semi arid areas of Kieni East and West, dairy goat easily adapt to the harsh climate and scarcity of fodder while in Mukurweini there are readily available fodders to feed the dairy goats, thus the high mineral components. Significant low levels of niacin and riboflavin were noted in Kieni west, while Mukurweini region gave high amounts of riboflavin and α-tocopherol as compared to the other two regions. In the high potential areas of Mukurweini the milk was significantly higher in palmitic and stearic acids, and low amounts of lauric acid. Mukurweini region also had significant High levels of methionine, phenylalanine, threonine, histidine and leucine were obtained from goat milk at Mukurweini region. The significant amounts of essential amino acids in milk protein were due to the high nitrogenous fodder given to the dairy goats in this region. Goat and cow milk Paneer cheese chemical composition, showed significant difference in fat content. There was a significant liking for cow milk Paneer cheese as compared to the goat milk Paneer cheese, in terms of taste and aftertaste, where cow paneer had creamy milky taste and nutty after taste, as compared to that of goat milk which had slightly bitter/sour taste. A smooth texture/appearance was characteristic of the two cheese samples while the cream of cow milk cheese and pure white colour of the goat milk cheese were both acceptable to the panelists. A reduction of the scores for body and texture was observed in both goat milk and cow milk natural yogurt. Among all analyzed types, the goat milk yoghurt with 2% starch revealed the highest overall acceptability, while natural yoghurt from goat milk scored the lowest overall acceptability. A higher score for goaty flavor in goat milk yogurt fortified with 2% starch and vanilla flavored was observed indicating a higher acceptability for the flavor of the new product. Analyzed results for odor showed a high score for all types of yogurt indicating that the goat milk yoghurt did not produce an off odour, as is perceived culturally. The study established that the geographical location of the dairy goat rearing affect both the quality and quantity of milk produced, which is also dependant on the type of fodder available in that region, feeding practices, age of the dam and the grade.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

The agriculture sector remains a key pillar of the Kenyan economy contributing about 25 percent of GDP. However, productivity in the sector is significantly lower (2-3 times) than international benchmark countries (Kamau *et al.*, 2010). The sector possesses additional opportunities to unlock potential of Kenyan land with a strong need for legal and institutional reforms. Kenya Vision 2030 envisages a transformation from the current practices to a more commercially oriented agriculture.

In Kenya, one way of mitigating the problem of malnutrition is to encourage sustainable production with overall balance of all nutrient requirements at farm level through integrated farming for crop production and animal rearing. While dairy goat farming is more sustainable as compared to cow farming on small pieces of land, it needs to be supported with good agriculture practices, with the farmer utilizing the manure for growing food crops and fodder for the goats. The small-scale farmers are faced with limited fodder for their livestock, due to the small sized farms; hence need to maximally utilize this space for sustainable production.

Increased human population pressure, and the ensuing land demarcation in Kenya, have stimulated use of dairy goats in rural development efforts, which according to Kosgey *et al.*, (2006), pure exotic or crossbred dairy goats and associated technologies are preferred as a fast means of improving animal production of smallholder farmers and, quickly boosting their economic status and diet quality.. Goats are a good pathway out of poverty for smallholders and the high quality of goat's milk can addresses malnutrition at the household level especially through value addition.

Factors favouring the rearing of goats are that they generally thrive well across agro-ecological zones, which is reflected by the degree of their adaptation (i.e., survival under environmental stresses like diseases, parasites and high temperatures), functional contribution (i.e., meat, milk, fibre and skins) and socio-economic relevance (i.e., security and income generation) (Devendra, 2001; Peacock, 2005). Other attributes of goats are multi-parity and multiple births, shorter generation interval, lower investment, higher digestive efficiency for roughage and lower feed requirements as compared to cattle. Raising one mature dairy cow is equivalent to raising five to six mature goats (Braker *et al.,* 2002).

Dairy goat production has been gaining popularity in many countries of the world in the recent years and among the small-scale farmers, as it does not require large areas to keep them, as well as the increasing demand for goat milk due to its unique and equally important nutritional value. Smallholder farmers in Kenya are increasingly turning to dairy goat rearing in some regions as a means to grow incomes while improving nutrition in rural areas, as well as commercial benefits of goat dairy products (DGAK, 2009). To increase milk production at farm level, selective breeding supplemented with good nutrition and management feeding as well as general care of a dairy goat is important, which calls for value addition to enable market penetration.

The study was carried out to evaluate how the quantity and quality of dairy goats' milk is affected by the age of the dam, grade, feeding, and geographical location of the goat rearing. This was achieved through investigating the milk yield of dairy goats reared in Nyeri County in two different geographical regions; Mukurweini representing high potential area and Kieni East and West representing semi arid area. The findings from this study formed the basis for dairy goat improvement across the board and value addition through locally adaptable technology that can be used to enhance the income of the poor farmers and enhance poverty eradication at village level.

1.2 Statement of the Problem

Food Security and poverty alleviation have been catapulted to the top of the World's priorities by the recent spike in world food prices. These problems have taken on an added dimension in the developing countries like Kenya, where major obstacles are still encountered in the fight against malnutrition and disease. One way of mitigating the problem of malnutrition is to encourage milk production enterprises among small-scale farmers, where business incubation enterprises will provide a long term response to these problems through securing food reserves and critically addressing the biting poverty that is pervasive in the rural areas of Kenya.

The production of goat's milk in Kenya has been increasing steadily over the past few years. However, very little scientific and technical information is available on the quantity and quality of milk produced by the different goat breeds raised in country. The status of dairy goat products acceptability and the communities' perception towards dairy goat products are also not known. With the aim of filling this knowledge gap, the milk yield and nutritional characterization of goat milk was evaluated to gain a better understanding of the relationship that exist between the physico-chemical properties of Kenyan goats' milk and milk processing technologies. However, dairy goat milk production has not gained much popularity, due to issues perceived to include cultural perception, lack of information on production, marketing and consumption as well as great preference of alternative dairy milk. There is also lack of product development and consumer preference evaluation of products developed from goat milk. Although several authors have examined the nutritive value of goat milk taking into consideration various factors [Andrade and Schmidely, 2006, Matsushita *et al.*, 2007, Pandya and Ghodke 2007) little is known about its composition in relation to geographical location in a specified area in Kenya. In areas where the land holding/family are too small (0.5 to 1.5 acres) to support large ruminant livestock, dairy goats have become appropriate targets for research and development attention and it is on this background that the researcher undertakes this project.

1.3 Overall objective:

To determine the milk yield of dairy goats reared in three regions of Nyeri County, and evaluate nutritional and chemical composition of their milk for product development.

1.3.1 Specific objectives

1. To determine the milk yield of Kenya Alpine dairy goat breeds in regard to age and grade of the goat in three regions of Nyeri County
2. To determine the nutritional composition of goat milk from the pedigree grade of Kenya Alpine dairy goat from different geographical areas of Nyeri County
3. To develop goat milk Paneer cheese and yoghurt from the pedigree grade and determine their consumer acceptability.

1.4 Research hypotheses

Hypothesis 1.There is no difference in milk quantity among goats of different age and grades in Mukurweini, Kieni East and Kieni West regions of Nyeri County

Hypothesis 2. There is no difference in milk quality among goats of pedigree grade in Mukurweini, Kieni East and Kieni West regions of Nyeri County

Hypothesis 3. There is no difference between sensory attributes of yoghurt and cheese products from goat and cow milk.

1.5 Expected output

Small holder farmers keep dairy goats to provide them with milk for home consumption and sale; manure to fertilize soil and income from sale of live goats. With the extra income, farmers can pay household bills; send children to school or reinvest in the farm.

The Dairy Goat Association of Kenya (DGAK) has been promoting dairy goat keeping in Nyeri County, with the aim of creating sustainability with various groups of small scale farmers, but there are no studies taken to assess the implication of this project, including documented management practices and effect of the dairy goat crossbreeding programme on the milk yield and quality. This project identified constraints, and opportunities for guidance and targeting of expansion of the dairy goat multiplication and how the programme can be improved, for income generation in Kenya. Policy recommendations towards better milk yields by the dairy goats and improved management practices aimed at cheaper and effectively utilized inputs may be a priority for the dairy goat industry. The findings from this project will form the basis for dairy goat improvement across the board and value addition through locally adaptable technology that can be used to enhance the income of the poor farmers and enhance poverty eradication at village level

1.6 Limitations

1. Dairy goat feeding practices was faced by nutritional limitations under normal circumstances where the goats relied only on natural vegetation. The main feed resources for smallholder farmers consisted of three categories; Napier grass, natural pastures and crop residues. The researcher had to conduct farmers training on feeding practice to ensure proper utilization of fodder available and good nutritional management before the project commenced. This lead to delay in initiating the baseline study to determine the milk yield in the three regions.
2. Some farmers were excluded from this project due to inadequate recording where no monitoring of animal husbandry could be undertaken. For smallholder farmers, most of whom are illiterate, the emphasis was to keep the recording system as simple as is practically possible. Poor recording was noted during this study, with some goat registration cards lacking the important information required by the researcher, resulting to elimination of such goats from the project. This was a big constraint to this work in the semi arid areas, where the researcher had to identify more goats in the same field of study, whose owners could consistently maintain records.
3. Another limitation faced by the researcher was designing the experiment to fit in with the scheduling and area under study. Mukurweini region was identified as a high potential area in Nyeri County that was sampled by census, where all the dairy goats qualifying to the requirements and registered with DGAK were included in the design. The households were scattered in the region, leading to great involvement in travelling and sampling. It took ample time to define exactly what data would be useful and analyzing. By the end of the study it was clear that the dairy goat diet was the most critical portion in determining milk production and quality. Efforts to establish a control farm in Mukurweini failed, where farmers identified sold the dairy goats and withdrew from the project.

CHAPTER TWO

LITERATURE REVIEW

2.1 Livestock production in Kenya

The agricultural sector is the backbone of the Kenyan economy as it contributes to around 25% of the GNP and employs 75% of the labour force (Ynze, 2008). The livestock sector numbers around 13 million cattle, 22 million sheep and goats and 1 million camels, and contributes 10% (Ksh. 79 Billion) to the GNP of which 3.5% originates from the dairy sector. It plays a crucial role at both the national and household level and has been identified as critical to the overall economic and social development (Ministry of Livestock and Fisheries, 2009).

Livestock farming is a key in the achievement of this important MDG, because it's the mainstay of most rural households, and contributes significantly to the livelihoods of the citizens of this country. Kenya Alpine dairy goats usually live in the Central and Eastern highlands of Nyeri and Meru Districts respectively, but in recent years they have spread to other areas of lower potential compared to the original entry areas. These areas are characterized by a humid to sub-humid climate with long, wet and cold wet seasons. Herds are usually zero grazed and stall fed on greens and very little or no concentrate supplementation is provided. Water is also provided in the shed. The kidding season is usually not synchronized but rather depends on conditions of pasture.

The Dairy Goat Association of Kenya (DGAK) has been promoting dairy goat keeping with various groups of small scale farmers in Nyeri County, but there are no studies taken to assess the implication of this project, including documented management practices and effect of the dairy goat crossbreeding programme on the milk yield and quality. There is need to identify constraints and opportunities for guidance and targeting of expansion of the dairy goat multiplication and how the programme can be improved, for income generation in Kenya. Policy recommendations towards better milk yields by the dairy goats and improved management practices aimed at cheaper and effectively utilized inputs may be a priority for the dairy goat industry.

The Dairy Production, is a major source of livelihood for the families of about 6 - 800,000 small-scale farmers for whom dairy farming is a primary activity (Kiptarus, 2005). Dairy sub-sector constitutes the largest share of livestock contribution to the country's GDP. Smallholder dairy production accounts for over 70% of total milk production (Kiptarus, 2005). The milk is primarily produced from cattle, camels and dairy goats, their relative shares in the estimated total milk output being 84%, 12% and 4% respectively (Kiptarus, 2005). The dairy industry is the most developed within the livestock sub-sector and is dominated by the small-scale producers who account for 80% of the dairy industry's output. The global market is highly competitive with great diversity of milk and milk products of high international standards. Therefore, there is a need to have intense co-operation between farmers industry, research institutions and government, to have high processing efficiency, which leads to lower consumer price and developed diversified global products.

Among the developing countries, Kenya has one of the most rapidly expanding dairy sub-sectors (ILRI, 2000). Smallholder farmers using exotic dairy cattle breeds, mainly in the highland areas, dominate the dairy sub-sector (Omore *et al.*, 1999). The major constraint to improving production and reproductive performance of dairy cattle is scarcity of feed resources and their poor quality (Methu *et al.*, 2001).

Almost 90% of the milk produced in Kenya, originates from cattle (MoLD, 2006). Camel milk is produced and consumed in the ASAL areas. Goats are kept in the high potential areas as well as in the ASAL areas, and goat milk constitutes about <0.5% of the total milk production (MoLD, 2006). In dry areas where it is difficult for dairy cows to survive, goats (and camels) play a greater role in providing milk.

Several studies indicated that people with cow's milk allergy could tolerate goat's milk (Restani and Fiocchi, 2004). Livestock products not only provide high-value protein but are also important sources of a wide range of essential micronutrients such as iron and zinc, and vitamins such as vitamin A. In addition to milk and meat, manure is also an important by-product for farmers in this area, and is used to fertilize vegetable plots. For the large majority of people in the world, particularly in developing countries, livestock remains a desired source of food for nutritional value and taste. Multipurpose goats can be recommended introduced, particularly in low-income household in order to maximize food production and security.

2.2 Sheep and Goat

Compared to cattle, keeping dairy goats has been found to be a cheap way of improving living conditions of many smallholders (WHO, 2008). In many parts of the world where the geophysical properties of the terrain are not suitable for other livestock species, goats seem to be the best choice. Based on the accumulated information on goat characteristics, it can be stated that goats have a specific place in the animal agricultural economy of many countries. They can withstand heat stress and can endure prolonged water deprivation. They have additionally great adaptability to adverse climatic and geophysical conditions, where cattle and sheep cannot survive. They can efficiently utilize poor quality forage and cover long distances looking for food. Their peculiar feeding habits make it easier to choose diets to meet their requirements. Goats are the most prolific domesticated ruminant. Faster reproduction contributes to the genetic progress that can be achieved and enables their owners to recover quickly. Farmers and pastoralists are increasingly relying on goats as means of survival and a way of boosting their income (Peacock, 2005). The increasing frequency of droughts, with long-term environmental degradation is causing pastoralists to change from cattle or sheep to camels or goats. Overgrazing makes rangelands increasingly suitable for browsing species such as goats. The widespread decline in services supplied by governmental agencies encourages farmers to move from keeping cattle to goats. Goats provide their owners with a broad range of products and socio-economic services that have played an important role in the social life of many people being used as gifts, dowry, in religious rituals and rites of passage (Peacock, 1996). Goats, especially dairy ones, are an ideal species for poverty reduction and economic development for the poor in developing countries. Several reasons make goats particularly attractive for poverty reduction and improvement of family food security and livelihood of the poor in developing countries: the poor easily acquire goats, as they require modest starting capital, the weak, women or children easily tend goats; and they provide people by valuable nutrients. Goat eats little, occupies a small area and produces enough milk for the average unitary family, whereas maintaining a cow at home cannot be afforded by the homeowner, hence, the growing popularity of goat as the poor person's cow.

Government and donor projects have promoted dual purpose meat and milk goats on highland farms, but it is unclear what proportion of Kenya's goats and sheep are milked (Roy and David, 2011). These animals are generally milked and exist in small numbers. Sheep are milked in ASAL areas, but the practice is not common. Goats are routinely milked in the arid and semi-arid regions of the country, but the exact proportion is undocumented. . According the 2009 census, there are 25,250,865 head of goats in ASAL regions of Kenya (Roy and David, 2011).

2.3 Dairy Goats Production

Dairy goats produce about 15.2 million metric tons (MT) of milk, accounting for about 2% of the world total amount of milk produced by livestock species (FAOSTAT, 2008). The developing countries produce approximately 83% of the total amount. Goat's milk is a very good source of calcium, protein especially the amino acid tryptophan, phosphorus, riboflavin (vitamin B2) and potassium. Previous research has found some anti-inflammatory compounds in form short-chain sugar molecules called oligosaccharides present in goat's milk that make it easier to digest, especially in the case of compromised intestinal function (Ensminger and Esminger, 1986). In animal studies, goat's milk has also been shown to enhance the metabolism of both iron and copper, especially when there are problems with absorption of minerals in the digestive tract (Elwood *et al.*, 2007). These factors and others are likely to play an important role in the tolerability of goat's milk versus cow's milk. Allergy to cow's milk has been found in many people with conditions such as recurrent ear infections, asthma, eczema, and even rheumatoid arthritis. (Kesse-Guyot *et al.*, 2007). Replacing cow's milk with goat's milk may help to reduce some of the symptoms of these conditions. Goat's milk can sometimes even be used as a replacement for cow's milk-based infant formulas for infants who have difficulties with dairy products.

According to Galal (2005), while the developing countries harbor the highest number of the world goats' population, it has only 60% of the breeds. Europe has the heaviest goat breeds with the largest litter size and milk production. Goats contribute largely to the livelihoods of low- and medium-input farmers, many of whom have few resources beyond their small holdings and livestock (Boyazoglu *et al.*, 2005). The high goat population in the developing world is largely due to the fact that goats are well adapted to the tropics, have short generation intervals, high fertility, prolificacy and fecundity; have high heritability for milk production (0.5); lower nutritional requirement as compared to the cow and they are a quick source of cash and food (Hossain *et al.*, 2004). The world's highest goat milk producers include India, Bangladesh, Sudan, Pakistan, France and Spain; they contribute 62.2 % of the goat milk produced in the world (Table 2.1). Most of the produced goat milk is directed to self-consumption while the rest is marketed as fresh-liquid milk and/or transformed into cheese or candies (FAOSTAT, 2012).

Table 2.1: Goat milk production in the world

Region	Milk Production (millions of litres)	Dairy goats (millions of heads)	Litres/goat/year
Asian	9,794	110.9	88.3
Africa	3,751	61.9	60.6
Americas	541	8.4	64.3
Europe	2,604	9.8	265.7
Total	16,690	191.0	

Source: FAOSTAT 2012

Several studies indicated that people with cow's milk allergy could tolerate goat's milk (Restani and Fiocchi, 2004). Livestock products not only provide high quality protein but are also important sources of a wide range of essential micronutrients such as iron and zinc, and vitamins such as vitamin A. In addition to milk and meat, manure is also an important by-product for farmers in this area, and is used to fertilize vegetable plots. For the large majority of people in the world, particularly in developing countries, livestock remains a desired source of food for nutritional value and taste. Multipurpose goats can be recommended introduced, particularly in low-income household in order to maximize food production and security.

Dairy farming in zero-grazing sheds is widespread in zones of high to medium agricultural potential where average household land holding is smaller than 5 acres (Ministry of Agriculture, 2008. Farmers with higher milk production practice modern animal husbandry that includes use of appropriate inputs (Republic of Kenya, 2006). The size of land holdings is rapidly decreasing owing to subdivision as a result of increasing human population (Gitau, *et al.*, 1994; Staal, *et al.*, 1998). About 80% of the dairy animals in the region are managed under zero-grazing production systems where farmers use cut-and-carry feeding methods (Staal *et al.*, 1998). About 80% of the households have improved dairy cows, with an average of 1.7 cows per family. The average milk production is 8 kg/cow/day; it is used both for home consumption and for sale (Minae and Nyamai, 1988, Murithi, 1998). Dairy goat rearing is a rapidly growing enterprise in the area, which is particularly suited to poorer households (Wambugu and Franzel, 2004).

Dairy goats are progressively entering into the livestock matrix of smallholder farmers in view of rising demand for milk in a situation of declining land holding. However, goat milk is yet to penetrate local markets which are dominated by cow milk whether in pure form or in products such as yoghurt.

2.4 Overview of dairy goat production in Kenya

In Kenya, goat population is approximated to be 13.9 million, with over 1 million dairy goats (MOLDF, 2009). There are two main indigenous breeds in Kenya; the East African and the Galla. Both breeds are kept mainly for meat production. However, the Galla is milked by the local farmers and has been known to produce up to 2 liters of milk daily. The main dairy breeds reared in the study area are the Alpines and the Toggenburg breeds, with Alpine breeds being the majority, estimated to be over 95%, and Toggenburg breeds less than 5% of the total dairy goat population (Kipserem *et al.,* 2011). The Kenya Alpine breed is a cross breed between the German Alpine and the local East African goat (Kipserem *et al.,* 2011). The majority of these animals are found in small holder farms in dry pastoral areas and in the highlands (Sibanda *et al.*, 1999; Juma *et al.,* 2010; Ahuya *et al.,* 2005). Interest in the value of goats as domestic livestock is presently widespread in the region due to their role in food production as well as other economic importance in the tropics and sub-tropics where they are concentrated forming an important component of traditional farming systems (Devendra, 1985). Kinyanjui *et al.*, (2010) studied the socio-economic issues of the dairy goat in Kenya and revealed that about 57% of the milk produced was consumed in the household. Thus, dairy goats enable households to access milk especially for the children, the sick and the old. Surplus milk is sold despite the little amount of goat milk produced. Kinyanjui *et al.*, (2010) was also able to establish that the farm gate prices for the milk ranged from Kenya Shillings 120.00 to 150.00 per liter in hospitals, hotels, church congregation and dairy processors who purchase goat milk for making cheese forming the dairy goat milk market in Nairobi.

Though dairy goat production is playing an important role in the improvement of income of the poor farmers, poverty and hunger alleviation, the dairy goat production is still faced by challenges such as diseases (diarrhea and pneumonia), inbreeding, poor feeding, lack of market and poor management practices (Ndegwa *et al*., 2000). Among infectious diseases, mastitis is one of the major diseases affecting dairy goat productivity. Several causative agents and predisposing factors have been implicated in dairy goat mastitis. Etiological agents include bacteria viruses and yeasts. Ndegwa, 1999 reported a overall prevalence of subclinical mastitis in Kenya to be 28.7%. Several risk factors including, milking hygiene, management practice, feeding, number of lactation days and geographical locality have influenced the type and frequency of isolation of organisms causing mastitis (Ndegwa *et al*., 2000).

Kenya Alpine dairy goats usually live in the Central and Eastern highlands of Nyeri and Meru Districts respectively, but in recent years they have spread to other areas of lower potential compared to the original entry areas. These areas are characterized by a humid to sub-humid climate with long, wet and cold wet seasons. Herds are usually zero grazed and stall fed on greens and very little or no concentrate supplementation is provided. Water is also provided in the shed. The kidding season is usually not synchronized but rather depends on conditions of pasture.

The German Alpine dairy breed has been used for crossbreeding with local goat with good results in Nyeri. The quality of dairy goats in the country was standardized when the dairy goat project started, through proper record keeping and choice bucks for breeding purposes. DGAK was involved in training farmers to ensure proper breeding practices, with each goats registered with the Kenya Stud Book (KSB). This ensured that the history of the dairy goats was well known. Farmers could rely on the records to get good quality goats whenever they wanted to buy them, but this is no more.

2.5 Dairy goat breeds

The Kenya Alpine dairy goat breeding has been implemented for close to twenty years, during which period breeding bucks were sourced from Germany. The foundation stock was all from German Alpine with no records of their pedigrees. There was repeated sourcing of breeding bucks from Germany but due to lack of proper recording, it was not clear if considerations were made about their relationships. Eventually, due to the outbreak of the "Bovine Spongiform Encephalopathy" (Mad Cow Disease) in Europe, importation of live animals was banned. Since then, breeding bucks have been sourced locally from within the small Alpine population but without proper records and procedures to establish their relationships, they could not be used to control inbreeding. The breed has not yet been stabilized and therefore effects of inbreeding would reverse the initial breeding objectives. Although inbreeding leads to reduced fitness, the degree to which populations suffer from inbreeding and its effects can vary widely depending on population history, the trait examined lineage effect and the environment (Bijma *et al.*, 2001; Frankham *et al.*, 2002; Reed and Frankham 2002).

Heifer Project International-Kenya (HPIK), one of the non-governmental organizations in Kenya, implemented a community-based dairy goat multiplication programme since the year 1994 using high value exotic genotypes (Saanen, British Alpine, Ango-Nubian and Toggenburg) to improve the nutrition and incomes of households adopting the technology (Ogolla *et al.,* 2011). Goats were introduced on a "pass-on" model contract and dairy entrepreneurial skills imparted to the farmers. The model is a loaning system whereby a beneficiary of a doe pays in-kind by giving out the first two female offspring free to the next listed beneficiaries who will in turn do likewise. This was supposed to ensure sustainable spread of dairy goats in the communities involved.

Factors favouring the rearing of goats are that they generally thrive well across agro-ecological zones, which is reflected by the degree of their adaptation (i.e., survival under environmental stresses like diseases, parasites and high temperatures), functional contribution (i.e., meat, milk, fibre and skins) and socio-economic relevance (i.e., security and income generation) (Devendra 2001; Peacock 2005). Other attributes of goats are multi-parity and multiple births, shorter generation interval, lower investment, higher digestive efficiency for roughage and lower feed requirements as compared to cattle (de Jong *et al.*, 1994; Braker *et al.,* 2002).

According to Kosgey *et al.,* (2006), dismal performance of programmes involving breed substitution of exotics for indigenous breeds and crossbreeding with temperate breeds have stimulated a recent re-orientation of breeding programmes in tropical countries to utilize indigenous breeds, and most programmes are incipient. The dairy goat entrepreneurs therefore need to improve the quality of breeds as the times go by. According to statistics, out of the 100,000 dairy goats in the country, only 12,000 are registered with the Kenya Stud

Book (Kamau *et al.,* 2010). Registered goats fetch premium prices as they are of higher breeding value in the class of pedigree

Breeding objective refers to the trait(s) that farmers want to genetically improve in their individual animals and flocks because in one way or another, they influence the flock returns or cost of flock production. Therefore, clear identification and statement of the breeding objectives is normally the first step in establishing any meaningful breeding programme (Philipsson 2000). The traits identified for improvement among the local goats include milk yield, mature body size and conformation, growth rate, docility, fertility (age at first kidding, kidding interval and rate, the high disease and heat tolerance/ resistance as well as certain coat colours. The quality of dairy goats in the country was standardized when the dairy goat project started, through proper record keeping and choice bucks for breeding purposes. DGAK was involved in training farmers to ensure proper breeding practices, with each goats registered with the Kenya Stud Book (KSB). This ensured that the history of the dairy goats was well known. Farmers could rely on the records to get good quality goats whenever they wanted to buy them, but this is no more.

Goats have become very popular with small scale farmers in urban and densely populated areas. Land sizes are too small to support daily cattle, in which case the goats are stall fed on fodder and crop residues. The main dairy goat breeds reared in Kenya include Toggenburg which is brown with white line on the face, legs, tail and has a high twining rate; Saanem which is white with pink skin pigmentation and has high twining rate, Anglo Nubian which is whitish brown with long drooping ears and adapted to hot climates and German alpine which is brown with a black stripe on the spine and shoulders.

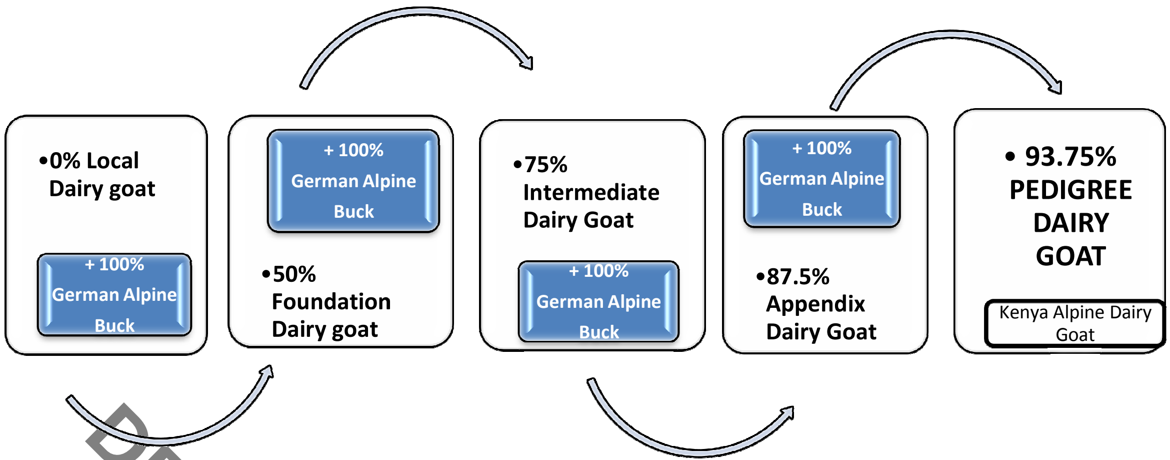

Figure 2.1: Dairy Goat Breeding Plan

The dairy goats are bred for milk production and are expected to produce up to 3 times that of the local goats. They multiply fast, kidding twice a year often producing twins or triplets. The quality of milk is also expected to be better than the local goats. The farmers have been trained on the breeding pattern and supplied with the German Alpine bucks for breeding purposes. The breeding trend is slowly being lost due to information to the farmers on the benefits of goat farming and the shortage of agricultural extension officers to ensure follow up.

The breeding plan is carried out through community buck stations owned and managed by the groups in one household belonging to a group member.

The pure Alpine are produced through community breeding stations owned by Dairy Goat Association of Kenya at the group level as well as the pure German Alpine bucks imported from Germany. The government's Arid Land Resource Management Project (ALRMP) is operating for free over 10 buck stations for local farmers to cross breed. The breeding goats are selected on the basis of the attributes of both goats.

In addition to increasing milk production crossbreds adapt well to the local climate. They mature fast and in a year they are ready to mate. On maturity they weigh over 35 kg compared to local breeds that weigh 15kg after three to five months. Some local breeds that can be cross bred are the Galla and Zebu (Ogola *et al.,* 2010)

2.6 Dairy Goat Feeding

Goat is a ruminant with a digestive system consisting of a four compartment stomach (rumen, reticulum, omasum and abomasum) and the small intestine. The rumen is the largest of compartments and contains many of the "bugs" (bacteria, protozoa, and fungi) that digest the feed. The bugs produce enzymes that aid in the breakdown of fiber. The breakdown of fiber or cellulose converts to volatile fatty acids which are absorbed through the rumen wall and provide up to 75% of the goat's energy (Irene 2003**)**.. Protein is produced by the bugs from nitrogen in the feed. Vitamin K and the B vitamins are also manufactured by the microorganisms. The reticulum (honeycomb structure) is the second area and is just below the opening of the esophagus. The omasum is a small round area which contains hanging layers of tissue. The large surface area of these folds allows for the absorption of moisture and volatile fatty acids from feed. The abomasum is considered the "true stomach". It functions like a simple stomach in a monogastric animals and contains hydrochloric acid and enzymes that breakdown feeds to be absorbed by the intestines. The intestines absorb amino acids, sugars, minerals, fats and other nutrients from digested feed.

Goats are kept in a wide range of agro-ecological zones and management systems in Africa (Peacock, 1996). There are many reasons for the sudden rise in popularity of the dairy goat in Kenya. One reason is that raising a dairy goat is more cost-effective than a cow. Goats feed on 5 to 8 kg of fodder per day while a dairy cow requires 50 to 100 kgs of feed per day. It is for this reason that farmers with land scarcity problems opt to keep dairy goats. Acquiring the desired dairy goats has been very difficult in Kenya. The shortfall in the supply of dairy goats is mainly attributed to limited breeders in the country as well as low levels of management. Goats are relatively cheap to acquire and reproduce quickly.

Initiation and maintenance of a successful lactation is a result of proper dry doe management Irene (2003). If the dry doe was maintained properly, the metabolic adaptations which occur after parturition should be fairly easy on the doe. After parturition, the doe has a high nutrient demand to support milk production. Several things occur to meet this demand. There is an increase in nutrient absorption by the udder tissue and increased mobilization of minerals (like Ca, P and Mg). The size of the gut and the absorptive capacity increases to allow for greater absorption of nutrients. To meet a high calcium demand, increased intestinal calcium absorption and mobilization of bone occurs. With proper management in the dry period, this calcium demand can be met without causing problems like milk fever. Energy demands as the doe reaches peak lactation follow a similar course. Energy is the most limiting nutrient to dairy goats. Sources of energy are grass, alfalfa, cereal grains such as corn, oats, wheat and barley and bypass fats. Energy limitations may result from inadequate feed intake, too much low quality feed, incorrect roughage to concentrate ratios. Insufficient energy can lead to weight loss, infertility and reduced production. Water is essential in digestion, assimilation of nutrients, excretion of waste products, control of body temperature, growth of young animals and milk production. Access to clean water is very important in dairy goat production.

The goats can be fed on many types of fodder including Napier grass, pasture grasses, sweet potato vines and household vegetable waste. In this study some respondents indicated that special fodder such as stinging nettle; *muchuthi* and *maigoya* are fed to the goats in order to increase certain ingredients during the production of milk.

The main feed for dairy livestock in the central region of Kenya is Napier grass *(Pennisetum purpureum)* grown on small plots, crop residues, and occasionally grass collected from the roadsides and neighbouring public land. Fodder shortages are mainly experienced during the dry season when the farmers traditionally supplement the grasses with banana pseudo stems and indigenous fodder shrubs. To meet the nutritional requirements of these animals, farmers are forced to spend part of their precious income on purchasing commercial dairy meal supplements (Franzel *et al.,* 2003). However, farmers often complain that the price of dairy meal is high and that they lack cash to buy and transport it from the market to the homestead. Many also suspect its nutritive value, mainly because of scandals in Kenya concerning fraudulent crop seeds, animal feeds and agrochemicals sold to farmers (Franzel *et al.*, 2003).

Fodder shrubs offer an alternative source of high-protein supplementary feed for dairy animals. Intensive research on production and utilization of fodder shrubs in Kenya was conducted in 1990s by joint projects involving Kenya Agricultural Research Institute (KARI), Kenya Forestry Research Institute (KEFRI), International Centre for Research in Agroforestry (ICRAF) and the International Livestock Research Institute (ILRI). Most of the agronomic fodder research in Kenya was conducted at KARI Regional Research Centre, Embu. The species that were found to have high potential in improving dairy productivity included *Calliandra calothyrsus*, *Leucaena trichandra*, *Sesbania sesban*, *Chamaecytisus palmensis* (tagasaste, or tree lucerne) and *Morus alba* (mulberry). Most of the available agronomic and socio-economic data is on *Calliandra calothyrsus,* because this is the species most widely adopted by farmers in the central region of Kenya and other sites in the East African region (Franzel and Wambugu, 2004).

Concentrates contain high-energy feedstuffs that are added to a ration primarily to increase its energy density. They are mostly cereals or cereal by-products, roots and tubers, liquid feeds like molasses, fats and oils. However, these energy sources also contain small quantities of other nutrients—proteins, minerals and vitamins. The energy is in the form of starch, with a crude protein content of 8–12%, high in phosphorus but low in both crude fibre and calcium. Concentrates also contain protein supplements, defined as feedstuffs that contain more than 20% crude protein on the basis of dry matter. Concentrates are characterized by; high nutrient density, high DM, less bulky, longer lifespan, low crude fibre. They can broadly be divided into two categories; Energy source and protein source: Energy sources available in Kenya include: maize germ and bran, wheat pollard and bran, sorghum and cassava, while protein sources are maize gluten feed/meal, cotton seed meal, sunflower, groundnut meal, soya meal, copra meal, bakers' yeast, fish meal etc. The commercial dairy feeds are produced on an industrial scale that involves the combination of many ingredients blended and mixed in proportions in accordance with dairy cattle feeding specification outlined by KEBS (NAFIS, 2016)

Table 2.3: Ordinary Dairy Meal:

Ingredient	%
Maize germ	43
Wheat pollard	16
Wheat bran	26
Sunflower meal	5.5
Cotton meal	6.75
Lime	0.5
Di-Calcium Phosphate (DCP)	1
Magadi Soda	1
Premix	0.25
Total	100

Note: KEBS specifications for 10.5 ME/Kg (Energy), CP=14-16%, Cal = 0.7% & P=0.5%

National Farmers Information Service (NAFIS) Republic of Kenya. http://www.nafis.go.ke/. Accessed on January 12th, 2016

A large proportion of the feed it eats is converted into milk. A goat can convert more dry roughage into milk compared to a dairy cow, but the forage must be clean and dry all the time. The amount of feed a goat eats depends on its body size and also on the quality of the feed. From the different types of feed given, a farmer can tell which type of feed it likes most. Remove waste feed at least twice a day. If there is a lot of waste, this should tell you the goat is either being given too much feed than it can eat or it does not like type of feed. A 45 kg goat that is being milked should be consuming up to 7 per cent of her body weight (about 3.4 kg) of dry matter and can drink 4 to 5 litres of clean water daily.

2.7 Dairy goats in Nyeri County

Nyeri district was the pioneer district of the Kenya Alpine dairy goat, the breed has spread out in other areas of Central, Eastern and Western provinces (Marete *et al.*, 2007). This meant that the Kenya Alpine dairy goat is continually being accepted as an alternative small holder milk production breed.

Nyeri County is one of the seven districts of Central Province and forms part of Kenya's eastern highlands. It covers an area of 3,266 sq km and is situated between Longitudes 36^0 and 38^0 east and between the equator and Latitude 0^0 $38^{'}$ south. (Ministry of Planning and National Development, 2005). Nyeri County constitutes six constituencies**;** Nyeri Town, Othaya, Tetu, Kieni, Mathira and Mukurwe-ini. Nyeri County is home to 693,558 people (male - 49% and female - 51%), according to the 2009 National Census. Nyeri county has some of the lowest temperatures in Kenya which range between 12°C in the cold months (June and July) and 27°C in the hot months (January-March and September-October) with high precipitation all year round. The rainfall average lies between 500 mm and 1500 mm during the short and long rains periods making it conducive for its diverse agricultural activity.

The northern part of the Nyeri County is flat, whereas further southwards and western, the topography is characterized by steep ridges and valleys, occasionally interrupted by hills such as Nyeri, Tumutumu and Karima,. The major rivers are Sagana and Chania, joined by other numerous streams that make the county self sufficient in surface and sub-surface water resources for domestic, agricultural and industrial development. Due to physiographic conditions in the county like soil erosion, road construction and farm mechanization, there is increased exploitation of land for settlement and agriculture.

Kieni East and West are the only semiarid areas of Nyeri County, which make up Kieni constituency which is one of the most expansive constituencies in the country, covering the entire span from the slopes of the Aberdares to the slopes of Mt. Kenya. As with other semi arid regions, Kieni is characterized by low primary vegetation productivity and high geographical and seasonal variability in water availability (both surface and accessible ground water). This also explains the scant vegetation in the two divisions. Livestock production is a major economic activity in the divisions. Agro-pastoralism is the dominant livelihood system in the divisions with households supplementing their agricultural income with livestock-based activities. The key livestock species are cattle, goats and sheep and are a supplement to agriculture production.

The other part of Nyeri District, mainly the southern part: Othaya, Tetu, Mukurweini, is a vibrant agricultural sector that provides the main source of livelihood for over 82% of its residents. Three commodities with varied histories - tea, coffee and dairy - are the main agricultural enterprises. In terms of livestock, the dairy sector leads with nearly every homestead having at least one or two exotic dairy cattle. Land in the district has been fragmented into very small units due to high population pressure. On average, each household owns about 0.64 hectares (Booker *et al.,* 2009)

Nyeri is one of seven districts that make up the Central Province of Kenya. It is the seventh most populous district in Kenya, the third richest in the province and is ranked as having the fourth lowest absolute poverty levels in Kenya (Pricewaterhouse Coopers. 2005).

In Nyeri County there are 250 registered dairy goat groups, under the DGAK, with 3250 members and 9750 numbers of goats (DGAK Office).

Dairy goats farming is most advanced in Kieni, Mukurweini, Tetu, Nyeri Central and Nyeri South sub counties. This enterprise is popular in high potential areas, where subdivision of land into small land units cannot sustain dairy cattle. The main breeds kept are the German Alpine crosses and a few Toggenburg and Saanen and their crosses. In 2013, the industry earned farmers a total of Kshs 19,800,000 (Nyeri County Government, 2015). The main stakeholder in this enterprise is the Dairy Goat Association of Kenya a farmers' organization which provides key services like routine de-worming, provision and rotation of breeding bucks, marketing of live animals and milk and registration of breeding stock

The main feed for dairy goats in Nyeri County are nappier grass (*Pennisetum purpureum*) grown on small plots, crop residues, and occasionally grass collected from the roadsides and neighbouring public land. Fodder shortages are mainly experienced during the dry season when the farmers traditionally supplement the grasses with banana pseudostems and indigenous fodder shrubs. Fodder shrubs offer an alternative source of high-protein supplementary feed for dairy animals.

Dairy goats in Kieni East and West are reared in an open grazing system sometimes with little or no grazing rotation. They rely on rain fed pastures that receive no supplementary irrigation throughout the year. Dependence on seasonal weather variations therefore, becomes a major influencing factor on their productivity, manifested in low milk production and loss of livestock body condition during the dry season and high production coupled with good body condition during the wet season. Sometimes the wet season is accompanied by such a high level of milk production that the capacity of the market to consume it is overwhelmed bringing about a milk glut (Mirara and Maitho, 2013)

Farmers are involved in keeping dairy cattle and goats for meat and milk purposes. The Dairy Goats Association of Kenya (DGAK) in Nyeri is receiving 250 litres per day from farmers (Phyllis and Muturi, 2015). The demand for goat milk is higher than the supply. In a study carried out by Wambugu and Kirimi (2010) on Dairying in Kenya, they indicated that the milk industry has a number of challenges along the chain caused by seasonality in production leading to reduced exports and loss of export market to competitors, cost of electricity/ fuel is high, heavy cost in initial investment, infrastructure bottlenecks, competition from cash based informal market, poor access to breeding, animal health and credit services; cost of artificial insemination (AI) and inefficient distribution mechanism, poor interaction and priority setting between research, extension and training and poor infrastructure.

To make the sector profitable to the farmers, value addition is important and processors need to expand to nontraditional markets outside the country. The government should ensure good infrastructure to ease transport and communication.

2.8 Dairy Goat Association of Kenya

Dairy Goat Association of Kenya is an Association of mainly small scale Dairy Goat keepers/breeders, which was registered in April 1994, as a non-profit making and non-governmental organization. It consists of groups of smallholder dairy goat farmers. As a Service Provider it helps in improving nutritional status in the family and in poverty alleviation. DGAK has an ordinary membership of more than 13000 farmers. The Association has a total of 1004 member groups distributed in most parts of Kenya, with an average of 15 farmers per group and an average of 3 goats per farmer

DGAK is aiming to raise the income of its members and enhance their food security through increasing their capabilities and skills in dairy goat breeding, dairy goat husbandry and marketing of dairy goats and their by-products.

The Dairy Goat Association of Kenya gives services to the farmers through; provision of breeding stocks (registered bucks and doe) through lease or purchase, buck rotation/exchange between groups or members to avoid interbreeding, registration of the dairy goats with Kenya Stud Book, marketing of milk and breeding goats through organised sales and provision of extension services through the DGAK Assistants in every location. The DGAK aims at poverty reduction and food security for small scale farmers through sustainable dairy goat farming. The goats are registered with cards of different colour for each type of grade. At the start of breeding a local goat carefully selected is crossbred with a pedigree alpine goat to produce a foundation grade, which is registered with a white DGAK card. The foundation goat then is crossbred with a pedigree alpine to produce an intermediate grade, registered with a yellow card. Subsequently appendix grade is produced and registered with a green card and finally upgraded to a pedigree that is registered with a pink card. The DGAK Assistants coordinate the registration and rotation of the buck to ensure harmony in the field. During the survey it was noted that some essential details are omitted in the cards, like the history of the buck, birth date and weight of the doe, and the service records. This caused a drawback to this project since some of the collected data was based on the DGAK register, making the researcher exclude such dams from the study.

2.9 Dairy Goat milk products

2.9.1 Yoghurt

Yogurt is the food produced by culturing one or more optional dairy ingredients with a characterizing bacterial culture that contains the lactic acid-producing bacteria, *Lactobacillus* *bulgaricus* and *Streptococcus thermophilus* (Olsen, 2002; CFR, 2008). One or more other optional ingredients may be added prior to culturing. Yogurt contains not less than 3.25 percent milk fat and not less than 8.25% milk solids not fat, and a titratable acidity of not less than 0.9%, expressed as lactic acid (Stephanie *et al.*, 2009)

Yoghurt is a dairy product of high nutritional value and healthful properties. The most important benefits of yoghurt consumption cover the reduction of blood cholesterol level, anti-cancer effects and the improvement of antimicrobial activity and immunity in the human body (Desobry-Banon, 1999)

The special properties of yoghurt begin with the unique properties of the microorganisms used in their production, which gives the product several benefits including; enhanced shelf life, appeal, and digestibility of the milk. Yogurt is a fermented dairy product resulting from the symbiotic growth of *Streptococcus thermophilus* and *Lactobacillus bulgaricus* to produce a smooth viscous gel with a desirable cultured flavor. In addition, *Lactobacillus acidophilus, Bifidobacteria* species, and other strains may be added for their purported health benefits.

After milk inoculation, *Streptococcus thermophilus* hydrolyzes milk proteins by its extracellular proteinases and generates amino acids, which are necessary for good growth of *Lactobacillus delbrueckii subsp. bulgaricus. Lactobacillus,* in turn, produces formate, which stimulates the growth of Streptococcus species (Bibek 2005). Both are necessary to produce a desirable product. Yogurt process and formulation variations determine the body and texture, depending upon the type of ingredients, processing, starter cultures, flavor, and packaging that is used. The processing involve various steps; blending, pasteurization, homogenization, culturing and cooling, packaging and storage.

In blending dry ingredients are incorporated in to the milk with agitation, without formation of foam that may give the product a weak body. The ingredients added to the yogurt base are very hygroscopic to avoid lumping. Milk is pre-heated to about 550C, prior to adding the dry ingredients, to completely hydrate the stabilizer and aid in mixing and suspension.

Pasteurization of yogurt mixes can be accomplished by several different methods. As with any other dairy product, the purpose for pasteurization is to heat treat milk to eliminate pathogenic bacteria. In addition, it is very important to denature the proteins to attain the highest level of functionality from the milk proteins. Pasteurization also aids in the hydration of the stabilizers and dry ingredients that were added during blending, as well as adding a pleasant cooked flavor. The yoghurt mix is then homogenized with the appropriate stabilizer, cooled to normal set temperatures range between 32 and 46^{0}C, and inoculated with appropriate culture. These incubation conditions are dependent upon the type of cultures used and the type of yogurt produced.

Beside the sensory quality, another important factor for the consumer's acceptance of the product are the rheological properties of yoghurt, such as apparent viscosity and flow behaviour. Yoghurt is a non-Newtonian, rheological unstable, viscoelastic and pseudoplastic fluid. It is also shear thinning, which means that its viscosity decreases as the shear rate increases and addition, behaves as pseudothixotropic because its structure cannot recover completely during the relaxation time, when shear forces are relented (Jacek, 2008). These properties are also of main significance in dairy technology, especially in the manufacturing, storage, process design, product development and establishment of the product's quality. Rheological and sensory properties of yoghurt may be influenced by some technological factors, which mainly include the type and amount of dry matter fortification, preheating intensity of the milk and whey protein denaturation, specific properties of starter culture and addition of stabilizers (Jacek, 2008). An important role is also played by the composition and physicochemical properties of milk which yoghurt is prepared from. Because of the differences in composition and physicochemical properties of goat, cow and sheep milk differences in the rheological properties and sensory quality of yoghurt from these types of milk can be expected.

2.9.2 Cheese

Numerous varieties of goat's milk cheese are produced worldwide, depending on the geographical location, milk composition and the technology used in the cheese making process. Until recently, in Kenya, goat's milk has been less appreciated than cow milk for various milk products and specifically cheese production. However, goat cheese consumption is undergoing a development process with various processors incorporating it in their process, like Raka Milk Processors in Nyeri.

Cheese aroma is a very complex perception, as it is the outcome of the action of many compounds that may also be found in other foods of different kinds (Urbach, 1997) and it is considered as a quality element of great relevance for cheese makers. Most cheese varieties contain similar volatile compounds but in different proportions. Cheese is a concentrated dairy food made from milk, obtained by draining the whey (moisture or serum of original milk) after coagulation of casein, the major milk protein. Casein is coagulated by acid, which is produced through the addition of select microorganisms and/or by coagulating enzymes, resulting in curd formation. Milk may also be acidified by adding food grade acidulants, which is the process often used in the manufacture of fresh cheese. Cheese can be made from whole, low fat or fat-free milk, or combinations of these milks. The concentrations and proportions of volatile and non-volatile flavour compounds are probably responsible for the specific flavour of each variety (Fox *et al.,* 2000) The specific aroma of goat cheese has been well identified by different authors (Carunchia-Whetstine *et al.*, 2003, Engel *et al.*, 2002). 4-Methyloctanoic and 4-ethyloctanoic acids have been found to be the main volatile compounds responsible for the goat flavour and they are perceived at very low concentration (Salles, 2002)

Sensory analysis is becoming increasingly widespread, and its use may often be considered scientifically rigorous; it is a key element in defining cheese quality and is therefore seen as an essential tool in the food industry, particularly in the dairy sector (Justa, *et al.,* 2008)

2.9.2.1 Paneer Cheese

Paneer means a product obtained from cattle milk by precipitation with sour milk, lactic acid, or citric acid. It shall not contain more than 70% moisture and the fat content should not be less than 50% expressed on dry matter. (Shahnawaz and Mohammad, 2011). Milk solids may also be used in preparation of Paneer. Paneer is used in a variety of forms like; base for variety of culinary dishes, ingredient for various vegetable dishes, snacks, among others.

Paneer is a rich source of animal protein available at a comparatively lower cost and forms an important source of animal protein for vegetarians. Over and above its high protein content and digestibility, the biological value of protein in Paneer is in the range of 80 to 86 (Shrivastava and Goyal 2007). In addition, Paneer is a valuable source of fat, vitamins and minerals like calcium and phosphorus. It has a reasonably long shelf life under refrigeration.Good quality Paneer is characterized by a marble white colour, sweetish, mildly acidic taste, nutty flavour, spongy body and closely knit, smooth texture (Shahnawaz, Mohammad, 2011).In a research carried out by Shukla *et al.*, 1988), they found that Paneer made from goat milk resulted in a product that lacked compactness. Agnihotri and Pal (1996) prepared good quality creamy white Paneer, free from goaty smell or salty taste, from Barbari goat milk with 4.86% fat and 8.96% SNF employing coagulation temperature of 87–88 °C using 0.15% citric acid. Prasad *et al*., (1990) made Paneer from goat milk with acceptable characteristics and without any goaty odour. Pal *et al*., (2008) standardized the processing variables (heat treatment of 90 °C, coagulation temperature of 90 °C and coagulant strength of 2% citric acid) for the manufacture of Paneer from ewe's milk with 6.94% fat.

The quality of Paneer depends upon the quality of milk from which it was made. Milk fat exerts significant effect on the organoleptic quality of Paneer. Pal *et al.,* (1991) observed that the sensory score of low-fat Paneer was greater when milk was heat treated at 118 °C rather than at 90 °C. Kumar *et al.,* (1998) found that the body and texture and overall acceptability scores of Paneer made using calcium lactate coagulant were better than those obtained for the product made using citric acid or sour whey. Citric acid yielded sensorily superior Paneer compared to malic acid; the body and texture of Paneer obtained using malic acid was quite poor (Pal et al., 1999). Syed *et al.,* (1992) found that the total sensory score of Paneer made using different milks tended to decrease in the following order: Paneer from buffalo milk with 6.0% fat (93.33 score) > Paneer from cow milk with 4.5% fat (88.97 score) > Paneer from skim milk with 0.1% fat (84.87). Arora *et al.,* (1996) observed that use of 0.05% $CaCl2$ in milk diluted with water to 4.6% fat and 8.0% SNF resulted in Paneer comparable to that made from normal milk (5.5% fat and 9.0% SNF). Kumar *et al*., (2007, 2008) found that the sensory score of Paneer decreased with an increase in the level of incorporation of the coagulant i.e. from 0.2 to 0.6%. Pal *et al.,* (2008) found that acceptable Paneer could be obtained from ewes' milk by coagulating the milk at 90 °C using 2.0% strength of citric acid solution. Paneer represents one of the soft varieties of cheese family and is used in culinary dishes/snacks. It's simple method of processing can easily be adopted at farm level, where farmers can utilize lemon juice as a coagulant, and use Paneer to enrich the locally available food.

2.9.3 Sensory evaluation

The application of sensory perception is one of the keys to the nearly ubiquitous wholesome and flavorful image that dairy foods continue to enjoy with consumers. Due to the pivotal role that sensory perception occupies with the marketing of dairy foods, some means of sensory measurement is often a final step in product development.

2.9.3.1 Acceptance testing

In acceptance testing, consumers are presented with products and asked to indicate their degree of liking on a scale. The most commonly used scale is the 9-point hedonic scale. This scale is bipolar – the anchors are dislike and like – and has been widely used since its invention in the 1940s (Schutz and Cardello, 2001). The scale is used to effectively indicate differences in consumer liking of products. The 9-point hedonic scale has proven to be a robust and perhaps more conservative estimate of consumer liking

2.9.3.2 Free choice profiling

Sensory characteristics of a cheese at the time of its consumption reflect the milk from which it was produced, the processes used in its production, and the physical and the chemical changes that occurred during maturation.

Free choice profiling (FCP) is a sensory technique developed to reduce the need for extensive panel training, and eliminates the pre-established measure of agreement among the panellists on their interpretation and meaning of the terms they will employ (Deliza *et al.,* 2005). Free choice profiling assumes that assessors do not differ in how they perceive sensory characteristics, just in the way they describe them. Assessors develop idiosyncratic vocabularies (Williams & Arnold, 1985), which will inevitably vary from assessor to assessor, as they are grounded in individual experience and familiarity with the product. These procedures require little training; assessors must be objective, capable of using line scales, and use their vocabularies consistently (Williams and Langron, 1984). The technique has shown results compatible to those obtained by more conventional procedures, and has many practical advantages (Williams and Arnold 1985).

In summary it can be said that limited research has been done to understand consumer perception and acceptability of the flavour profiles of cheese, using preference mapping techniques (Young, *et al.*, 2004). Factors, like diverse processing procedures and demographics contribute to different attitudes relating to consumer acceptability of cheese. There is no specific reports that exist of free choice profiling on goat milk cheese attributes.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Determination of Dairy Goat milk yield

3.1.1 Study design

The study adopted a descriptive survey method, which was considered ideal for the study, because it sought to gain insight into a phenomenon as a means of providing basic information in the area of study. It provided quantitative and qualitative descriptions of some parts of the population that described and explained the larger population (Bless and Higson-Smith, 2000).

In order to meet the objectives for this study both secondary and primary data were used to generate the information required. The primary data was collected through an in depth face to face interview using a questionnaire (Appendix IV). This questionnaire comprised closed and open ended questions. Participant observation was also used. Besides, secondary data on dairy goat entrepreneurs was obtained from existing sources that were available at the DGAK, reviewed journals and books. Two-group simple randomized design was applied, by defining the population first and then from the population a sample was selected randomly, for the baseline survey. The selected samples were randomly assigned to the experimental and control groups, for the nutritional evaluation and product development.

3.1.2. . Study site

The study site was in Nyeri County, which is partly an agriculturally high potential region with plenty of rainfall, and 51 percent of the County being semi-arid (Price Water House Coopers, 2005). The semi arid areas are Kieni East and Kieni West, which are characterized by low primary vegetation productivity and high geographical and seasonal variability in water availability.

Nyeri County is located in central Kenya, about 150 Kilometers north on Nairobi. It borders Laikipia to the North, Meru to the North East, Kirinyaga to the East, Murang’a to the South and Nyandarua to the West. It covers an area of 3337.1km^2 and is situated between Longitudes 36º and 38º east and between the equator and Latitude $0^0$38 south (Phyllis, 2015). The county lies in the dissected slopes of the Aberdare Ranges (4,001m) to the West, 1,500 m above sea level, but has greater topographic variability. Human habitation extends up to the mountain about 2,100m above sea level (Phyllis and Muturi, 2015).

The study site included two sub counties of Nyeri County; Mukurweini as the high potential area, and Kieni as the semi arid areas, which was subdivided into Kieni East and Kieni (Appendix III)

3.1.3. Study Population

The study population comprised farmers or household families who are engaged in dairy goat rearing in the entire study area, and were registered with the Dairy Goat Association of Kenya (DGAK) having undergone adequate training in dairy goat keeping, practicing good husbandry and producing milk. The farmers were identified with the help of the DGAK Assistants who could indicate potential farmers where the researcher could obtain adequate and accurate data.

3.1.4. Sampling procedure and sample size

Two sampling techniques were applied;

Mukurweini Sub County – Sampling done by census, where a 100% of the population was sampled. All the farmers practicing good animal husbandry and maintaining proper records were included in the study.

Kieni Sub County - Purposive sampling techniques. The respondents from the target population was purposively selected after considering factors such as accessibility and the significance of the study information from the farmers and other stakeholders to be collected. Using this approach, the researcher selected a sample of registered dairy goat groups which represented a cross section of area of study. The criteria for selecting sites depended largely on dairy goat registration with DGAK (Appendix V). The farmers were interviewed and provided with questionnaires (Appendix IV) seeking information on goat identity, types of fodder used, goat milk perception by the farmer and goat milk utilization.

The technical team included the DGAK Assistants in each area of study, and the researcher. Farmers interviewed were as listed in Table 3.1. Total number of dairy goats sampled for all the households were 191. Some households had more than one dairy goat.

Table 3.1: Dairy goat farmers from the study areas

Area	Number of households (Farmers)	Number of goats
Mukurweini	**39**	**39**
Kieni East	**40**	**79**
Kieni West	**40**	**73**
Total	**119**	**191**

3.1.5. Data Collection

Questionnaires containing structured and semi structured questions were used (Appendix IV) collect quantitative information, comprising animal husbandry practices, type of feed given to the dairy goats, dairy milk production, dam birth weight and age of the goat. Reference was made to the DGAK registration card (Appendix V) for each goat. Additional data was on type of kids, their birth weight, weaning weight and growth weight.

The milk yield data collection was based on two categories:

Category 1 – Pre-weaning period

The dam was milked once per day- The dairy farmers practiced a partial suckling system, allowing the kids to stay with their dams during the day, but separated at night, for one months

Daily yields during the suckling period were obtained by doubling the yield recorded in the mornings.

Category 2 - Post weaning period

The dam was milked twice a day (morning and evening) and the yields recorded separately for one month

3.2. Dairy Goat Milk Nutritional and Chemical Composition

3.2.1. Sample Collection

Pedigree dairy goats reared in three regions were identified and selected for milk analysis on nutritional quality. Ten pedigree goats in ten farms per region were identified, based on the best animal husbandry practices, like cleanliness, feeding and dairy upkeep of the goats. For product development, dairy cows in the same farms were identified to draw milk for making products that could compare with goat milk products.

Milk collection was done once a week in each farm, where 200ml of milk was drawn per milking session.

Samples were collected from the farms and frozen at -20^{0}C. Before analysis samples were thawed at room temperature, and warmed to 37^0 – 40^{0}C by transferring it to the beaker and keeping it in a water bath maintained at 40^0 - 45^{0}C, with slow stirring for proper homogenization. The samples were mixed thoroughly by pouring back into the bottle, mixing to dislodge any residual fat sticking to the sides and pouring it back in the beaker. The samples were allowed to come to room temperature (26^0 - 28^0 C) and withdrawn immediately for analysis.

3.2.2. Determination of Milk total solids and Solids-not-fat

Determination of total solids was carried out by gravimetric method (AOAC 2005)

The moisture dishes were heated with their lids alongside in the drying oven at least for 1 hour, and then the lid placed on the dish and immediately transferred to a desiccator. These were allowed to cool to room temperature (at least 30 minutes) and weighed to the nearest 0.1 mg. 5 ml of prepared sample was added , the lid placed on the dish and weigh again. The dish was placed without the lid on the vigorously boiling water bath in such a way that the bottom of the dish was directly heated by the steam. Heating continued till most of the water was removed. The dish was removed from the water bath, wiped on the underside and placed in the oven alongside the lid and dried in the oven for 2 hours, then transferred to the desiccator. The dish was allowed to cool and weighed to the nearest 0.1 mg. The dish was again heated with its lid alongside in the oven for another 1 hour, and transferred to the desiccator to cool and weighed again. This was repeated until the difference in the two consecutive weightings did not exceed 1 mg. The lowest mass was recorded

$$\text{Total Solid Content} = \frac{m_2 - m_0}{m1 - m\,0} \times 100$$

Solids-not-fat was determined by subtracting the amount of fats from the total solids.

3.2.3. Crude protein

Protein content (N x 6.38) was determined using Semi-Micro Kjeldahl Method according to the AOAC (2005) procedure 978.04

Digestion: About 1 g of sample was accurately weighed then transferred to a digestion flask together with a catalyst composed of 5 g of potassium sulphate and 0.5 g copper sulphate and 15 ml of concentrated sulphuric acid. The mixture was heated in a fume hood till the digest colour turned blue signifying the end of digestion process. The digest was then cooled and transferred to a 100 ml volumetric flask and topped up to the mark with distilled water. A blank digestion was also prepared.

Distillation and titration: The distilled sample was subjected to distillation and titration using KJELTEC AUTO 1030 analyzer (Tecator AB, Hoganas, Sweden).

3.2.4. Determination of Ash content

The ash content was done according to the AOAC (2005) method 923.05. 2-5 g sample were weighed in pre-conditioned crucibles. The samples were first charred by flame to eliminate smoking before being incinerated at 550°C to the point of white ash. The residues were then cooled in desiccators and the weights taken.

3.2.5. Determination of Fat content

Fat content was determined using Gerber method by weight as described in AOAC Official Method 2005:18, for fat content of raw and pasteurized whole milk.

Milk test samples were placed in water bath maintained at 39 $\pm 1^0$C. Level of water was maintained at or above milk level. The milk was mixed 10 times by inversion. If fat line remained on inside surface of container, hot water was run over outside surface for 15 to 20 seconds. The milk was mixed thoroughly by inversion and test portions weighed immediately. The milk was not allowed to remain in water bath more than 15 min after reaching 38^0C.

Sulphuric acid, 10.0 ± 0.2 ml, were added into a butyrometer, and tarred on an analytical balance. 11.13 ± 0.03 g tempered milk test sample were weighed into the butyrometer, adding milk slowly at first to prevent charring and violent reaction with acid. 1 ± 0.05 ml isoamyl alcohol was added to the butyrometer with test portion. Lock stopper was inserted securely using hand-held key. Wearing insulated gloves, the butyrometer was grasped at graduated neck with stoppered end up. Without allowing small bulb to empty, shaking was done until all traces of curd disappeared. Holding butyrometer by both stoppered end and graduated neck, it was inverted at least 4 times to mix acid remaining in the small bulb and graduated neck with the contents of larger bulb. The butyrometers was placed in centrifuge, small bulb pointing up, and counterbalanced. Centrifuging was done 4 min after proper speed was reached. The butyrometers was transferred to a water bath maintained at 60–63^0C and immersed leaving only small bulb exposed. The fat column was left to equilibrate for ≥5 minutes. The scale was promptly read at bottom of upper meniscus to nearest 0.05%

Analysis was repeated if fat column was turbid or dark in colour, or if there was white or black material at the bottom of fat column. Acceptable fat columns were pale to strong yellow and uniform throughout with ni light or dark particles.

Sulphuric acid, 10ml, was measured into a butyrometer tube without wetting the neck of the tube. 10ml of milk was then be added into the butyrometer tube along the side wall without wetting the neck. 1ml of amyl alcohol was then be added and the butyrometer cocked with a stopper. The butyrometer will then be shaken until homogenous and placed in a water bath for 5minutes at 65^{0}C then centrifuged for 5minutes at 1100rpm. The centrifuge was then being allowed to come to rest and the tube removed and placed in a water bath for 5minutes.The butter fat content and specific gravity of the samples were used to calculate the solids non-fat (SNF) content of the milk by Richmond's formulae as follows:

3.2.6. Fatty Acids Profile og goat milk

This was carried out using the Bligh and Dyer method *(*1959), with modifications.

1ml of milk was measured and to it added 3.75 ml of a mixture chloroform/methanol (1/2), then vortexed for 10-15 min. The mixture was added 1.25 ml chloroform with mixing for 1 minute and 1.25 ml water with mixing for another minute, then centrifuged. The upper phase was discarded and lower phase collected and brought to dryness in a rotary evaporator. The lipid residue in the flask was completely dried under vacuum in a desiccator over fresh KOH pellets (about 1-2 h), and the weight of lipids measured and expressed as percent on dry matter basis. This oil was used for fatty acid analysis by gas liquid chromatography (GLC), and also for vitamin E analysis.

Methyl esterification of lipids for fatty acids test by gas chromatography (GC) was done by refluxing 2-5 mg of oil in 2 ml of 95% methanolic hydrochloric acid (HCl) for 1 hour. Methyl esters formed were extracted thrice using 2 ml of n-hexane. A small amount of anhydrous sodium sulfate was added to the extract, to remove water. The solvent was evaporated to concentrate the extract to 0.3 ml using a stream of nitrogen. This was injected to the GC machine for the fatty acid profile. Identification of fatty acids was done by comparing with known methyl ester standards from Sigma (Code 189-4, 189-17, and M-3378).

Instrumentation: The analyses were performed using a Shimadzu GC-9A (Shimadzu Co., Tokyo, Japan) fitted with a glass column, prepacked and preconditioned by Shimadzu; Shinchrom E-71 5% Shimalite (80-100 Aw), 3.1 m in length by 3.2 mm internal diameter and flame ionization detector. Isothermal column temperature of 200^0C was used and injector/detector temperature of 230^0C.

Flow rate was 8 ml/minute, injection Volume 1µl. Gases used were nitrogen carrier gas at 2.63 kg/cm^2; Hydrogen at 0.68 kg/cm^2 and air at 0.35 0.68 kg/cm^2. Shimadzu integrator software was used to calculate the peak areas.

3.2.7. Determination of Mineral composition

Sample treatment: The ash was dissolved in 15 ml 6 N HCl in a volumetric flask which was then topped up to 100 ml mark with distilled water. This was used for mineral determination according to the AOAC method (2005). Iron, copper, calcium, sodium, magnesium, potassium and zinc were determined by Atomic Absorption Flame Emission Spectrophotometer (Shimadzu Corp., Tokyo Japan, Model AA 6200), using the respective cathode lamps. The individual mineral element composition was calculated from the AAS readings obtained for both the blank and the test solution.

Phosphorus was determined with the vanadomolybdate colorimetric method (Pearson, 1976) with potassium phosphate as the standard. 50 ml sample were pippeted into 125 ml Erlenmeyer flask and added a drop of phenolphthalein indicator. 8 ml combined reagent (5 N sulfuric acid, ammonium molybdate solution, 0.1M ascorbic acid) were added and mixed thoroughly. Absorbance was measured after 10 minutes, at 880 nm, using a blank reagent as the reference solution. All determinations were done in triplicate and reported in mg/100g sample.

3.2.8. Determination of Vitamins

3.2.8.1. Determination of Vitamin E

Vitamin E (α-Tocopherol) was analyzed using Perkin-Elmer (PE) series 400 liquid chromatography fitted with a UV detector using the method of Ubaldi *et al.,* (2005), with some modification. Milk sample was treated with a methanol/ethanol solution to denature lipoproteins. Alkaline saponification of the test material eliminates fats and liberates vitamin E from test material as unsaponifiable material that is successively extracted with petroleum ether. The extract was dried, solubilized with methanol and injected in HPLC (C18 column, reversed-phase). The quantitative determination of vitamin E was carried out by UV detector settled at 294 nm.

After homogenization, milk samples were divided in 10g aliquots, conserved in polyethylene tube and frozen at –20°C until analysis. Milk samples, at room temperature, were mixed and 10g were put into a round-bottom fl ask, 10ml of ascorbic acid solution were added and brought to 80°C in water-bath while purging with helium gas. At boiling point (after about twenty minutes) 2ml of KOH solution were added. After 20 minutes the flask was removed from water-bath and kept in the dark until cooling.

After cooling, test material was put into a separating funnel, rinsed two times with 5ml water and successively with 30ml ether. The funnel was closed and mixed several times. Aqueous phase was recovered in the round-bottom fl ask and ether phase was put into a fl ask. Extraction procedure was repeated 2 times with 30ml ether. Ether phases were combined and transferred in the separating funnel, rinsed 6 times with 50ml water, and recovered in a round-bottom fl ask. Separating funnel was rinsed with 10ml ether recovered in the round-bottom fl ask. Then, the test material was evaporated to dryness in a rotary evaporator under partial vacuum at water-bath temperature of 45°C (5 minutes). After cooling, test material was recovered with 5ml methanol, well mixed and transferred in a glass tube, centrifuged at 4000 rpm for 5 minutes. To prepare four samples about four hours were needed.

Standard curve was prepared using known concentrations of α -tocopherol against tocopherol internal standard ration. Linear regression analysis was used to predict concentrations of the unknown.

The analysis were performed using a HPLC Model LC-10AS, Shimadzu Corp., Kyoto, Japan fitted with UV detector at 205-340 nm wavelength filter, stainless steel column NOVA-PAK C_{18}, 3.9 mmX15 cm column at 35^0C oven temperature. Mobile phase: methanol: water 95:5 (both HPLC grade) at a flow rate of 8 ml/minute and injection volume of 20 µl. Shimadzu software was used to calculate the peak areas. Peak heights of tocopherol in the sample extracts were measured and compared with those of the standards.

3.2.8.2. Determination of Water Soluble Vitamins

3.2.8.2.1. **Determination of Ascorbic acid, thiamin and niacin**

Ascorbic acid, thiamin and niacin were determined as described in the method by Ekinci and Kadakal (2005). Deionized water (50ml) was added into 5 g sample, and the mixture homogenized for 1 minute, then centrifuged for 10 minutes at 14 x 10^3 rpm. The stationery phase was flushed with 10 ml methanol and 10ml water then adjusted to pH 4.2 to activate the stationery phase. Acidified water was prepared by adding a 0.05 M HCl solution drop by drop with stirring until the pH reached a predetermined value. The sample was eluted with 5 ml water (pH 4.2) then 10ml methanol at a flow rate of 1ml/minute. The eluent was collected in a bottle and evaporated to dryness. The residue was dissolved in mobile phase, filtered through 0.45 µm micro filters, and injected into the HPLC column.

The column eluate was monitored with a photodiode-array detector at 265 nm for vitamin C, 234 nm for thiamine, 261 nm for niacin, 324 nm for pyridoxine, 282 nm for folic acid, 204 nm for biotin and pantothenic acid.

Standard curve: Standard curves were prepared using known concentrations of vitamin standard (ascorbic acid, niacin, pantothenic acid, pyridoxine, thiamine, folic acid and riboflavin) against vitamin internal standard ration. Linear regression analysis was used to predict concentrations of the unknown water soluble vitamins.

Instrumentation: The analysis were performed using a HPLC (Shimadzu, Japan) PE series 400 liquid chromatograph fitted with a photo-diode detector, a C_{18} column ODS 250 mm x 4.0 mm stainless steel at 35^0C oven temperature. Mobile phase was 0.1 mol/litre di-potassium phosphates (pH 7): methanol 90:10, flow rate 0.7ml/min and injection volume 20 µl. Shimadzu software was used to calculate the peak areas.

3.2.8.2.2. Determination of Riboflavin

HPLC AOAC 2005 method was used. The sample was homogenized using a mechanical blender. 10 ml of the homogenate sample was accurately weighed and transferred into a 100ml round bottomed flask. 20 ml of 0.1N sulphuric acid was added to each sample and the mixture stirred. The mixture was hydrolyzed over boiling water for 1 hour. The pH of the mixture was adjusted to 4.5 using 2.5M sodium acetate and then cooled to room temperature and added 0.3g of papain. The sample extract was incubated for two and a half hours in the oven at 45^0C. The extract was cooled to room temperature and filtered under vacuum using the Whatman filter paper No. 42. The residue was centrifuged for 10 minutes at 10,000 revolutions per minute. The supernatant was transferred into a 50ml volumetric flask and made to the mark with diluted- deionized water. The mixture was filtered through the Millipore filters and an aliquot of 10μl was injected into HPLC for analysis.

The mobile phase was made by mixing 0.01M sodium phosphate buffer containing 0.005M 1-hexane sulphonic acid (pH 7.0) methanol and acetonitrile in the ratio of 90:10. The mixture was filtered through Millipore filter and degassed for 10 minutes.

Standard curve: Standard curves were prepared using known concentrations of riboflavin standard against vitamin internal standard ration. Linear regression analysis was used to predict concentrations of the unknown water soluble vitamins.

Instrumentation: The analysis were performed using a HPLC (Shimadzu, Japan) PE series 400 liquid chromatograph fitted with a UV detection detector, a C_{18} column ODS 150 mm x 4.6 mm stainless steel at $35^{0}C$ oven temperature, at 270 nm. Shimadzu software was used to calculate the peak areas.

3.2.9. Amino acids profile of goat milk

Amino acid profile of milk samples was performed following the protocol of Adeela (2013) with modification from Walsh and Brown (2000). The milk samples were centrifuged at 5000 rpm for 15 min at 4°C to separate the fat. Hydrochloric acid (6 M) was added to the sample vial for a final concentration of 5 mg of protein/ml of HCl. Hydrolysis vial was placed in an ultrasonic cleaner and flushed with nitrogen gas before sealing under vacuum. Samples were placed in a heating block for 4 hr at 145°C. Afterwards, samples were removed from the heating block and allowed to cool before filtration through 0.2 μm filter. Samples were dried with nitrogen gas and dissolved in a dilution buffer. The prepared samples were analyzed for amino acid profile by running through Automated Amino Acid Analyzer. Areas of amino acid standards were used to quantify each amino acid in representative sample.

3.3 Dairy Goat Milk Product Development

3.3.1 Product preparation

3.3.1.1 Paneer cheese

Paneer cheese was prepared using Goat milk and cow milk as per the method of Shahnawaz & Mohammad (2011). Fresh goat milk was pasteurized with stirring to 90^0C for 20 seconds. This was followed by coagulating the heated milk with a 0.2% citric acid solution. The curds and whey were allowed to cool for half of an hour, then strained through a muslin cloth and the curd pressed overnight. The Paneer was cut into pieces and packed for freezing. The Paneer cheese from goat milk was clean white.

3.3.1.2 Yoghurt

Pedigree dairy goat milk was heated to 55^0C, added 6.5% sugar and brought to boil at 85^0C for 5 minutes, with stirring, and finally cooled to 45^0C. A culture containing *Streptococcus thermophillus*, and *Lactobacillus bulgaricus*, was inoculated and the milk held for 4 hours at 45^0C. Afterwards the coagulum was broken by stirring to obtain goat milk yoghurt.

The same procedure was repeated using cow milk to obtain cow milk yoghurt for sensory evaluation comparison test. The products were refrigerated for a maximum of three days, for sensory evaluation.

3.3.2 Compositional analysis

3.3.2.1 Paneer cheese

The cow milk and Paneer cheese were analyzed for crude protein, fat content and ash contents following the procedure described by AOAC (2005).

3.3.2.2 Yoghurt

Goat and cow yoghurt were analysed for total solids, ash, protein, fat (Gerber method) and total sugars of yoghurt samples were determined according to AOAC (2005). The pH of yoghurt samples was measured after 1 day of storage at 4^0C using an Hanna pH meter calibrated with two standard solutions buffered at pH 4.00 and 7.00.

3.3.3 Sensory Evaluation

A group of twenty untrained panelists were selected from the Food Science and Technology students and staff, to evaluate the organoleptic quality of Paneer cheese and yoghurt products.

3.3.3.1 Acceptance Test

Sensory analyses were based on Vargas et al. (2008) with some modifications. Evaluation was based on five sensory attributes; Paneer cheese - texture/appearance, taste, smell, colour and aftertaste; and yoghurt - smoothness, colour, taste, odour and overall acceptability. Prior to the formal testing sessions, training sessions were performed to define and describe the attributes, find appropriate quantitative references and familiarize the panel with the samples and methodology.

A thirty member untrained panelists were used, for each session, which was repeated four times with different groups of Food Science and Technology students and staff. Yoghurt and cheese samples were placed in white plastic cups, labeled and placed on benches in a way that there was no interference between the panelists. Samples were tasted in the order presented form left to right. Water was provided for the panelists to rinse their mouth after each test.

Sensory attributes were analyzed by 12 trained panellists in terms of lower or higher intensity using an unstructured scale anchored on the left with ‘weak’ and on the right with ‘strong’. Each judge on the sensory panel performed the test three times. The acceptance sensory test was conducted with 120 untrained yoghurt consumers, 18–40 years of age. The evaluation was conducted using a 5-point hedonic scale (1 = dislike very much and 5 = like very much). See appendix VI and appendix VII.

The reference sensory properties are as follows:

- Colour – typical, characteristic, intensive white,
- Taste – sour, characteristic,
- Smell – characteristic and intensive,
- Texture/Appearance/Smoothness – uniform and compact, creamy not lumpy, without syneresis

3.3.3.1 Free Choice Profiling

This involved development and understanding of vocabularies before the analysis with the assessors being asked to taste two of the samples and generate as many terms as possible to describe appearance, texture, aroma, mouth feel, taste, and aftertaste. In order to ensure that panelists were not influenced in any way, no information with regard to the nature of the samples was provided. Panellists received two cubes of 2 x 2 x 1cm Paneer cheese samples from both goat and cow milk. This size, considerably larger than average bite size, was employed to ensure enough sample was available to evaluate all the necessary categories.

3.4. Data analysis

The data was analyzed using the Statistical Package for Social Scientists (SPSS) software Version 18 of 2010 (IBM Corporation). General Linear Model (GLM) Univariate procedure was used to perform a two-factor analysis of Variance at 5% significant level for milk yield, and descriptive statistic techniques including frequency and crosstabs, were applied for nutritional composition and product development

CHAPTER FOUR

RESULTS

4.1 Dairy Goat Feeding Practices

Data on dairy goat feeding for the study area is presented in Table 4.1. All the farmers included in the study fed the dairy goats with natural pastures which include weeds, shrubs; banana leaves, potato peels, fodder crops like nappier grass, maize stalks, sweet potato vines, green leafy twigs. They mainly used available plant material found on the farm. Only few farmers supplemented the feed with concentrates, a fact that contributed to the dairy goats low milk production, which is in agreement with findings of Ogola *et al.*, (2010).

Table 4.1: Dairy Goat Feeding Practices

Type of Feeding	**Kieni East (n=78)**	**Kieni West (n=73)**	**Mukurweini (n=39)**
Normal Pasture	100%	100%	100%
Normal Pasture + Concentrates	43%	5%	13%
Normal Pasture + Mineral supplements	48%	32%	0%

4.2 Kenya Alpine Dairy Goat Breed Milk Yield

4.2.1 Effect of Dam Grade on Dairy Goat Milk Yield

Using the General Linear Model (GLM) Univariate to perform a two-factor analysis of variance, the effect of grade per region on daily milk production was evaluated as presented in Table 4.2. The highest milk yield was found in Kieni East, with significantly higher amount of 2.69 litres per day.

Table 4.2: Effect of Dam grade per region on average dairy goat milk yield

Dam Grade	Kieni East (n=78)	Kieni West (n=73)	Mukurweini (n=39)
Original	2.28±0.94[b]	1.00±0.00[a]	1.33±0.40[a]
Foundation	1.25±0.35[a]	1.53±0.47[b]	0.98±0.17[a]
Intermediate	2.04±0.70[b]	1.81±0.77[b]	1.08±0.25[a]
Appendix	2.69±0.35[c]	1.77±0.40 [b]	1.34±0.39[a]
Pedigree	2.07±0.75[b]	2.15±0.62[c]	2.31±0.66[b]

The data are mean value ± standard deviation (SD) of six replicates.
[a] values within a column marked with different superscript are significantly different (P <.05).

The difference in milk production is significantly (P<0.05) lower for dairy goats in Mukurweini region, except the Pedigree grade, that gave significanly (P<0.05) high amounts of 2.31 litres. The appendix grade in Kieni East gives the highest milk production of 2.69 litres per day. This being a semi arid area the high milk production could be attributed by the good feeding programme as demonstrated in Table 4.1.

Table 4.3, shows the significance value of the F test in the ANOVA, which is 0.001, an indication that the dairy goat milk production for different grades is significantly different for each region under study. However the R square shows a weak relationship of 29% among the different regions and grades.

Table 4.3: Analysis of variance for effect of dam grade and region on daily milk yield

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	38.34[a]	14	2.74	5.198	0.000	0.294
Intercept	335.86	1	335.86	637.620	0.000	0.785
Region	10.122	2	5.06	9.608	0.000	0.099
DamGrade	15.33	4	3.83	7.277	0.000	0.143
Region DamGrade	*14.54	8	1.81	3.450	0.001	0.136
Error	92.18	175	0.52			
Total	816.94	190				
Corrected Total	130.51	189				

[a.] R Squared = .294 (Adjusted R Squared = .237).

4.2.2 Effect of Age on Pedigree Dairy Goat Milk yield

The Effect of dam age on milk yield was evaluated in the study areas as presented in Table 4.4. The pedigree dam starts to produce milk at the age of 2 years. The average milk production between the ages of 2 to 2.9 years was not significantly different ($P<0.05$)), for the three regions. At the age of 3.0 to 3.9, Kieni East gave significantly higher amount of 2.34 litres, as compared to Kieni West and Mukurweini with 2.19 and 1.88 litres respectively. A further similar increase was noted for the daily goats at the age of 4.o to 4.9, with Kieni East having significant higher amount of 2.66 litres as compared to other two regions. There was a notable increase at the prime age of 5.0 to 5.9 where Mukurweini significantly gave the highest amount of 2.96 litres per day.

There was, however, significant increase in milk production at the age of 5.0 to 5.9 years for both Kieni East and Mukurweini, giving 2.84 and 2.96 liters per day, respectively.

Table 4.4: Effect of Pedigree dam age on daily milk yield per region

Age	2.0 - 2.9 years	3.0 - 3.9 years	4.0 - 4.9 years	5.0 - 5.9 years
Kieni East (n=10)	1.82 ± 0.21^{a}	2.34 ± 0.45^{b}	2.66 ± 0.26^{c}	2.84 ± 0.36^{c}
Kieni West (n=10)	1.64 ± 0.56^{a}	2.19 ± 0.47^{b}	2.38 ± 0.22^{c}	2.40 ± 0.36^{c}
Mukurweini (n=10)	1.79 ± 0.61^{a}	1.88 ± 0.71^{a}	2.28 ± 0.55^{b}	2.96 ± 0.19^{c}

The data are mean value ± standard deviation (SD) of six replicates.
[a] Values within a row marked with different superscript are significantly different (P<0.05).

4.3 Nutritional and chemical composition of pedigree dairy goat milk

The chemical composition of milk from pedigree dairy goats in different geographical locations is shown in Table 4.5. According to this study variations were noted in milk chemical composition for dairy goats in semi arid and high potential areas under the study. Non-protein nitrogen and lactose were not significantly different (P<0.05) in the three regions. Mukurweini Region had significant (P<0.05) higher amount of ash, fat and protein as compared to the other two regions of the semi arid area.

Table 4.5: Chemical composition of pedigree goat milk from the three regions

g/100ml	Kieni East (n=10)	Kieni West (n=10)	Mukurweini (n=10)
Moisture	84.87 ± 0.7^{a}	87.46 ± 0.1^{b}	85.03 ± 0.1^{a}
Ash	0.20 ± 0.00^{a}	0.25 ± 0.00^{a}	0.96 ± 0.01^{b}
Fat	2.49 ± 0.1^{a}	3.43 ± 0.03^{b}	4.01 ± 0.01^{c}
Protein (N x 6.25)	3.42 ± 0.2^{a}	3.43 ± 0.02^{a}	4.58 ± 0.5^{b}
Non-protein Nitrogen	0.001 ± 0.00^{a}	0.002 ± 0.00^{a}	0.003 ± 0.00^{a}
Lactose	4.64 ± 0.10^{a}	4.02 ± 0.07^{a}	4.76 ± 0.24^{a}
Total solids	15.13 ± 1.00^{b}	12.54 ± 0.54^{a}	14.51 ± 0.94^{b}
Solids-non-fat	12.64 ± 1.07^{b}	9.11 ± 0.49^{a}	10.50 ± 0.37^{a}

The data are mean value ± standard deviation (SD) of six replicates.
^{a} Values within a row marked with different superscript are significantly different ($P<0.05$).

The mineral composition differed clearly among the three regions as shown in Table 4.6, with Mukurweini region giving significantly ($P<0.05$) higher amounts of calcium, magnesium, iron, zinc, sodium, potassium. Copper content was not affected by the treatments, while equal amounts of phosphorous was obtained in both Kieni East and West.

Table 4.6: Mineral composition of pedigree goat milk from the three regions

Minerals mg/100ml	Kieni East (n=10)	Kieni West (n=10)	Mukurweini (n=10)
Calcium	41.69±1.10^{a}	50.33±1.10^{b}	152.61±3.80^{c}
Magnesium	3.92±0.30^{a}	4.31±0.50^{a}	19.90±1.50^{b}
Iron	0.12±0.01^{a}	0.15±0.01^{a}	0.84±0.04^{b}
Zinc	0.15±0.01^{a}	0.18±0.01^{a}	0.57±0.01^{b}
Copper	0.03±0.00^{a}	0.03±0.00^{a}	0.06±0.01^{a}
Sodium	13.95±0.40^{a}	15.99±0.40^{b}	51.04±0.40^{c}
Potassium	50.32±1.06^{b}	46.09±1.23^{a}	196.65±4.76^{c}
phosphorous	1.12 ±0.07^{b}	1.12 ±0.01^{b}	0.86 ±0.02^{a}

The data are mean value ± standard deviation (SD) of six replicates.
[a] Values within a row marked with different superscript are significantly different (P<0.05).

The vitamin compositions of goat's milk from the three geographical regions are shown in Figure 4.2. Water soluble vitamins and tocopherols indicated that dairy goat milk obtained from the three regions did not differ significantly (P<0.05) in thiamine, content, while significant (P<0.05) low levels of niacin and riboflavin, were noted in Kieni west. Mukurweini gave significantly (P<0.05) higher amounts of riboflavin 1.04μg mL^{-1} and α-tocopherol 1.35 μg mL^{-1} as compared to the other two regions.

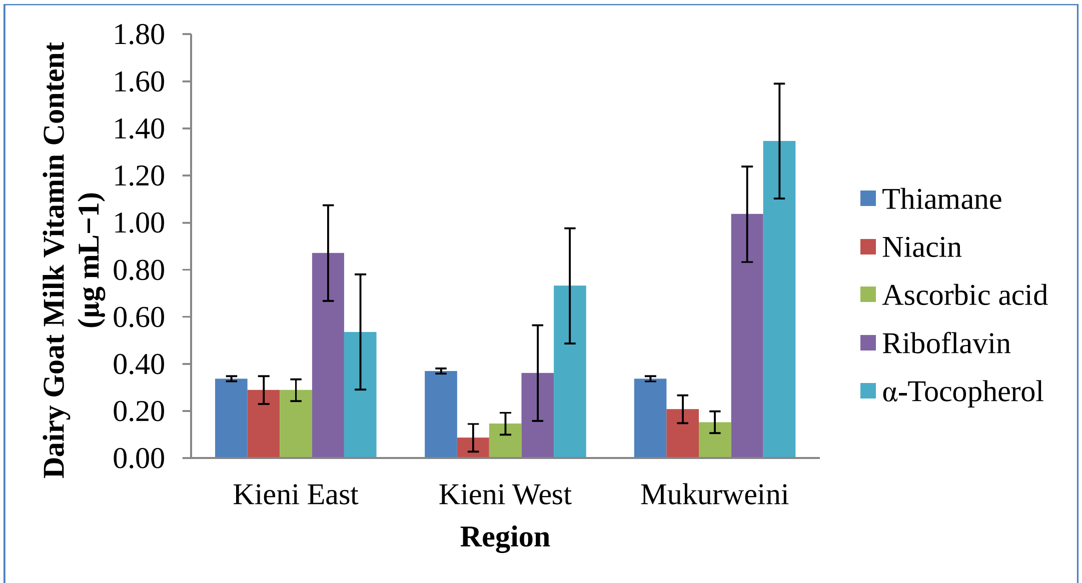

Figure 4.1: Vitamin Composition of pedigree goat milk from the three regions

The fatty acid profile of goat's milk and its changes resulting from the geographical area are shown in Table 4.7. No significant differences in the polyunsaturated, monounsaturated, and in most saturated fatty acid levels among the goat milk samples from the three regions.

In the high potential areas of Mukurweini the milk was significantly ($P<0.05$) higher in saturated fatty acids; palmitic 28.56% and stearic 22.77% than milk produced in the semi arid areas, and significantly ($P<0.05$) low amounts of lauric acid 3.66%.

Table 4.7: Fatty acid composition (%total fat) of pedigree goat milk from the three regions

Fatty acid %	Kieni East (n=10)	Kieni West (n=10)	Mukurweini (n=10)
Caproic (6:0)	0.30 ±0.09 [a]	0.46 ±0.35 [a]	0.28 ±0.75 [a]
Caprylic (8:0)	1.56 ±0.52 [a]	1.72 ±0.41 [a]	1.65 ±0.28 [a]
Capric (10:0)	8.99 ±3.41 [a]	11.81 ±6.31 [a]	9.67 ±2.74 [a]
Lauric (12:0)	4.46 ±1.27 [b]	7.41 ±0.21 [c]	3.66 ±0.53 [a]
Myristic (14:0)	9.92 ±0.71 [a]	9.81 ±3.56 [a]	10.84 ±0.50 [a]
Pentadecanoic (15:0)	1.04 ±0.51 [a]	1.11 ±0.00 [a]	0.89 ±0.57 [a]
Palmitic (16:0)	21.13 ±5.71 [a]	17.00 ±7.29 [a]	28.56 ±3.11 [b]
Heptadecanonoic (17:0)	0.48 ±0.31 [a]	0.54 ±0.11 [a]	0.70 ±0.22 [a]
Stearic (18:0)	15.22 ±4.34 [a]	17.04 ±6.52 [a]	22.77 ±5.65 [b]
Myristoleic (14:1)	0.41 ±0.20 [a]	0.31 ±0.21 [a]	0.31 ±0.21 [a]
Palmitoleic (16:1)	1.56 ±0.92 [a]	2.24 ±1.52 [a]	2.13 ±0.36 [a]
Oleic (18:1) cis	2.18 ±3.51 [a]	2.13 ±9.92 [a]	2.19 ±8.06 [a]
Elaidic (18:1) trans	2.27 ±1.06 [a]	3.17 ±1.60 [a]	3.12 ±1.51 [a]
Linoleic (18:2) cis	1.74 ±041 [a]	2.36 ±1.00 [a]	1.77 ±0.47 [a]
Linolelaidic (18:2) trans	1.49 ±8.19 [a]	1.87 ±1.68 [a]	1.01 ±0.60 [a]
Linolenic (18:3)	2.54 ±0.18 [a]	2.55 ±3.68 [a]	2.85 ±1.98 [a]
Arachidonic (20:4)	0.54 ±0.34 [a]	0.35 ±3.38 [a]	0.96 ±0.73 [a]

The data are mean value ± standard deviation (SD) of six replicates.
[a] Values within a row marked with different superscript are significantly different ($P<0.05$).

The amino acids profile of pedigree dairy goat milk is shown in Table 4.8. Since tryptophan is destroyed by acid hydrolysis (McKenzie, 1970), its values are not reported. Because glutamine is converted to glutamate and asparagine to aspartate during the hydrolysis, the values reported as glutamate include both glutamate and glutamine and those for aspartate include both aspartate and asparagine. Total amino acid concentration is the sum of all particular amino acids analyzed. Significant ($P<0.05$) higher amount of amino acids were obtained in both Kieni East and Mukurweini regions, with lysine 7.62% and 7.92% respectively , isoleucine 5.62% and 5.99% respectively and valine 7.62% and 7.98% respectively. Mukurweini region also had significant ($P<0.05$) high amount of methionine 2.84%, phenylalanine 5.56%, threonine 4.79%, histidine3.61% and leucine 10.73%. The significant amounts of essential amino acids in milk protein were due to the high nitrogenous fodder given to the dairy goats in this region.

Table 4.8: Amino Acids profile of pedigree goat milk from the three regions

Amino acid concentration (g/100g protein)			
Essential amino acid	**Kieni East (n=10)**	**Kieni West (n=10)**	**Mukurweini (n=10)**
Lysine	7.62±0.33^{b}	6.69±0.45^{a}	7.92±0.34b
Methionine	2.24±0.31^{a}	2.13±054^{a}	2.84±0.46^{b}
Phenylalanine	4.98±0.31^{a}	5.01±0.25^{a}	5.56±0.57^{b}
Threonine	4.15±0.35^{a}	3.98±0.43^{a}	4.79±0.22^{b}
Histidine	2.90±0.06^{a}	2.70±0.24^{a}	3.61±0.13^{b}
Leucine	10.24±0.08^{a}	9.81±0.15^{a}	10.73±0.19^{b}
Isoleucine	5.62±0.15^{b}	5.31±0.26^{a}	5.99±0.24^{b}
Valine	7.62±0.45^{b}	6.05±0.25^{a}	7.98±0.33^{b}
TEAA [1](%)	45.37	41.68	49.42
Non- essential amino acid			
Aspartate[2]	8.68±0.40^{a}	8.54±0.15^{a}	8.10±0.40^{a}
Serine	2.90±0.51^{a}	2.52±0.64^{a}	2.54±0.51^{a}
Alanine	3.54±0.06^{a}	3.26±0.22^{a}	3.76±0.06^{a}
Cysteine	2.87±0.08^{a}	2.81±0.17^{a}	3.01±0.08^{a}
Tyrosine	3.68±0.15^{a}	3.62±0.40^{a}	3.86±0.15^{a}
Arginine	3.31±0.12^{a}	3.32±0.42^{a}	3.46±0.12^{a}
Glutamate[3]	21.26±0.42^{a}	21.21±0.12^{a}	22.35±0.42^{a}

[a]Mean values having different letters within column are significantly difference at $P<0.05$
[1]TEAA = total essential amino acids
[2]aspartate includes both aspartate and asparagine
[3]glutamate includes both glutamate and glutamine

4.4 Goat Milk Products

4.4.1 Product Chemical Composition

The composition of Paneer cheese developed from goat milk is shown in Table 4.9. Compared to the composition of fresh cow milk, goat milk had higher fat, protein, and total solids, with the total protein content being higher than values reported for goats' milk of different worldwide breeds (Guo *et al.,* 2001; Stelios and Emmanuel 2004; Pirisi *et al.*, 2007). Goat and cow milk Paneer cheese chemical composition, showed significant ($p<0.05$) difference in fat content, with cow Paneer giving the highest amount of 24.98 g/100ml. Both goat and cow Paneer cheese had significantly ($p<0.05$) high amount of ash, fat and protein as compared to their fresh milk, because of whey draining that gives a concentrated product, with higher total solids.

Table 4.9: Proximate Composition (%) of Goat and Cow Fresh Milk and Paneer Cheese

Sample		Ash	Fat	Protein
Fresh Milk	Goat	0.96±0.01 [a]	4.01±0.01 [b]	4.58±0.5 [b]
	Cow	0.91±0.75[a]	3.56±0.26[a]	3.62±0.64[a]
Paneer Cheese	Goat	1.57±0.81[b]	20.95±1.07[c]	10.61±0.82[c]
	Cow	1.45±0.32[b]	24.98±0.41[d]	10.93±0.29[c]

The data are mean value ± standard deviation (SD) of six replicates.
[a]Values within a column marked with different superscript are significantly different ($p<0.05$).

The pH of the fresh milk was remarkably decreased from 5.83 to 5.72 for goat milk natural yogurt and from 6.04 to 5.59 for cow milk natural yogurt. Fortification with starch did not significantly affect the pH of the products from that of natural yoghurt. The ash and protein slightly increased in yoghurt products fortified with starch at both 1% and 2%.

Table 4.10 Proximate Composition (%) and pH of Goat and Cow Fresh Milk and Yoghurt Products

Sample		pH	Total Solids	Ash	Fat	Protein
Fresh Milk	Goat	5.83 ± 0.65^{b}	14.51 ± 0.94^{c}	0.96 ± 0.01^{a}	4.01 ± 0.01^{b}	4.58 ± 0.5^{b}
	Cow	6.04 ± 0.15^{b}	12.97 ± 0.48^{a}	0.91 ± 0.75^{a}	3.56 ± 0.26^{a}	3.62 ± 0.64^{a}
Natural Yoghurt	Goat	5.72 ± 0.25^{a}	14.74 ± 0.15^{c}	0.97 ± 0.53^{a}	4.10 ± 0.54^{b}	4.59 ± 0.57^{b}
	Cow	5.59 ± 0.41^{a}	13.12 ± 0.57^{a}	0.92 ± 0.57^{a}	3.61 ± 0.68^{a}	3.65 ± 0.22^{a}
yoghurt (1% starch)	Goat	5.73 ± 0.36^{a}	14.84 ± 0.35^{c}	0.99 ± 0.53^{b}	4.11 ± 0.35^{b}	4.61 ± 0.04^{c}
	Cow	5.60 ± 0.81^{a}	13.68 ± 0.68^{b}	0.95 ± 0.53^{a}	3.65 ± 0.54^{a}	3.68 ± 0.53^{b}
yoghurt (2% starch)	Goat	5.74 ± 0.86^{a}	15.29 ± 0.35^{d}	1.00 ± 0.54^{b}	4.12 ± 0.42^{b}	4.60 ± 0.25^{c}
	Cow	5.61 ± 0.35^{a}	13.93 ± 0.45^{b}	0.98 ± 0.35^{b}	3.65 ± 0.18^{a}	3.69 ± 0.15^{b}

The data are mean value ± standard deviation (SD) of six replicates.
[a] Values within a column marked with different superscript are significantly different ($p<0.05$).

4.4.2 Sensory Evaluation

4.4.2.1 Paneer Cheese

Preference test of the two Paneer cheese products is presented in Table 4.11. There was a significant ($P<0.05$) liking for cow milk Paneer cheese as compared to the goat milk Paneer cheese.

Table 4.11: Least square mean values for the preference of Paneer Cheese samples (n=120)

Paneer cheese samples	Liking (Mean value of 9)	P-Value
Goat milk Paneer cheese	1.81[a]	
Cow milk Paneer cheese	3.79[b]	<0.05

[ab] Samples with different letters are significantly preferred to one another

Sensory attributes for Paneer cheese from goat and cow milk samples are presented in Table 4.12 and 4.13. There cow milk Paneer cheese was preferred in terms of taste and aftertaste, which had creamy milky taste and nutty after taste, as compared to that of goat milk which had slightly bitter/sour taste. A smooth texture/appearance was characteristic of the two cheese samples while the cream of cow milk cheese and pure white colour of the goat milk cheese were both acceptable to the panelists.

Table 4.12: Sensory attributes for Paneer cheese from goat and cow milk samples.

Attributes	Goat milk Paneer cheese	Cow milk Paneer cheese
Texture/ Appearance	4.12±0.35[a]	4.85±0.21[a]
Taste	4.15±0.24[a]	4.92±0.26[b]
Smell	3.85±0.13[a]	3.21±0.28[a]
Colour	4.98±0.15[b]	3.00±0.21[a]
Aftertaste	3.25±0.30[a]	4.64±0.22[b]

[a]The data are mean value ± standard deviation (SD) of six replicates.
[a] Values within a row marked with different superscript are significantly different ($P<0.05$).
5 point Hedonic scale

Table 4.13: Free choice profiling - List of idiosyncratic sensory attributes developed by ten semi-trained panelists to describe the goat and cow milk Paneer cheese samples (n=20)

	Texture/ Appearance	**Taste**	**Smell**	**Colour**	**Mouthfeel**	**Aftertaste**
Goat Paneer cheese	Smooth	Milky	Creamy	White	Hard	Nutty
	Rough	Sour	Flat	White	Fatty	Sweet
	Soft	Slightly sweet	Off	Cream	Astringent	Creamy
	Fine	Flat	Milky	Bright	Dry	Fatty
		Watery	Odorless			
		Fatty	Less creamy			
		Slightly bitter	Nutty			
		Less creamy				
Cow Paneer cheese	Rough	Sour cream	Dairy	Cream	Hard	Nutty
	Smooth	Sour	Flat	White	Fatty	Sweet
	Coarse	Sweet	Milky	Milky white		Creamy
		Milky	Creamy	creamy		Fatty
		Bitter				

4.4.2.2 Yoghurt Product

Yoghurt products were prepared from goat and cow milk, and subjected to sensory evaluation, as shown in Table 4.14. A reduction of the scores for body and texture was observed in both goat milk and cow milk natural yogurt. Among all analyzed types, the goat milk yoghurt with 2% starch revealed the highest overall acceptability of 4.1, corresponding to “like” in a 5-point hedonic scale, while natural yoghurt from goat milk scored the lowest overall acceptability of 2.88, corresponding to “neither like nor dislike” in a 5 point hedonic scale. A higher score for goaty flavor in goat milk yogurt fortified with 2% starch and vanilla flavored was observed indicating a higher acceptability for the flavor of the new product. Analyzed results for odor showed a high score for all types of yogurt indicating that the goat milk yoghurt did not produce an off odour, as is perceived culturally.

Table 4.14: Yoghurt products sensory analysis

Sample		**Smoothness**	**Colour**	**Taste**	**Odour**	**Overall acceptability**
Natural yoghurt	Goat	3.29 ± 0.32^{a}	2.88 ± 0.30^{a}	2.76 ± 0.28^{a}	4.27 ± 0.32^{a}	2.88 ± 0.30^{a}
	Cow	3.65 ± 0.31^{b}	4.24 ± 0.14^{c}	3.65 ± 0.23^{b}	4.62 ± 0.31^{a}	3.59 ± 0.28^{b}
Yoghurt (1% starch)	Goat	3.00 ± 0.26^{a}	3.40 ± 0.29^{b}	2.70 ± 0.21^{a}	4.06 ± 0.26^{a}	3.50 ± 0.32^{b}
	Cow	3.50 ± 0.23^{b}	3.70 ± 0.23^{b}	2.10 ± 0.27^{a}	4.53 ± 0.23^{a}	3.50 ± 0.28^{b}
Yoghurt (2% starch)	Goat	4.20 ± 0.26^{c}	4.4 ± 0.81^{c}	4.2 ± 0.21^{c}	$4.25\pm.27^{a}$	4.1 ± 0.45^{c}
	Cow	3.90 ± 0.28^{c}	3.8 ± 0.25^{b}	3.4 ± 0.73^{b}	4.19 ± 0.28^{a}	3.6 ± 0.29^{b}

The data are mean value ± standard deviation (SD) of six replicates.
[a] Values within a column marked with different superscript are significantly different ($P<0.05$). 5 point Hedonic scale

CHAPTER FIVE

DISCUSSION

5.1. Dairy Goat Feeding Practices

Data on dairy goat feeding for the study area is presented in Table 4.1. In all study sites, Kieni East, Kieni West and Mukurweini, 100% households fed the dairy goats with natural pastures which include weeds, shrubs; banana leaves, potato peels, fodder crops like nappier grass, maize stalks, sweet potato vines, green leafy twigs. The farmers have set aside patches of land for grazing on their own land in addition to off farm grazing. However, most grazing land comprises unimproved natural pastures, with mixtures of grasses e.g. Kikuyu, star and couch grasses. They mainly used available plant material found on the farm. Only few farmers supplemented the feed with concentrates, a fact that contributed to the lower milk production by the dairy goats, which is in agreement with findings of Ogola *et al.,* (2010). Most Grazing hours varied between 5 – 9 hours depending on season and feeding system. Farmers offered additional forage or supplements to dairy goat that varied across farms and sites depending on season and farm productivity. Generally more forage was offered during the wet season than during the dry season. For example shrubs, sweet potato vines, weeds and vegetable crop residues**.** In the high potential area of Mukurweini, the fodder also comprised nitrogenous rich shrubs like *Calliandra, Tithonia, Lantana camara,* Sweet potato vines, *Lucerne, Desmodium,* and green nappier grass. In Kieni East and West, fodder mainly comprised, dry grass, tree shrubs, and vegetable crop residues from the dominant crops like maize, beans, potatoes and cabbages and other less dominant crops like peas, wheat, onions and carrot. But beaten by the harsh climate, farmers have embraced goat rearing in this region, with the dairy goats providing them plenty of milk for house hold use a swell as income generation.

Dairy meal was the principal commercial concentrate offered to dairy goats, which was available at a cost from livestock feed stores located within several rural-urban centers in the study area and was normally offered to lactating goats during milking time. In Kieni East and Kieni West 43% and 5% of farmers respectively, used concentrates, as indicated in Table 4.1. In Mukurweini 13% of the farmers used concentrates during milking. Mineral supplements was provided inform of blocks where, Kieni East and Kieni West used 48% and 32% respectively. Farmers in Mukurweini did not use supplementation due to the high nutrient fodders available that are known to contain adequate nutrients. Mineral supplements blocks were placed inside the pens where dairy goats accessed them when housed. During the study, it was noted that there is need to educate farmers on efficient feed utilization to achieve maximum returns. Feed supplementation with concentrates and mineral supplements was higher in Kieni East than the other two areas, a factor that contributed to higher milk production. Feeding higher amounts of concentrate in early lactation has been shown in Kenya to increase lactation milk yield by 20% (Romney *et al.*, 2000).

When giving concentrates as a supplement to the basic pasture-dominated diet, milk yield can increase due to a stabilized body weight and good body condition (Rufino *et al.*, 2009, Musalia *et al.*, 2007). Concentrates has a higher digestibility and often a higher concentration of energy and protein compared to forage. Kitalyi *et al.*, (2005) found out that few smallholder farmers give their animals concentrates mainly depending on lack of capital in the African set up. Amount of energy required for milk production varies among breeds due to differences in milk yield and the fat content (Kitalyi *et al.*, 2005). Goats should have free-choice access to mineral in loose form rather than in a block, and salt and bicarbonate of soda supplements at all times (Dairy Goat Society of Western Australia 2008)

Goats are by nature browsers not grazers - this means that they prefer eating leafy plants, weeds, and woody plants, reflected by pasture grasses and hay. They require five major classes of feeds, energy, protein, vitamins, water and mineral salts. Goats consume a wide variety of grasses, weeds and small branches of bushes and trees, leaves, peelings and roots of vegetables, husks of corn, citrus and banana peeling and other waste plant residues. Also being fastidious feeders they thrive well in drought stricken areas like Kieni East and West regions of Nyeri County. For good milk production, dairy goats need to be fed with maximum amounts of high quality fodder balanced with a grain ration containing enough protein, minerals and vitamins to support production and animal health. Dairy Goats are fairly picky eaters and will resist eating soiled food unless starved. Dietary needs of dairy goat can be easily met through a balanced combination of forages, feed based on grain and grain by-products (corn, wheat, sorghum, sunflower and cotton seed), and the integrated use of nutritional supplements (minerals, salt) in the feeding program.

On overall, the adequacy and timeliness of feeding management was found to be among the factors that mainly contributed to low milk production, which was in agreement with findings of Ogola *et al.,* (2010). Generally, proper feeding would enhance production of the dairy goats and, consequently, better milk yields which can enable farmers to cater for their household needs as well as for enterprise.

Estimate by Reynolds *et al.*, (1996) showed that smallholder dairy farmers produced about 70% of the feed required from their own resources and this situation has remained relatively the same, even in the semi arid areas of Kieni East and West. Inadequate nutrition is a major constraint that impact negatively on the growth and viability of the dairy farming in Kenya

(Njarui *et al.*, 2009). Inability to provide sufficient quantity and quality of feed to livestock is widespread in East Africa (Hall *et al.*, 2007). In Kenya, majority of smallholder farmers keep more animals than they can feed from their own land. Maintaining access to adequate quantity and quality of feed resource is crucial for milk production in dairy goats

5.2. Kenya Alpine Dairy Goat Breed Milk Yield

5.2.1. Effect of Dam Grade on Dairy Goat Milk Yield

A study on milk yield and milk composition is important to evaluate the milk production ability of milking animals. Milk yield of the Kenya alpine dairy goat addresses the amount of milk produced per day Milk yield by the doe is determined by several factors including genetical composition, feeding regime, stage of lactation, production system and suckling/milking frequency (Goetsch *et al.*, 2011). The average milk yields by Kenya Alpine dairy goats in the present study were similar to those obtained by Eik *et al.*, (1996) who obtained the average daily yields ranging from 1.0 liter per day to 2.3 liters/day. Huge individual variations in daily milk production were observed among the different dairy goat grades in the three regions as shown in Table 4.2. The Appendix grade in Kieni East region gave significantly ($P<0.05$) highest amount of milk, 2.69 litres per day, while the foundation grade in Mukurweini region gave significantly ($P<0.05$) lowest amount of milk, 0.98 litres per day. The low milk production in Mukurweini could have been due to low concentrates, 13%, fed to the dairy goats in this region, and no mineral supplementation (Table 4.1) n. However, the pedigree grades in the three regions of Kieni East, Kieni West and Mukurweini did not significantly ($P<0.05$) differ in milk yield with 2.07, 2.15, 2.31 litres per day respectively. The pedigree grade being an improvement of the local goats is expected to yield more milk per day in all the regions.

Mukurweini region has good crops yield, therefore farmers tend to concentrate more on crop production and cattle rearing, as there is enough fodder for the cattle, hence the diminishing interest in dairy goats rearing.

The average daily milk production of the dairy goat was mainly affected by the dam grade as well as feeding program. Proper improvement of the breeding, through record keeping and follow up can lead to superior pedigree grades with higher milk production. Due to lack of concentrates and mineral supplements, the farmers should utilize plant material already available on the farm such as nappier grass, herbaceous and shrub legumes, plants rich in nitrogenous matter like forage legumes and Calliandra, among others, in order to achieve high milk yields. Increasing milk production at lower costs will not only improve the nutritional status of resource-poor communities but will also improve the incomes of smallholder dairy farmers. To produce adequate milk, a dairy goat requires a well-balanced diet for both self-maintenance and production of milk (Kamau *et al.*, 2008).

Volume and composition of milk produced is controlled by the goat's genetics but greatly influenced by the diet consumed (Robert *et al.*, 2008). Crossbreeding local goat with the German alpine breed was a way of realizing faster genetic improvement than by selection, matching genotype with the environment and benefiting from the complementarity of the breeds involved. The benefits that farmers enjoy include faster growth rates and more milk from the crossbred goats. According to the findings of this study, the results were in contrary with those of Lina (2011), who found that crossbreeding greatly led to increase in milk yield in exotic breeds. There was significant increase in daily milk production with crossbreeding in Kieni West, where the original gave significant ($P<0.05$) lowest yield of 1.00 litres per day and pedigree gave 2.15 litres per day. Consequently, there was no improvement in daily milk production in the crossbred goats occurred as a result of the crossbreeding in the Kieni East and Mukurweini.

5.2.2. Effect of Age on Pedigree Dairy Goat Milk Yield

The results in Table 4.4 indicate that dairy goats start to produce milk at the age of 2.0 to 2.9 years in the three regions. Milk yield showed significant variation in different age groups in the three regions. At the age of 2 to 4 years the doe is kidding hence producing less milk. This result agrees with the report of Akers (2002) who stated that pregnancy has a negative effect on milk yield. A decline in milk yield with pregnancy in dairy animals was also reported by Khan *et al*., (2011). This may be due to hormonal changes, causing regression of the mammary gland and nutrient requirements of the foetus, reducing available nutrients for milk production. The results also agree with those of Eik *et al.,* (1996) where the milk yield was lower in the suckling does compared to does without suckling kids.

There was a significant ($P<0.05$) increase in milk production for the pedigree grade at the age of 5.0 and 5.9 years. At this age the dams are past the kidding age, giving more milk for household use. In the present study age significantly influenced the milk yield by the goat, where as the goat gets mature, milk yield increases. This is similar with Solaiman (2010) who showed the increase in the goat milk production with age and the peak production was attained in the fourth year of age. The increase in the milk yield with respect to the age of the goat could be due to the in the increase in body weight which is related to the increase in the udder and the volume of gastro intestinal tract which is related to the increase in the digestive capacity and the increase in the cisternal capacity as the age of the doe is increased (Goetsch *et al.,* 2011). Despite the increasing demand for dairy goats due to diminishing land sizes, milk production is growing very slowly due to poor breeding and management practices at the farms.

The increase in milk yield with advancement in age of the doe concurs with the study by Muller (2005) who reported that does which kidded at a younger age had lower milk yield compared to those with higher age. Further, Ciappesoni *et al*., (2004) reported a similar increase in milk yield with age of the doe.

5.3. Nutritional and chemical composition of pedigree dairy goat milk

According to this study variations were noted in milk chemical composition (Table 4.5) for dairy goats in semi arid and high potential areas under the study. The non-protein nitrogen and lactose were not significantly different (P<0.05) in the three regions. Lactose is the main determinant of milk volume. A close relationship between lactose synthesis and the amount of water drawn into milk makes lactose a stable milk component (Pollott 2004). As in cows, lactose constitutes the main carbohydrate in goat milk. Goat milk does contain less lactose than cow milk (on average, 4.1% vs. 4.7%), but cannot be regarded as a dietary solution to people suffering from lactose intolerance (Silanikove *et al.,* 2010). Milk composition and quality are important attributes that determine the nutritive value and consumer acceptability. However, when different geographic regions and feeding practices are considered, the various nutritional components vary considerably.

Goat milk protein content in Kieni West 3.43 g/100ml, and Kieni East 3.42 g/100ml were within the normal range for goat milk (Guo *et al.,* 2001; Vilanova *et al.,* 2008) and similar to values reported in other goat breed (Kuchtík and Sedláčková, 2003; Ciappesconi *et al.,* 2004). However, Mukurweini Region had significant (P<0.05) higher amount of ash 0.96 g/100ml, fat 4.01 g/100ml and protein 4.58 g/100ml as compared to the other two regions of the semi arid area. Ash content was low in Kieni West, 0.25g/100ml and Kieni East 0.20g/100ml, and significantly increased in Mukurweini region, 0.96g/100ml. As indicated in Appendix II, goat's milk reported to provide higher proportion of total solids, protein and fat than cow milk (Eissa, *et al.,* 2010). Nutritional value of milk is closely related with its composition, which is highly affected by factors such as breed, feed, and stage of lactation, season (Greyling *et al.,* 2004). Total protein content was comparable to values reported for goats' milk of different worldwide breeds (Guo *et al.,* 2001; Hadjipanayiotou 2004; Stelios and Emmanuel 2004; Güler 2007; Pirisi *et al.,* 2007) while, fat in Mukurweini was comparable to goat milk from other breeds (Güler 2007). The fat content in Kieni East was significantly low as compared to Kieni West. The goat milk from Mukurweini was rich in terms of ash, fat and protein, which can be contributed by the nutritious types of fodder available in that area. The percentage of total fat in goat and cow milk is quite similar, and the fatty acid composition depends to a large extent on the diet composition in both species (Silanikove *et al.,* 2010). Two characteristics of goat milk fat have important consequences for manufacturing. One is the smaller size of the fat globules in goat milk in comparison to those in cow milk. In both species the fat globules range from 1 to 10μm, but the number of fat globules smaller than 5μm is approximately 60% in cow milk whereas it is approximately 80% in goat milk. This difference results in the softer texture of goat milk products, though it makes manufacture of butter from goat milk difficult. The second feature is the fatty acid composition of goat milk. It contains a higher proportion of medium-chain fatty acids, i.e., caproic (C6:0), caprylic (C8:0) and capric (C10:0), which are partly responsible for the characteristic "goaty" odour of goat milk, as much of the odour originate from the buck.

Goat milk do not differ significantly from cow milk (Appendix I) in terms of protein percentage and, in contrast to milk fat, the protein content in both species is less amenable to dietary manipulation. Aganga *et al.*, 2002; Othmane *et al.*, 2002; Guo *et al.,* 2004; and Soryal *et al.,* 2005, reported that the content of total protein in goat milk was highly dependent on the stage of lactation. However, casein micelles in goat milk are large, 100 and 200 nm as compared to cow milk, 60–80 nm (Silanikove *et al.,* 2010). Another key difference between species is the low level of α_{s1}-casein, where in goat milk it ranges from 0 to 7 g/L (Martin-Diane *et al.*, 2002). This variability is associated with polymorphisms within the alpha $_{s1}$-casein gene, which are very common in goats (Martin-Diane *et al.*, 2002). As human milk lacks α_{s1}-casein, the low levels of α_{s1}-casein in goat milks and higher proportion of β-casein means that goat milk casein profile is closer to human milk than that of cow milk (Clark and Sherbon, 2000). Bevilacqua *et al.*, (2001) noted that contradictory results that have been reported on the use of goat milk in cow milk allergy could be due to the high genetic polymorphism of goat milk proteins, particularly, α_{s1}-casein. Goat milk is reported to form a finer curd than cow milk following acidification, which mimics the conditions in the stomach, suggesting it would be more readily digested (Park, 2007). Variuos research studies have established that the protein of goat milk is more digestible (López-Aliaga *et al.*, 2003; Haenlein, 2004), and less allergenic (Lara-Villoslada *et al.*, 2005). Similarly, the fat of goat milk is more digestible (Alférez *et al.*, 2001), and it may be considered an excellent source of energy for use in various metabolic processes and even for combating metabolic diseases (Sanz -Sampelayo *et al.*, 2007).

Raynal-Ljutovac *et al.*, (2008) reported total solids up to 14.8% (w/w), fat up to 5.63% (w/w) and crude protein contents up to 4.09% (w/w) which were far beyond the levels that were found in this study, but close to those of Mukurweinin region. However the values for proximate composition obtained in this study are close to the average concentrations given by Souci et al., (2000) and Vedran *et al.*, (2010), which is very often used by food chemists as a source of reference values concerning the composition of foods, (13.4% total solids, 3.92% fat and 3.69% crude protein).

Milk is an important source of mineral substances, especially calcium, phosphorus, sodium, potassium, chloride, iodine, magnesium, and small amounts of iron. The main mineral compounds of milk are calcium and phosphorus, which are substantial for bone growth and the proper development of newborns (Al-Wabel 2008). The mineral composition differed clearly among the three regions as shown in Table 4.6, with Mukurweini region giving significantly ($P<0.05$) higher amounts of calcium 152.61mg/100ml, magnesium 19.90 mg/100ml, iron 0.84 mg/100ml, zinc 0.57 mg/100ml , sodium 51.04 mg/100ml , potassium 196.65 mg/100ml. Copper content was not affected by the treatments, while equal amounts of phosphorous 1.12 mg/100ml was obtained in both Kieni East and West. In the semi arid areas of Kieni East and West, dairy goat easily adapt to the harsh climate and scarcity of fodder while in Mukurweini there are readily available fodders to feed the dairy goats, thus the high mineral components. Although the dairy goats in Kieni East and Kieni West used supplementation, this did not lead to milk with more ash as well as minerals as compared to milk from the high potential area of Mukurweini. The results show that farmers in this region do not supplement the feed with neither concentrates nor mineral supplements, since the type of fodder used is sufficient to supply the necessary nutrients. The high bioavailability of these minerals influences the unique nutritional value of milk. Goat milk is characterized by the lowest concentration of iron, zinc, and copper (Barłowska, 2011). Despite the low iron concentration in goat milk, iron is more bioavailable in goat milk than it is in cow milk. The explanation for that is that goat milk contains a higher share of nucleotides which contribute to heightened absorption in the intestine (Raynal-Ljutovac *et al.,* 2008).

Milk is a valuable source of vitamins, both water-soluble and fat-soluble ones. According to Figure 4.1, water soluble vitamins and tocopherols indicated that dairy goat milk obtained from the three regions did not differ significantly ($P<0.05$) in thiamine, content, while significant ($P<0.05$) low levels of niacin 0.09μg mL^{-1} and riboflavin 0.36μg mL^{-1}, were noted in Kieni west. Mukurweini gave significantly ($P<0.05$) higher amounts of riboflavin 1.04μg mL^{-1} and α-tocopherol 1.35 μg mL^{-1} as compared to the other two regions. Goat milk is a good source of vitamin A, niacin, thiamin, riboflavin, and pantothenic acid. However, it contains 5 times less vitamin B_{12} and folic acid than cow milk does (Barłowska 2011). The α-tocopherol is chemically and biologically the most active among the vitamin E molecules, an important component of the cellular defense system and protects the cell membrane and cell content from oxidative damage (Slavica, 2012). Vitamin E is only biosynthesized by plants and distributed in milk principally as α-tocopherol.

In the high potential areas of Mukurweini the milk was significantly ($P<0.05$) higher in saturated fatty acids; palmitic 28.56% and stearic 22.77% than milk produced in the semi arid areas, and significantly ($P<0.05$) low amounts of in Lauric acid 3.66%, as shown in Table 4.7. Mukurweini being a cooler area as compared to the other two regions, this is in agreement with study carried out by Soják *et al., (*2012), where it was found that cool climate affect milk yields and composition, and both are negatively correlated. Milk composition can have significant differences in major and minor components (Haenlein 2004), which are confounded with climate and diet effects. Regardless of genetics, the composition of the dairy diet and its amount in relation to production requirements can cause significant changes in milk composition (Haenlein, 1995). In order to cover nutrient needs of high production, the energy and protein density of the daily feed intake must increase, because of the limitation of the rumen in volume capacity. Roughages like grass, hay or silages are mostly low in energy and protein density because of high fiber and/or water contents (Haenlein, 1995).

The high-quality protein in milk plays a crucial role in nutrition which could provide amino acid (AA) for the human body, especially in developing countries where diets are largely cereal based. Very few data are available on the amino acid composition of goat during the lactation period, which are vital nutrients for growth and maintenance of health in dairy goats. The amino acids profile results in Table 4.8 indicate that some of the essential amino were significantly ($P<0.05$) higher in both Kieni East and Mukurweini regions. These were acids lysine 7.62% and 7.92% respectively, isoleucine 5.62% and 5.99% respectively and valine 7.62% and 7.98% respectively. These essential amino acids make the milk nutritious in terms of protein content. Mukurweini region also had significant ($P<0.05$) high amount of methionine 2.84%, phenylalanine 5.56%, threonine4.79%, histidine3.61% and leucine 10.73%. The significant amounts of essential amino acids in milk protein were due to the high nitrogenous fodder given to the dairy goats in this region. The other two regions being semi arid have dry shrubs that are low in nitrogenous matter. Due to the great variability in the protein composition of goat milk, careful control of the amino acid pattern of protein used is important, when the milk is used in the manufacture of other products. The non essential amino acids were not significantly ($P<0.05$) different in the three regions under study. Glutamate which includes both glutamic acid and glutamine, was the highest amino acid identified for the three regions, Kieni West 21.21g/100g protein, Kieni East 21.26 g/100g protein and Mukurweini 22.35 g/100g protein. According to Guo *et al.,* 2007; and Sheng *et al.,* 2008, bovine milk is a good supply of glutamic acid that could be used in the biological protein metabolism in the body.

Amino acids pattern in milk protein changes only within the frame of experimental error. The amino acids analysis was done to detect typical amino acids that are present in milk. Hydrolysis was carefully done to avoid destroying sensitive amino acids and hydrolyzing reagents removed by evaporation then derivatized with a fluorometric reagent before detection. Of the essential amino acids present, the most abundant in both the goat milk were lysine, leucine and valine which were in agreement with findings of Sabahelkheir *et al.,* (2012). In accordance with findings of Hejtmánková *et al.,* (2004), goat milk amino acid profile is similar to that of ewe and also cow milk. Amino acids are vital nutrients for growth and maintenance of health in humans. Further research and more data are needed for determination and validation of the real pattern of sulfur amino acids in goat milk. The content of nitrogen components in goat milk varies according to breed, genetics, season, stage of lactation and feed (Park, 2007; Park *et al.*, 2007). The goat milk has a natural whey-to-casein ratio of about 20:80. Total non-protein nitrogen content is around 5-8 % of total nitrogen (Prosser *et al.,* 2008). The main components of the non-protein nitrogen fraction are urea (30 %), free amino acids (with taurine, L-glycine, L-glutamic acid and L-glutamine being the most abundant), nucleosides, nucleotides and polyamines (Park *et al.*, 2007; Prosser *et al.,* 2008). According to Velíšek and Hajšlová (2009), the abundance of cysteine in goat, ewe, and also human milk is very similar and always higher than in cow milk (in goat milk up to twice), however cow milk contains more methionine.

Amongst branched chain amino acids, leucine plays an important role in dietary protein metabolism. The breakdown of leucine takes place in the liver and skeletal muscles (Layman, 2003). It undergoes transamination in the muscles by transferring into glutamine or alanine that ultimately converts to glucose in the liver through gluconeogenesis; a unique pathway, for the maintenance of blood glucose level (Borsheim *et al*., 2003). Hence dietary proteins rich in essential and branched chain amino acids particularly leucine provide health benefits that are not usually observed for diets containing protein from other sources (Wolfe, 2002).

5.4. Goat Milk Product development

5.4.1. Proximate Composition

5.4.1.1 Paneer Cheese

Goat milk is of great importance for milk technology and nutrition, due to its small-sized globules, uniform protein and fat distribution that make it easily digestible. Nutritional value of milk is closely related with its composition, which is highly affected by factors such as breed, feed, stage of lactation and season (Nuray, 2010). Compared to the composition of fresh cow milk, goat milk had higher fat, protein, and total solids, with the total protein content being higher than values reported for goats' milk of different worldwide breeds (Guo *et al.*, 2001; Stelios and Emmanuel 2004; Pirisi *et al.*, 2007). Goat and cow milk Paneer cheese chemical composition, showed significant ($p<0.05$) difference in fat content, with cow Paneer giving the highest amount of 24.98 g/100ml. The latter being taken as reference milk product, there is a significant difference in fat. Both goat and cow Paneer cheese had significantly ($p<0.05$) high amount of ash, fat and protein as compared to their fresh milk, because of whey draining that gives a concentrated product, with higher total solids. There was no significance ($P<0.05$) difference in ash and protein content of both the goat and cow milk cheese. The chemical composition of Paneer reported in earlier research showed a significant variation (Sunil *et al.*, 2011). These differences may be attributed to the differences in the initial composition of milk, method of manufacture and losses of milk solids in whey.

5.4.1.2 Yoghurt

Proximate Composition (%) and pH of Goat and Cow Fresh Milk and Yoghurt Products is shown in Table 4.10. Preparation of yogurt slightly changed the level of protein, fat, ash, total solids and for both goat and cow milk products, suggesting the effect of the indigenous microflora on such constituents. The pH of the fresh milk was remarkably decreased from 5.83 to 5.72 for goat milk natural yogurt and from 6.04 to 5.59 for cow milk natural yogurt. Results for pH were higher than those found by Stelios and Emmanuel (2004) and Maria et al., (2012) in goat milk yoghurts from Alpine goats, Greek goats and a mixture of goat and sheep milk (50⁄50): 3.97, 4.15 and 4.28, respectively.

Fortification with starch did not significantly affect the pH from that of natural yoghurt. Constituents in yogurts are influenced by the fermentation process, draining of yogurt, cooking, and manufacturing utensils (Güler 2007). The ash and protein slightly increased in yoghurt products fortified with starch at both 1% and 2%. Goat's milk reported to provide higher proportion of total solids, protein and fat than cow milk (Haenlein 1996). Ash and protein contents are close to what Martin-Diana *et al.*, (2003) and Maria *et al.*, (2012) previously found for caprine yoghurt with probiotics.

The nutrient compositions of goat milk can be greatly influenced by several factors such as season, stages of lactation, breed, diet, individual animal and environmental management conditions (Haenlein 2004).

5.4.2. Sensory Evaluation

5.4.2.1 Paneer Cheese

Goat and cow Paneer cheese were evaluated for consumer acceptability. Preference test for the Paneer cheese samples shown in Table 4.11, gave a significant ($P<0.05$) liking for cow milk Paneer cheese (3.79) as compared to the goat milk Paneer cheese (1.81). As indicated in Table 4.12, there was significant ($P<0.05$) liking of cow milk Paneer cheese in terms of taste and aftertaste, which had creamy milky taste and nutty after taste, as compared to that of goat milk which scored significantly ($P<0.05$) low due to slightly bitter/sour taste. However the goat milk cheese had an appealing white colour giving it an attractive appearance. A smooth texture/appearance was characteristic of the two cheese samples while the cream of cow milk cheese and pure white colour of the goat milk cheese were acceptable to the panelists.

Free choice profiling was carried out according to Table 4.13, in order to relate sensory characteristics of Paneer cheeses, to hedonic data obtained from the untrained panelists. Semi trained consumers described and perceived the fresh goat and cow milk cheese, and used their own attributes to describe and quantify the cheese products. According to Berridge (1996), preference assessments are dependent on the psychological or functional components of pleasure of eating as complexity of neuron system, determined the liking extent unconsciously. The free choice profiling results revealed that Paneer cheese from dairy goats can be described as smooth soft texture, milky taste, creamy smell, white colour, dry mouthfeel and nutty fatty aftertaste, while that form cow milk is characterized by coarse texture, creamy sour taste, cream white colour, fatty hard mouth feel and nutty sweet taste. Sensory characteristics of a cheese at the time of its consumption, reflect the milk from which it was produced (e.g., a goats' milk cheese is distinct from a cows' milk cheese), the processes used in its production, and the physical and the chemical changes that occurred during processing. Understanding the development and variations in flavour that occur during the development of cheese, is an important tool in defining consumers' expectations of taste. Free choice profiling is a sensory technique developed to reduce the need for extensive panel training. It also eliminates the pre-established measure of agreement among the panellists on their interpretation and meaning of the terms they will employ (Deliza *et al.*, 2005).

5.4.2. Yoghurt

Goat milk yoghurt was compared with cow milk yoghurt as shown in Table 4.14. A reduction of the scores for body and texture was observed in both goat milk and cow milk natural yogurt, scoring the lowest overall acceptability of 2.88, corresponding to “neither like nor dislike” in a 5 point hedonic scale. Natural goat milk yogurt was evaluated as less consistent and more acid, with a non-typical yogurt taste and flavor. Similar sensory characteristics were reported by other researchers (Duboc and Mollet 2001; Vargas *et al.*, 2008) of yoghurt manufactured from goat milk. These poor characteristics were improved by fortification with starch at both 1% and 2%, together addition of vanilla essence. Among all analyzed types, the goat milk yoghurt with 2% starch revealed the highest overall acceptability of 4.1, corresponding to “like” in a 5-point hedonic scale. A higher score for goaty flavor in goat milk yogurt fortified with 2% starch and vanilla flavored was observed indicating a higher acceptability for the flavor of the new product. It may be due to the masking ability of the peculiar thinness by the addition of starch as a thickener. There was a significant liking of goat milk yogurt fortified with 2 % starch, giving an overall acceptability of 4.1 due to the thick consistency and viscosity. According to research by Maria *et al.*, (2012), the higher fat content in the milk matrix is important for strengthening the structural network formed by caseins during the fermentation process of yoghurt, as it contributes to higher viscosity in yoghurt with higher concentration of milk.

Analyzed results for odor showed slightly higher score for all types of yogurt indicating that the goat milk yoghurt did not produce an off odour, as its perceived culturally. Average overall acceptability scores ranged from 3.5 to 4.1 among the three goat milk and cow milk yogurt samples thickened with starch. Moreover, the results showed that the overall acceptability of cow milk yoghurt with 1% was not significantly different (P>0.05) from goat milk yogurt with 1% starch although goat milk yogurt with 2% starch gained a higher overall acceptability. Natural yoghurt from goat milk occurred to have a loose and weak consistency, high syneresis than yoghurts from cow milk. The sensory quality of yoghurts from non-concentrated goat, cow and sheep milk was assessed similarly by Pazáková *et al.,* 1999. In their investigations goat milk yoghurt had a markedly “goat" flavour, which negatively influenced the sensory quality. Fresh goat milk yoghurt analyzed in this work revealed no "goat" flavour. The pedigree goats selected for the study, were not housed with the buck that is known to contribute to the goaty off flavour. Although consumers are clear in indicating the products they prefer, any description given by consumers tends to be of a hedonic nature and not descriptive. It is therefore necessary to be able to relate external information about the products to consumer preference ratings, not only to understand the market, but also to generate a successful new product (McEwan *et al.*, 1998).

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1. Conclusions

The study established that the geographical location of the dairy goat rearing affect the quality of milk produced, which is also dependant on the type of fodder available in that region. Dairy goat milk production is also affected by the age of the dam, the grade (breeding), and feeding practices. The households in the study sites of Kieni East, Kieni West and Mukurweini, relied on natural pastures as a source of feed for dairy goats. Feed supplementation with concentrates and mineral supplements was higher in Kieni East than the other two areas, a factor that contributed to higher milk production. Farmers in Mukurweini did not use supplementation due to the high nutrient fodders available that are known to contain adequate nutrients. The Appendix grade in Kieni East region gave the highest milk yield, while the foundation grade in Mukurweini region produced the lowest amount of milk per day. There was no direct pattern in the increase of milk yield with crossbreeding in the three regions. The milk yield showed significant variation in different age groups, with age significantly influencing milk yield, where as the dairy goat progresses in age, milk yield increases.

Nutritional and chemical composition of dairy goat milk was affected by the geographicl region, where Mukurweini produced milk with high amount of ash fat and protein as compared to the other two regions of the semi arid area. Also dairy goat milk from Mukurweini region had higher amounts of calcium, magnesium, iron, zinc, sodium, potassium than the milk from the other two regions, as well as riboflavin and α-tocopherol; and palmitic and stearic fatty acids. Goat milk from Mukurweini region had higher amount of the essential amino acids:- methionine, phenylalanine,, threonine, histidine, and leucine than the other two regions. In the semi arid areas of Kieni East and West, dairy goat easily adapt to the harsh climate and scarcity of fodder while in Mukurweini there are readily available fodders to feed the dairy goats, which are wholesomely nutritious thus the high composition of the essential nutrients..

Chemical composition of Paneer cheese made from either goat or cow milk showed differences in fat content with goat milk cheese having significantly lower fat content than cow milk. There was higher rating of the preference of cow milk Paneer cheese in terms of taste and aftertaste, as compared to that of goat milk. However the goat milk cheese had an appealing white colour giving it an attractive appearance. A smooth texture/appearance was characteristic of the two cheese samples while the cream of cow milk cheese and pure white colour of the goat milk cheese were acceptable to the panelists.

Comparison of goat milk yoghurt with cow milk yoghurt indicated a reduction of the scores for body and texture. A higher score for goaty flavor in goat milk yogurt fortified with 2% starch and vanilla flavored was observed indicating a higher acceptability for the flavor of the new product. It may be due to the masking ability of the peculiar thinness by the addition of starch as a thickener. Analyzed results for odor showed slightly higher score for all types of yogurt indicating that the goat milk yoghurt did not produce an off odour, as its perceived culturally. Natural goat milk yoghurt in comparison to cow milk yoghurts was less acceptable organoleptically due to its looser and weaker consistency. However this was improved by fortifying with starch as a binder and thickener as well as vanilla flavour that lead to a highly acceptable product. Different proportions of starch in goat milk led to important differences in terms of physicochemical and sensory characteristics of yoghurts, mainly in respect of total solids content, fat, sensory acceptance. The addition of 2% starch increased total solids, fat and overall acceptance of yoghurt, besides masking the goaty flavour, all relevant parameters in consumer acceptance. Yoghurts made from caprine milk, 2% starch flavored with Vanilla extract reached good sensory scores and when compared to natural goat and cow milk yoghurt and that fortified with 1% starch, received the best sensory scores among the milk mixture samples. Considering the socioeconomic importance of goat milk, product stability could be further investigated for the development of new fermented dairy products for the market.

6.2. Recommendations

6.2.2. Recommended for research

Further research is recommended on goat milk cheese product development where trials can be done for other types of cheese, and addition of flavourings for consumer acceptability. Further consumer education is required to make goat milk and its products acceptable locally. Other factors that may be of interest in continued studies include shelf stability, variation in flavors and colors, and alternative post-processing pasteurization techniques. Economic feasibility and marketing research will also need to be performed to ensure the success of the product.

6.2.1 Recommendations for policy and practice

Improving the production and marketing of dairy goats kept by smallholder farmers especially in the semi arid areas of Nyeri County has the potential to be a route out of poverty for millions of families in the region. Selective breeding is important, but farmers require extensive services on dairy goat nutrition and management feeding and general care of a dairy goat in order to improve dairy goat production. Nevertheless, this will result to increase in milk production, which calls for value addition to enable market penetration. There is need for the development of an appropriate goat technology at the learning institutions like incubation centres, where farmers can contact to acquire the necessary knowledge in dairy goat rearing. These institutions can also be involved in agricultural shows and exhibitions to educate the public.

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Appendix I: Average composition (g/kg) of basic nutrients in caprine, ovine, bovine and human milk

Composition (g/kg)	***Goat***	***Sheep***	***Cow***	***Human***
Total solids	119.4	190.0	128.9	127.4
Fat	33.5	79.0	38.5	40.0
Solids, nonfat	89.0	120.0	90.0	89.0
Lactose	45.5	49.0	47.0	69.0
Protein	33.0	62.0	33.3	12.0
Casein	25.5	42.0	27.0	4.0
Albumin, globulin	7.5	10.0	6.5	7.0
Nonprotein N	4.0	8.0	2.0	5.0
Ash	8.0	9.0	7.3	3.0
Calories ([a]kcal/100 mL)	70	105	69	68
Cholesterol	0.10	n/a	0.13	n/a

Source: Vedran *et al.*, 2010

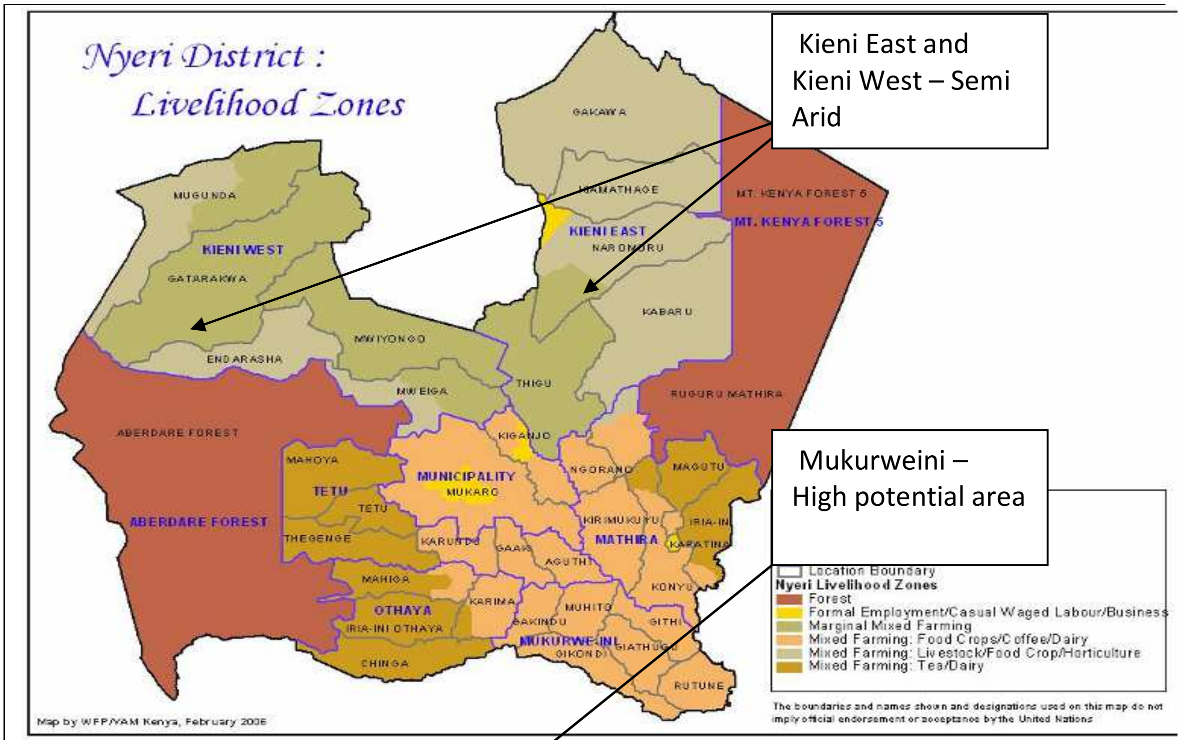
Appendix II: Gross composition (%) and pH of goat and cow fresh milk and yogurt

Sample		pH	Fat	Protein	Ash	Moisture	Total solids
Fresh milk	Goat	5.98[b]	4.30[b]	5.18[a]	0.82[a]	87.2[b]	13.2[a]
	Cow	6.31[a]	3.70[c]	3.35[d]	0.72[c]	87.3[a]	12.6[c]
Yogurt	Goat	5.71[c]	4.41[a]	5.10[b]	0.84[a]	87.3[b]	13.2[a]
	Cow	5.60[d]	3.71[c]	3.51[c]	0.75[b]	87.4[a]	12.8[b]
±SE		0.11	0.20	0.47	0.15	0.50	0.22

Values are means of three independent determination. Mean values having different superscript letters in a column for each sample are significantly different ($P<0.05$)

Source: Eissa, *et al.*, (2010).

Appendix III: Nyeri county research areas (indicated by arrows)



Appendix IV: Dairy Goat Questionnaire

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

FOOD SCIENCE AND TECHNOLOGY DEPARTMENT

(RESEARCH QUESTIONNNARE)

<u>DAIRY GOAT RECORD CARD</u>

Name of the Farmer: ______________________

Group: ______________________

Name of goat: ______________________

Type of goat rearing:

Grazing: ______________________

Full housing: ______________________

How do you use:

Goat milk: ______________________

Dairy goat meat: ______________________

Skin: ______________________

Manure: ______________________

How do you perceive goat milk? ______________________

Fat: ______________________

Odour: ______________________

Sweetness/taste: ______________________

What kind of feed do you give your goat? ______________________

____

____

Have you been selling goat milk? If so where and how much per litre? ______________________

____

____

How have you benefited from the group: ______________________

____

____

Appendix V: DGAK Dairy Goat Registration Card

DAIRY GOAT RECORD CARD

1287

SEX .... BREED Intermediate

Name of Goat Julia
Date of Birth/Kuzaliwa 14/09/08
Tattoo No. E27089
KSB: Volume .... No. ....
Litter type/Mapacha Twins
Birth weight 2½ (Kg)
Weaning weight .... (kg)

Name of Breeder Mary Mercy Wamai
Address P.O. Box 49 Naromoru
Branch Nyeri

District Nyeri Division Nyeri North Sub location Kabendera

Parents/Wazazi

Mother ♀	Father ♂
Dam name	Sire name Kirima
Tatto number	Tatto No. ....
KSB: Volume .... No.	KSB Volume .... No. ....
Breed/Aina Foundation	Breed/Aina Kenyan Alpine
Place of origin/Ilipotoka Nyeri	Place of origin/Ilipotoka Kenya
Grand Sire	Grand Sire ....
Volume .... No.	Volume .... No. ....
Grand Dam	Grand Dam ....
Volume .... No.	Volume .... No. ....

SERVICE RECORDS

Date of Service*	Buck Tatto No.	Breed of Buck	Date of Kidding	KidsBorn No. (wt) ♀	KidsBorn No. (wt) ♂	Kids Weaned ♀	Kids Weaned ♂	Remarks
1st								
2nd 12/12/10	B10463	K.A	10/5/11	1	1	1	1	Bwo. 2.1 ww. 11.8
3rd 20/10/11	B10463	K.A	16/3/12	1	2	1	2	Bw. 2¼ ww. 11.5, 13
4th								
5th								
6th								
7th								
8th								
9th								
10th								
11th								

TRANSFER RECORDS

2nd Owner's name ....
Address ....
Date ....

3rd Owner's name ....
Address ....
Date ....

4th Owner's name ....
Address ....
Date ....

* - Indicate repeat service for date with "R"

Issued by Salome W. Gathonga Sign [signature] Date 29/11/08

Printed 2007

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Appendix VI: Cheese Products Ranking Questionnaire

Preference Test – Ranking

Name:……………………………………………… Date:……/……../……………

Tester Number:……………………………………

Please rinse your mouth before starting
You may rinse again during the test if you need to

Please taste the two samples in the order presented, from left to right
You may re-taste the samples once you have tried all of them

Rank the samples with the terms given from the most preferred to the least preferred, using the following

1. Dislike very much, 2. Dislike, 3. Neither like nor dislike, 4. Like, 5. Like very much

		389	374	Comment
1	Texture / Appearance			
2	Taste			
3	Smell			
4	Colour			
5	Aftertaste			

Appendix VII: Yoghurt Products Ranking Questionnaire

Preference Test – Ranking

Name:……………………………………………… Date:……/……../……………

Tester Number:……………………………………

Please rinse your mouth before starting
You may rinse again during the test if you need to

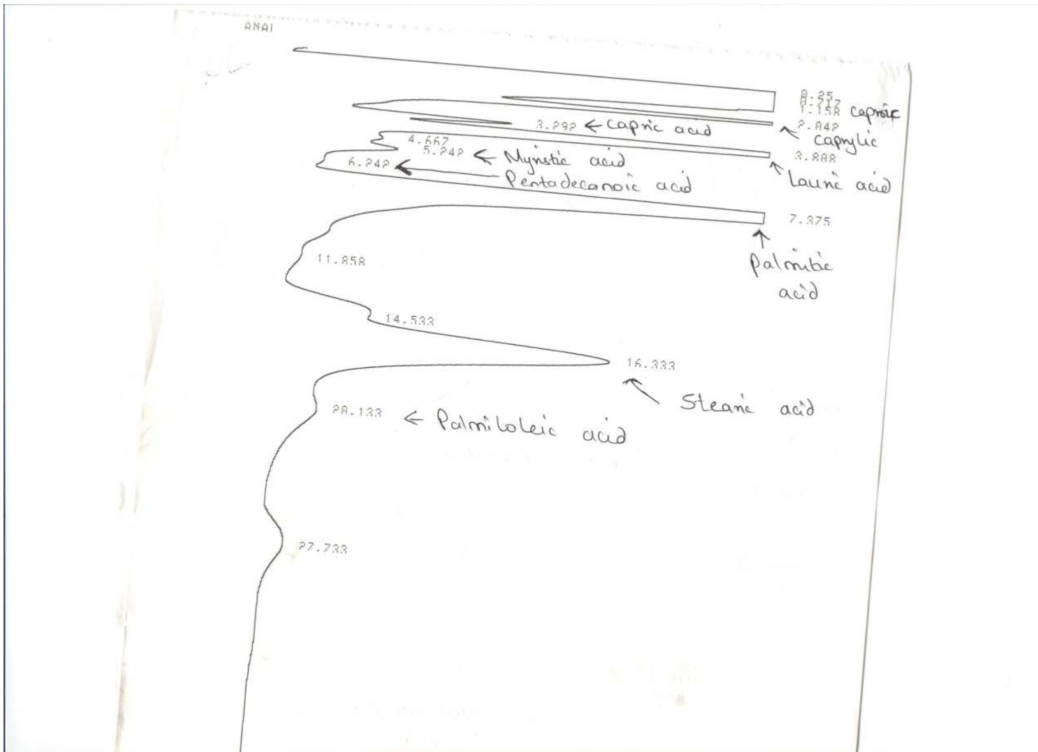
Please taste the six samples in the order presented, from left to right
You may re-taste the samples once you have tried all of them

Rank the samples with the terms given from the most preferred to the least preferred, using the following

1. Dislike very much, 2. Dislike, 3. Neither like nor dislike, 4. Like, 5. Like very much

		589	387	233	694	521	428	Comment
1	Smoothness							
2	Colour							
3	Taste							
4	Smell							
5	Overall acceptability							

Appendix VIII: Dairy Goat Milk Fatty acids Profile



Appendix IX: Products for Sensory Evaluation

Dairy Goat Paneer Cheese cubes

Sensory evaluation Session