EVALUATION OF FACTORS AFFECTING KEEPING QUALITY OF RAW MILK UNDER DIFFERENT PRODUCTION SYSTEMS IN KILIMANJARO AND COAST REGIONS

BY

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ABSTRACT

A study was carried out in Kilimanjaro and Coast region to evaluate factors affecting the keeping quality of raw milk under different production systems. General milking practices were studied including milking methods; place of milking, milking time, cleanliness of milking and storage vessels, milk preservation and also the time taken before milk reaches the collection or selling point. A total of 80 producers were interviewed using a questionnaire. From Kilimanjaro and Coast region, 40 milk samples each were collected for analysis. The samples were taken to Sokoine University laboratory where the samples were analysed for chemical composition and bacteriological quality. Visual appearance and smell were performed in the field, also the keeping quality was assessed in the laboratory on samples stored at 4^0C and 20^0C and then acidity and total plate count was determined at different storage time intervals. The General Linear Model (GLM) was used in analysing the laboratory results for differences between different categories of observations and regression analysis was done to asses the relationship between thiocyanate content in milk with bacterial count. From the data obtained it was observed that all samples collected had normal organoleptic characteristics. It was also noted that 85% of milk samples collected had a normal density of between 1.026 and 1.029g/cc. Tests for acidity indicates that most of the raw milk samples collected from Kilimanjaro and Coast region had an acidity range of 0.16% lactic acid to 0.2% lactic acid. Results on bacteriological quality showed that the LSMeans for total plate counts for raw milk samples ranged from $5x10^5$ to $1.9x10^6$ cfu/ ml. The LSMeans for the thermoduric count performed, ranged from $6x10^3$ to $17.7x10^3$ cfu/ ml. Also the coliform count was found to range from $9.2x10^2$ to $5.2x10^3$ cfu/ ml respectively. Chi square test was

also performed to test if there was any significant relationship between different milking practices and bacterial count in raw milk samples, from the $\chi 2$ test performed it was observed that the practices had highly significant influence on bacterial count at 0.1% level of probability. For the compositional quality of milk it was found out that the LSMeans range for total solids from Kilimanjaro and Coast regions was 12.21±0.12 to 14.08±0.57. The LSMeans for butterfat content ranged from 3.94±0.38 to 6.32±0.63. Solids not fat content in milk samples from both regions did not differ significantly ($P>0.05$) and it ranged from 7.9±0.34 to 8.39±0.17. Lastly the crude protein content was high in milk samples from the traditional dairy cattle keepers from Coast region and low in the same production system in Kilimanjaro region. However, the cyanide content in feed samples was low as it ranged between 0.0012 to 1.7 µg CN/ kg of feed. Thiocyanate levels had an apparent bacteriostatic effect on bacterial multiplication at 4^0C and 20^0C in raw milk as samples with high thiocyanate content had lower total plate count with coefficient of determination R^2 of 0.84 and 0.83 respectively. Therefore from the study it can be concluded that bacterial count was dependent on the production system in question as it was observed that milk from the traditional cattle keepers was having the highest bacterial counts compared to milk from the large scale producers and the smallholders. High bacterial counts obtained from different production systems in Kilimanjaro and Coast regions might have been contributed by type of milk containers used, milk hygiene level and time taken to deliver milk to collection/ selling point several milking practices carried out in those production systems.

DECLARATION

I, REHEMA JOHN MAGESA, do hereby declare to the senate of Sokoine University of Agriculture that this dissertation is my original work and has not been submitted for higher degree in any other university.

Signature ..... Magesa .....

Date 9th November 2001

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DEDICATION

This work is dedicated to my beloved parents, Mr Nyatarangwa Magesa and Mrs. Zena Magesa.

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LIST OF SYMBOLS AND ABBREVIATIONS

A.L	Milk quality acceptable limit in Tanzania
AOAC	Association of Official Agricultural Chemists
BF	Butter fat
cc	cubic centimeter
cfu	colony forming units
CO_2	Carbon dioxide
cm	Centimeter
CP	crude protein
CSC	Cotton seed cake
DM	Dry matter
^0C	Degree centigrade
^0F	Degree fahrenheit
α	Alpha
β	Betta
FAO	Food and Agriculture Organisation
g	gramme
HNO_5	Nitric acid
HOSCN	Hypothiocyanous acid
Hrs	Hours
ICMSF	International Commission on Microbiological Specification for Foods
IDF	International Dairy Federation
ILRI	International Livestock Research Institute

KIA	Kilimanjaro International Airport
Km	Kilometre
L.A	Lactic acid
LSM	Least Square Means
LSC	Large scale commercial dairy producers
LP	Lactoperoxidase
LPS	Lactoperoxidase system
m	metre
M	molar
M.C	Moisture content
MDB	Marketing Development Bureau
ml	Millilitre
mg	Milligramme
MALD	Ministry of Agriculture and Livestock Development
MOAC	Ministry of Agriculture and Cooperatives
n	number of dairy producers
NaOH	Sodium Hydroxide
nm	nmoles
NORAD	Norwegian Agency for Development Cooperation
OSCN	Hypothiocyanous acid
P	Probability
pH	Hydrogen ion concentration
ppm	Parts per million
%	Percentage

rpm	revolution per minute
SAS	Statistical analysis system
SCN-	Thiocyanate ion
s.e	Standard error
SHC	Small holder commercial dairy producer
SNF	Solids not fat
Spp	Species
SUA	Sokoine University of Agriculture
SSC	Sunflower Seed Cake
TBS	Tanzania Bureau of Standards
TCA	Trichloroacetic acid
TRA	Traditional cattle keepers
TSHZ	Tanzania Shorthorn Zebu
TS	Total solids

CHAPTER ONE

1.0 INTRODUCTION

Milk production in Tanzania is dominated by the traditional cattle keepers, the smallholder dairy cattle holders and a few large scale commercial producers. Over the years, the dairy sub sector has been facing a lot of problems, leading to low growth rate in domestic dairy production (MALD, 1990).

Among the problems affecting milk production from different production systems is quality deterioration of milk. Milk quality can be considered in terms of keeping time without spoilage and composition of the desirable constituents (Loth, 1998). Therefore milk keeping quality can be considered as a function of bacteriological metabolism and catalytic reaction due to the presence of certain metals (IDF, 1961). Milk keeping quality is influenced by milking hygiene, cleanliness of milking equipment and other environmental factors such as feeding, weather and place where the cows live.

Milk quality deterioration is more serious where milk is not cooled down immediately after milking and the poor, unhygienic handling from milking to marketing of milk. In West Africa alone (being a sub region with the least adequate system for milk collection) the World bank estimates that 5 million litres of milk per year are thrown away because of lack of appropriate milk preserving method and hence quality deterioration (FAO, 1999). Also it has been reported that more than 10 percent of milk produced in India is lost due to spoilage (Hibbs and Walter, 1995).

It has been reported by many workers (FAO, 1972; Nell, 1990; Kurwijila, 1990; FAO, 1993) that most of tropical environment has high ambient temperatures and hence result in spoilage of milk within a very short time. In these regions, there is high risk of spoilage of milk if hygienic standards of production and handling are poor (Van den berg, 1988). This is the case with indigenous products at farm level or by small scale producers. The deterioration of composition and the organoleptic properties of milk produced in the tropics reflect the situation.

Under tropical conditions of temperatures around 30^0C, cooling of milk is the best method that could be applied. Cooling of milk slows down the rate of changes caused by bacteria and enzymes. Also cooling milk can be used to protect the keeping quality of raw milk during storage and transportation. Unfortunately, cooling facilities are expensive to operate and as noted by IDF (1961), cooling of milk at farm cannot serve as a substitute for general hygiene during production or cleaning of milking equipments.

The natural antibacterial system in milk enhances the bacteriostatic properties of milk and hence milk lasts for one to three hours without spoilage depending on temperature of storage (Björk, 1978). The quality of milk therefore, can be prolonged by the natural antibacterial systems found in milk (lactoperoxidase system), which inhibits the growth of bacteria within the first three hours after milking.

In view of quality deterioration problem there is a need to emphasize on appropriate

milk quality control measures. This will start from establishing the important factors leading to milk qquality deterioration, through the identification of causes of milk deterioration. Also there is a need to study factors affecting the levels of thiocyanate levels in milk and establishing the influence of thiocyanate levels on the potential keeping quality of milk in warm developing countries.

1.1 OBJECTIVE

The study aimed at evaluating the factors affecting the keeping quality of raw milk under different production systems in Kilimanjaro and Coast region.

1.1.1 General objective

To evaluate factors influencing the keeping quality of milk from different production systems (traditional, small scale and large scale producers) in Tanzania.

1.1.2 Specific objectives

i) To evaluate the types, sources and the extent of bacteriological contamination of milk under different production systems.

ii) To determine the effect of different feeds on the levels of the principle factor of natural antibacterial systems in milk and associated potential keeping quality of milk under specific storage and handling conditions.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Keeping quality of milk

Keeping quality of raw milk can be assessed by the length of time milk will keep at a specific temperature before it becomes sour and unusable. As the keeping quality of milk depends mainly on the number and type of bacteria, which it contains, the storage life of milk can be obtained by estimating the number of bacteria in milk (Castle and Watkins, 1984).

Milk keeping quality from bacteriology point of view implies the current and rate of growth of germs in milk as well as the products resulting from bacterial metabolism. In other words, it is the time interval needed until a certain limit of bacterial count in milk is reached or until milk shows the products resulting from a decrease of heating or processing properties or defects in taste and flavour (IDF, 1961).

In chemical terms it refers to time interval elapsing before catalytic reactions due to the presence of certain metals (e.g. copper) can be detected, or until exposure to light results in fat oxidation or alteration of proteins or vitamins (IDF, 1961). Generally the shelf life of raw milk is taken to have expired when the milk becomes susceptible to coagulation under the clot on boiling test, whereby milk has pH of 5.8 or lower (0.24% L.A). Without refrigeration milk will become positive on clot on boiling test within 12 to 24 hours depending on bacterial load and ambient temperature (Lampert, 1975).

2.2 Microorganisms in milk

Microorganisms are important in the dairy industry, either because their metabolism produces products that are undesirable and cause spoilage or because their metabolism result in ripening or maturing process, which are required in the production of various types of milk and dairy products (Van den Berg, 1988). At secretion, milk is sterile in the udder but bacteria contaminate it even before it leaves the udder. Except in the case of mastitis, the bacteria at this point are harmless and few in number. Further infection of milk by microorganisms can take place during milking, handling, storage and other pre processing activities (IDF, 1988).

Healthy cows, *i. e* cows free of udder infection can produce high quality milk. Cows with elevated somatic cell counts or mastitis are incapable of producing high quality milk until the inflammation and infection in the udder are brought under control (Bodman, 1983).

There are two main known groups of bacteria in the dairy industry, the lactic acid bacteria and the coliforms. The lactic acid bacteria generally overgrow the other bacteria quickly and they are able to ferment lactose to lactic acid causing milk to curdle easily. They are normally present in milk and are also used as starter cultures in the production of cultured dairy products such as yoghurt. Lactic acid bacteria include *Lactococci* and *Lactobacilli* (Van den Berg, 1988).

The other group, the coliforms comprises all aerobic and facultative anaerobic, gram-negative nonspore forming rods capable of fermenting lactose with the production of acid and gas at 32°C within 48 hours (FAO, 1999). The coliforms are closely associated with the presence of pathogens but not necessarily pathogenic themselves. The general source of these organisms is the intestinal tract of warm blooded animals and it is also proved that bacteria of faecal and non faecal origin are members of this groups. The genera *Escherichia* and *Enterobacter* form the coliform group of bacteria (Mahanta, 1985). The coliforms do not cause disease to man but their presence in milk is undesirable because of their relationship to other organisms of intestinal origin. Coliform bacteria count is used as an index of the level of sanitation or water quality employed in the handling and processing of milk and milk products (Karen, 1996). However, it has been suggested that for high quality milk, the number of coliforms should be less than 100/ml (Bodman, 1983).

Table 2.1: Various sources of infection in raw milk indicating bacterial count/ Millilitre of raw milk

Source of infection	Bacterial count/ millilitre of milk
Udder infection	300 to 6000
Contamination during milking	500 to 15000
Mastitis	< 25000
Milking equipment	< 50000

Source: Worstoff *et al.*, 1980

2.3 Source of microorganisms in raw milk

2.3.1 The cow

The body of the cow may be a good source of bacterial contamination in milk, *i.e.* skin surface of the teats, udders and udder hair, particles of loose hair, manure and bedding materials may drop into milk together with microorganisms (Atherton and Newlander, 1977). Harmless *micrococci* are the ones commonly found in aseptically drawn milk but *Streptococci* also occur very often. The number of bacteria present in milk drawn aseptically from the udder has been estimated to be 300 to 6000 bacteria per ml (Worstoff *et al.*, 1980). Fore milk usually contains a larger proportion than the last. Thus it is recommended that the body and surrounding of the cow should be kept clean as clean cows reduce milking time, labour, udder infection and bacterial contamination (Bodman, 1983).

2.3.1.1: Effect of udder washing on milk bacterial quality

Dirty udders and teat contaminate milk during milking. Joergensen (1980) reported that total colony counts of raw milk obtained from first calf heifers with very dirty udders, which were wiped off with dry towels but not washed, ranged from 10,000 to 100,000/ml. Use of boiled towels and fresh water lowered the colony counts to 400 colonies per ml of raw milk, while boiled towel combined with the use of hypochlorite solution lowered the colony counts to 200 colony forming units/ ml of milk.

2.3.2 Mastitis

Mastitis is an inflammation of the udder, which might be caused by any injury to the udder, the use of high vacuum with milking machines, or leaving the machine on after the flow of milk has stopped (Van den Berg, 1988). Vasavada and Cousin (1993) defined mastitis as an inflammation of the mammary gland regardless of the cause.

It has been reported that due to mastitis, a large number of body cells appear in milk during the early stages of mastitis and milk becomes alkaline with pH above 6.8. Mastitis leads to the development of millions of infectious organisms per millilitre of milk. Also mastitis lowers the following compounds in milk, lactalbumin, potassium, fat concentration, SNF, lactose, casein, β-lactoglobulin, α-lactalbumin and those of blood serum albumin, immunoglobulin, and chloride are increased (Kinabo and Assey, 1983; Vasavada and Cousin, 1993; and Nangwala, 1996). The common microorganism causing mastitis is *Streptococcus agalactiae, S.pyogenes* and *Staphylococcus aureus* (Lampert, 1975).

From the studies done in Tanzania farms, it has been reported that mastitis is associated with a number of losses in milk production and this loss is caused by both clinical and sub clinical mastitis. Sub clinical mastitis has been shown to account for 70% reduction in milk production (Timms and Schultz, 1984). Infected herds have been shown to produce 30% less milk than the ones that are not infected. In large scale farms it has been reported that the average annual incidence of clinical and sub clinical mastitis range between 2.2-2.8% and 40 - 71.6% respectively (Kinabo and Assey, 1983; Said, 1987; Mshana, 1989) while the level of mastitis in Norway was found to be 31% (Vasavada and

Cousin, 1993). Also it has been reported that mastitis influences raw milk keeping quality as in clinical cases of mastitis, milk being removed from the infected quarter will be heavily contaminated with pathogenic bacteria and will have changed in appearance, taste and its quality (Joergensen 1980).

2.3.3 Personnel hygiene

All people involved in dairying should keep themselves clean and in sound health. Organisms may drop from hands, clothing, nose, mouth and from sneezing and coughing. Milkmen as a possible source of pathogenic bacterial should be free from infectious diseases such as tuberculosis (Kurwijila, 1988).

2.3.4 Milking equipments

Filtering milk does not reduce any significant number of bacteria since bacteria are very small and hence they pass freely through the filter mesh of the strainer (Artherton and Newlander, 1977). Other milk handling and storage equipment must be properly cleaned and sanitised after each milking so that milk with low bacterial count can be produced (Artherton and Newlander, 1977). It is recommended that equipment surfaces should preferably be of seamless, stainless steel fabrication to reduce to the minimum, the effect of undesirable flavour and bacteriological quality of milk.

2.3.5 Air and dust

Bacterial concentration varies with seasons of the year, lower in cooler and rainy months. Comparatively, yeast and mould spores are found in higher concentrations

in rainy seasons compared to acid forming bacteria (Lampert, 1975). Feeding in milking barns by dusty hay or maize stover just before milking may increase milk bacterial count should the dust fall into milk (Björk, 1978).

Palmer (1980) also suggested that the presence of pathogenic organisms particularly *Staphylococcus aureus* in the air could serve as an indicator of the presence of microorganisms in the evaluation of cowshed hygiene. Hence, proper citing of the milking premises so as to avoid aerial contamination from farm wastes or animals is important.

2.3.6 Water

Palmer (1980) stated that from water supplies, unless properly protected, may be contaminated at source with a wide variety of microorganisms including coliforms, *Psychrotrophics*, *Pseudomonas* and indeed human pathogens. Palmer (1980), also stated that, it is unlikely that contaminated water is a major source of bacterial contamination in milk unless such water is added directly to milk. However, lactose fermenting and milk souring organism have been isolated from farm water supplies. The use of such water supplies for udder washing and for rinsing of cleaned equipment can cause contamination of milk.

2.3.7 Temperature

Temperature influences the growth of microorganisms in milk. Most of the microorganisms prefer temperature between 20^0C and 36.7^0C. Many of the pathogenic organisms are mesophiles and are the ones thriving at temperatures

below 20^0C. Species of *Pseudomonads, Achromobacter, Flavobacterium*, and *Alcaligens* are among *Psychrotrophic* bacteria, which may cause flavour defects and odours. The thermophilic organisms withstand heat and like warm surroundings but are able to reproduce at the temperature of 63^0C, hence low temperatures slow down their growth and lower the rate of reproduction. It has been reported that at 26.7^0C the number of organisms in a sample of milk doubled in about one and a half hours, at 15.6^0C, more than four hours are needed to double the number originally present; at 10^0C about eight hours are required and if milk was held at 4.4^0C about 39 hours are required (IDF, 1961).

Souring of milk results from lactic acid bacteria activity on milk, they grow rapidly at temperatures exceeding 15^0C with an optimum temperature of 30^0C or above. Growth is very much reduced at temperatures below 10^0C, therefore cooling of milk immediately after production is very important in order to prolong the milk shelf life (IDF, 1961).

Table 2.2: Effect of the temperature at which milk is held on bacterial growth and keeping quality of raw milk

Milk temperature (^{0}C)	Plate count per ml after 24 hours
5	3.1×10^3
10	1.2×10^4
15	1.8×10^5
20	4.5×10^5
30	1.4×10^9

Source: Van den Berg, 1988.

2.3.8 Abnormalities in raw milk as a factor of quality deterioration

The factors affecting keeping quality of raw milk lead to undesirable flavours in milk and lactic acid prodduction hence tend to shorten the shelf life of milk. The degradation of milk fat, proteins and acid from lactose comprise the most undesirable bacterial change in raw milk, which interfere with processing. Raw milk suffers from variety of flavours including malt flavour, rancid flavour, ropiness, broken or bitty flavour, soapiness and also sometimes blood in milk (Joergensen, 1980).

2.3.8.1 Malty or fruity flavour

These flavours are very common and are usually bacterial in origin, the main causative organism being *Streptococcus lactis.* Fruity flavour may also occur due to the action of *Pseudomonas fragi,* and *Achromobacter butyri* (Joergensen, 1980).

2.3.8.2 Rancid flavours

Rancid flavours might be due to bacterial action, *Pseudomonas* group and *Oidium lactis* being able to release lipases, which break down milk fats, various acids are then liberated and a strong pungent odour and rancid taste are noticeable (Joergensen, 1980).

2.3.8.3 Ropiness

Ropiness is a defect found in raw milk due to impure water supply or improperly cleansed utensils and equipments. The principal organism causing ropiness in milk is *Escherichia* group and some forms of *Staphylococci* (Joergensen, 1980).

2.3.8.4 Soapiness in raw milk

Soapiness in raw milk is due to *Lactis saponacis*, which originates in feeding stuffs or straw. If shaken soapy milk gives fine vesicular tenacious foam. Foaming or frothiness may also be due to agitation during transport or to the action of *Bacillus aerogenes*, this defect being very noticeable in tropical areas (Joergensen, 1980).

2.3.8.5 Blood in milk

Blood in milk occurs on many occasions due to the rupture of blood vessels. This may be either due to injuries to the udder or teats or to over milking when the milking machine units are left attached to the udder for too long or when excessive vacuum is employed (Van den Berg, 1988).

2.3.9 Influence of breed on milk composition

Breed and strain have very important effects on composition of milk. It has been reported that even with the same species, breeds differ in the composition of their milk. The main difference is in the content of fat, and that of solids not fat which tend to vary in the same direction, but not to the same extent (Henderson, 1971). Vanstone and Dougall (1960) reported that breeds producing large amounts of milk such as Friesian secrete milk of lower fat content. Therefore Jersey and Guernsey breeds are the richest in fat, while Friesian has the lowest fat content.

Table 2.3: Influence of breed on milk composition quality

Breed	%Fat	%SNF	%CP
Zebu	5.6	8.8	3.9
Jersey	5.1	9.8	3.8
Guernsey	4.9	9.01	3.8
Ayshire	3.82	8.78	3.8
Shorthorn	3.6	8.79	3.4
Friesian	3.4	8.86	3.4

Source: O'Connor, 1995

2.3.10 Influence of grazing on milk bacteriological quality

Hansen (1973) observed that during grazing the udder was generally dryer and cleaner compared to the period when the cows were housed, thus promoting low bacterial count of the farm milk from the udder surface. However, this was not reflected by the bacterial count of the farm milk because milking equipment often constituted the main source of bacterial contamination (Joergensen, 1980). Also the author stated that the feeding environmental changes of the cows equally influenced a qualitative change of flora as the udder surface (Joergensen, 1980). Bulk milk also contained five to ten times as many anaerobic spores per ml in the housing period when silage was fed than in the grazing period, even when udder of cows were washed in hypochlorite solution prior to milking.

2.3.11 Influence of milking systems on bacteriological quality of milk

The bacteriological quality of raw milk can further be affected by the milking system used. There are two commonly used methods in milking; these are machine milking and hand milking. Machine milking method has been found to

have influence on the bacteriological quality of milk in the tropics and the World at large.

From the study done in Tanzania by Mosha *et al.* (1992) in different farms in Morogoro and Coastal region it was evident that on the same farms hand milked milk was of better bacteriological quality than milk harvested by machine. On thermoduric count it was reported that the counts were much higher in machine milked milk than in milk harvested by hand.

From another study done in France and Africa to compare the bacteriological quality of milk produced under relatively simple conditions of hand milking and that of machine milking in France have higher bacteriological contamination than hand milked milk in tropics (IDF, 1968).

2.4 Methods of improving keeping quality of raw milk

2.4.1 Cooling and refrigeration

Cooling of milk immediately after milking is an effective method of arresting bacterial growth and thus milk spoilage. Fresh milk from the udder (32^0C) should be cooled to lower temperature possible depending to the availability of the cooling medium, this can be achieved through the use of cold water, placing milk vessel in a cool air stream, use of ice and refrigerator (IDF, 1990).

Under the condition of low ambient temperature (e.g. at high altitudes in tropics and sub tropics) milk of good hygienic quality may be kept in shade and without

refrigeration for periods of 12 hours and longer without noticeable organoleptic changes (Van den Berg, 1988). But the higher the ambient temperature the quicker milk will spoil.

Under tropical condition where milk may have a temperature around 30^0C and higher, the increase in bacterial counts is disastrous. At 10^0C the increase in bacterial count is four times as fast as at 5^0C. Under condition of poor hygiene, total plate count of $5x10^5$ units are no exception and with plate count that are four times as high as $2x10^6$ biological changes of fat, protein and sugar becomes noticeable, this is why hygienic milk production and rapid cooling of milk are necessary (Van den Berg, 1988).

2.4.2 Pasteurisation

Pasteurisation is a process of heating a liquid, particularly milk, to a temperature between 63^0C and 74^0C to destroy harmful bacteria without materially changing the composition, flavour, or nutritive value of milk. This method also arrests bacterial growth in milk and if done properly it will reduce the growth of most bacteria. If temperature will be raised enough (up to sterilization temperatures) it will destroy a large proportion of the microorganisms and produce a commercially sterile product (IDF, 1990).

2.4.3 Time factor

Timing of cooling is useful only if it is done immediately, after milking before multiplication of bacteria or during the lag phase. Milk must be cooled

immediately. The quicker milk is cooled to 4^0C the better the quality. Under this condition milk can be held up to 72 hours without bacterial degradation (IDF, 1990).

2.5 The natural antibacterial system in milk

Milk contains several antibacterial factors. The antibacterial system used includes the Lactoperoxidase/ thiocyanate/ hydrogen peroxide system. The antibacterial activity of the LP system in milk depends on the bacterial species or strain and thus the antibacterium effect can be bactericidal or bacteriostatic. These antibacterial compounds interfere with the metabolism of bacteria, such as *Streptococci* and Lactobacilli and it results in temporary inhibition of *Escherichia coli*, *Salmonella* and *Pseudomonads spp*, it leads to an irreversible inhibition, i.e. killing of bacteria, and thus the bacteriostatic properties of the milk, which will last for one to two hours without spoilage (Björk, 1978). The bacteria in milk undergo the lag phase, which takes 3 to 6 hours depending on the storage temperature. The lag phase is also known as the germicidal period (Atherton and Newlander, 1977). During this period there is a decrease in number of bacteria due to the natural antibacterial system as it is active between one and two hours after milking. The germicidal period is influenced by temperature and hence the natural bacterial system is destroyed at temperatures above 62^0C.

2.5.1 The lactoperoxidase system

Lactoperoxidase is the most abundant enzyme in cows' milk. Lactoperoxidase enzyme is heat stable and can be retained in normal pasteurisation of milk at 63^0C

for 30 minutes or 72^0C for 15 seconds, but it is destroyed at 80^0C in 2.5 seconds (Korhonen *et al.*, 1977). LP is found in all cows milk but its content varies over a wide range from almost nil up to 50 mg/ litre. Breed, age, and lactation stage of the cow, nutrition and health condition affect the concentration of lactoperoxidase (Korhonen, 1980). Lactoperoxidase on its own has however, no antibacterial effect. It is made active only after the presence of hydrogen peroxide and thiocyanate in milk. This is created by the oxidation of thiocyanate by hydrogen peroxide and the reaction is catalysed by lactoperoxidase to form the antibacterial compounds (Korhonen, 1980).

Thiocyanate in milk is derived from blood in which its concentration is about 10 times higher than in milk. The thiocyanate content is highly dependent on feeding regime of the cow as many plants contain thiocyanate precursors. These can be converted into SCN^- by different biochemical transformation such as the detoxification of cyanide, which is present in clover, and enzymatic hydrolysis of glucosides, which are present in *Brassica* and *Raphenus* species (IDF, 1988). In recent years there have been attempts to raise the level of SCN^- in cow's milk through feeding of feeds containing high levels of cyanide e.g rapeseed cake,

2.5.2 Antibacterial spectrum of the Lactoperoxidase system

The activity of lactoperoxidase has been established against a wide range of bacteria. The antibacterial effect of the lactoperoxidase is mediated by the reaction of hydrogen peroxide and thiocyanate under lactoperoxidase catalysis and the resultant generation of short-lived hypothiocyanate (Karen *et al.*, 1996)

The antibacterial property of the lactoperoxidase system is based upon inhibition of vital bacterial metabolic enzymes brought on by their oxidation by hypothiocyanate (Karen *et al.*, 1996). Lactoperoxidase oxidises thiocyanate ion in the presence of hydrogen peroxide and then by this reaction thiocyanate is converted to hypothiocyanous acid (HOSCN). At this stage the pH of milk is dissociated and HOSCN exists in the hypothiocyanate ions ($OSCN^-$). This agent reacts specifically with free sulphydrl groups thereby inactivating several vital metabolic bacterial enzymes, consequently blocking their metabolism and ability to multiply (IDF, 1988).

Lactoperoxidase system is considered to be non specific in antibacterial activity but considerable differences in sensitivity are found between different bacteria e.g. gram negative are more sensitive than gram positive, whereas gram positive are temporarily inhibited. Most *Lactobacilli* and *Streptococci* are only temporarily inhibited and not killed by the LP system. Among *Streptococci species* only *Streptococcus pyogenes* is known to be killed by LP system (Korhonen, 1980). It has also been found that the LP system is strongly bactericidal for *Pseudomonas species* and other *Psychotropic* bacteria as these organisms are known to cause spoilage when they grow in refrigerated milk (Björk, 1978).

Furthermore, Reiter (1981) showed that *Pseudomonas fluorescens* growth could be slowed by about 200 hours at 4^0C and 20 hours at 30^0C by the activation of the lactoperoxidase system in refrigerated raw milk. Martinez *et al.* (1988) showed that when the lactoperoxidase system was activated every 48 hours in both raw and

pasteurised milk by maintaining concentration of thiocyanate and hydrogen peroxide, shelf life were extended at 4, 8 and 16^{0}C by three to six days.

2.6 Influence of different production systems on milk keeping quality

In Tanzania milk producers are divided into four categories, the parastatal farms, government institutions, commercial dairy farmers (smallholders and large scale) and traditional sector (MALD, 1988). According to Kurwijila and Kifaro (1998) it was estimated that the total numbers of dairy cattle in Tanzania were about 300,000.

FAO (1972) reported that in any milk production system it is a commercial necessity for the milk to reach the plant or consumer in a condition suitable for processing or consumption. Kurwijila (1990) reported that good milking practices are essential for obtaining optimum amount of milk from the lactating cow, maintaining the health of the cow, and utilising labour and equipment efficiently and for production of milk of high quality.

Milk production from different production systems depends on the type of production system in question and the respective milking practices and hygienic conditions imposed during milk production (Loth, 1998).

The milking practices imposed include the milking technique, type and cleanliness of milking, the hygienic conditions imposed during milking and handling, the source and condition of water used to wash hands, udder, vessels, the cleanliness of milkers and their health status; cleanliness and health status of cows udder, the place

and the cleanliness of milking places. Types of feed used during milking and the appropriate preventive methods applied once the milking exercise is over are to be considered (Kurwijila, 1990).

2.6.1 Milk production systems in Tanzania

2.6.1.1 Traditional cattle keepers

The traditional sector is the major sector for the dairy industry in Tanzania. It provides 340 to 368 million litres per annum which accounts between 80% and 90% of total milk produced in the country (Mdoe *et al.*, 1994). It has been stated that in this sector milk production is just a secondary reason for keeping livestock (MALD, 1988). Though this sector contributes much to the dairy sector, it can not be relied upon to satisfy the country's increasing demand because the Tanzanian Shorthorn Zebu mostly kept by the traditional cattle keepers are genetically very poor producers of milk and the husbandry of the animals particularly on feeding is still very poor (Mtumwa and Mwasha, 1995).

2.6.1.2 Smallholder cattle keepers

This is a system in which a farmer or a milk producing farmer keeps small number of cows near the farm or the farmer uses the cut and carry grass and crop by products and the animal is milked for family use or local sale (Matthewman, 1993). Farmers in this sector own between 1 to 25 dairy cows (Massae, 1993) and these types of farmers are found on the periphery of urban centres or on areas having high altitude (Mtumwa and Mwasha, 1995). The small scale cattle keepers are divided into four groups, which are small scale semi intensive dairy meat draught - manure, smallscale

extensive dairy -meat- draught manure, small scale intensive urban dairy and small scale intensive and semi intensive dairy manure (MOAC /SUA /ILRI, 1998)

a) Small scale intensive urban dairy cattle production system

This type of production system is practised in Dar es Salaam, Tanga, Iringa, Mbeya and Arusha. This system is characterised by high input cost particularly for purchased forage and high milk prices due to high and stable demand (MOAC / SUA / ILRI, 1998).

b) Small scale intensive rural and semi intensive dairy manure cattle production system

This production system dominates over 70% of dairy cattle in Tanzania. The regions where the intensive production system is practised are Arusha, Kilimanjaro, Kagera and southern highlands. The farmers in this production system practice cut and carry or zero grazing system using crop by-products and forage. About 70% of farmers from this production system practice zero grazing while the rest 30% practice a semi intensive production system with semi zero or free grazing especially in the areas with larger farms in lowlands and low population density areas of southern highlands (MOAC/ SUA/ ILRI, 1998).

c) Small scale semi dairy meat draught manure cattle production system

Farmers in this production system practise small scale semi intensive production with predominantly Zebu herds and a few crosses in the same agro climate as intensive producers. Farmers practising this system own up to 30 cattle, which are mostly

grazed. They comprise about 1,000,000 households. The objective of these farmers is not only producing milk but also frequently sell surplus animals for draught and meat (MOAC/ SUA/ ILRI, 1998).

2.6.1.3 Large-scale system of milk production

a) Large scale dairy cattle production system

The numbers of herds in large scale producing system varies with the place where the dairy industry is practised. In Tanzania a large-scale producer is the one having about 100 cows or above though any farm with 20 cows is classified as large scale (MOAC/SUA/IRLI, 1998). From survey done by Kurwijila *et al.* (1996) it has been observed that the total population of cattle in this production system to be approximately 10,000 heads. Milk production from the large scale dairy farms seem not to be a viable method of increasing milk to satisfy the even expanding demand but their existence is still important as they save as the basis for nucleus herd of exotic breeds which shall definitely be required for the expansion of the overall dairy sector (Mtumwa and Mwasha, 1995). The most popular dairy herds are Friesian, Ayrshire, Jersey, Guernsey, Sahiwal and their crossbreeds (MDB, 1989).

b) Large scale extensive dairy meat -cattle production system

Pastoralism and agro pastoralism dominate this system in Tanzania keeping Tanzania short horn Zebu in areas with low rainfall. This system is found in the northern and central regions of Arusha, Shinyanga, Mwanza and Singida. The

number of cattle in pastorals herds is also skewed with a minority of pastorals owning herd sizes of over 150 heads (MOAC /SUA /ILRI, 1998)

Table 2.4: Cattle numbers by production system in Tanzania

Production system	Genotype	Cattle population		Milk offtake		Proportion contribution %
		'(000)	%	'(000)	%	
Large scale intensive parastatal dairying Large scale intensive dairying Small scale intensive with urban dairying Small scale intensive and semi intensive dairy manure	Exotic/ crosses	250	1.6	171	25	95
Improved beef	Exotic/ crosses	100	0.7	-	-	-
Small scale semi intensivedairy meat draught-manure Smallscale extensive dairy meat draught -manure Large scale extensive dairy- meat	Zebu	15300	97.7	509	75	5

Source: MOAC/ SUA/ ILRI, 1998

2.6.1.4 Dairy production systems in Kilimanjaro

In all milk sheds dairy production is influenced by seasonality in feed quality and availability. In the highlands of Mount Kilimanjaro and Mount Meru, crop residues including bananas, maize and other cereal crops are commonly fed to cattle, especially in dry season (Mruttu, 1997; Mdoe and Wiggins, 1996) to supplement nappier grass (*Pennisetum purpureum*), which is the most important planted fodder. Other planted feeds include leucaena (*Leucaena leucocephala*), Guatemala grass (*Tripsacum laxum*) and various kinds of legumes. Farmers also feed purchased grain concentrates and milling by-products such as brans, wheat pollard, cotton and sunflower seed cakes and some dairy meal. Variable amount of concentrates are usually fed to cows at milking time with many smallholders feeding a flat rate of about two kilograms per day throughout lactation (Shem, 1985). The inadequate availability of feed resources and their frequent poor quality results in low dry matter intake for the majority of smallholder dairy cattle and low milk yields and collapsing lactation curves (Donald, 1985; Laurent and Centres, 1990).

2.6.1.5 Milk production in Coast

Coast region having 40,490 indigenous dairy cattle herds and about 21,824 improved dairy cattle is a potential milk production region in the coastal area (MALD, 1996). Coast region has traditional dairy, smallscale and large scale commercial producers. The traditional dairy cattle keepers have Zebu cattle for mixed dairy, and beef enterprises. Zebu is the main cow kept and accounts for over half of all milk production. In the traditional production system cash inputs are minimal, breeding is done with bulls rather than artificial insemination. The animals

in this production system are fed with forage and water.

The smallholders and large scale commercial producers keep either a mixture of Zebu and improved herds or improved dairy herd only. In this sector the calving interval are shorter, milk production much higher, marketed sales of milk and the use of variable cash input much more important. The animals are stall fed and farmers from these systems rely on artificial insemination for breeding purposes and have much higher investment in housing as well as cattle (Mmari, 2000).

Table 2.5: The nutritive values of feeds from Kilimanjaro region (1989)

Feed	CP% of DM	48 hour degradability
Local grasses	9.1	61.0
Banana leaves	12.7	45.6
Banana pseudostem	3.9	75.3
Maize stover	2.5	54.2
Bean straw	5.8	54.8
Elephant grass	11.4	69.7
Guatemala grass	9.4	67.6
Desmodium sp	17.6	70.2
Leucaena leaves	23.0	69.3

Source: Massae E.E (1993)

2.6.1.6 Effect of feeding system and type of feeds on performance of dairy cattle in Tanzania

From the study done by Mulangila (1997), it has been observed that different feeds and feeding system were major sources of variations in performance of dairy cattle. Also from a study carried out by Sarwatt and Njau (1990), it was revealed that the feeding system which were practised in Morogoro region included zero grazing

partial grazing and grazing, partially grazed cows out yielded zero and full grazed cows by 1.2 and 3.2kg/day.

From the study done by Scheinman *et al.* (1992) on the performance of dairy cattle in Lushoto district, about 88% of respondents who zero grazed and supplemented their cattle with concentrates, produced 2 - 3 litres per cow per day higher than unsupplemented cows (8 - 10 vs. 6 - 7) litres per cow per day. Swai *et al.* (1993) observed a big difference in milk yield between cows attributed to diverse feeds and feeding techniques by farmers. The diversity of feeds ranged from forages (harvested natural pastures, nappier grass, Guetamala grass, legumes and crop residues) to mineral and home made concentrates. From the study done by Mchau (1991) it was shown that intensive and semi intensive feeding system was practised with an element of preferential feeding of concentrates to exotic cows than crossbreds. Thus the improved fodder, concentrates and minerals were made available to *Bos Taurus* cows than crossbreeds. The corresponding milk yields were 7.3±0.1 and 6.1±0.1 litres per cow per day respectively.

2.7 Milk handling at the producer's level

2.7.1 Multiplication of bacteria during farm storage

The decrease in number of bacteria is due to lactenin, which is present in milk. Lactenin kills some of the microorganisms while other organisms die because, milk medium does not suit their development (Atherton and Newlander, 1977). The germicidal period is influenced by temperature such that it becomes longer at lower temperatures but gets destroyed at 62^0 to 72^0C.

2.7.1.1 Effect of time

The multiplication of bacteria in raw milk is particularly dependent on the time of storage. Different workers had shown a critical time, which lies between 60 to 70 hours (Gehriger, 1980). The temperature of storage was between 20 and 4^0C. The experiments carried out to prolong the storage period of raw milk in farm tanks, showed that it is possible to store milk at temperatures of 1.5^0 to 4^0C for 96 hours when the initial quality of milk is good.

2.7.1.2 Effect of temperature

The storage temperature has a decisive influence of growth of microorganisms in raw milk (Gehriger, 1980). Acid producers, which may multiply rapidly at temperatures above 15^0C, are usually the cause of sour milk and they also increase with time of keeping. Gehriger, (1980), established the relationship between temperature and growth rate of bacteria, they found out that growth rate of bacteria is decreased with decreased storage temperature i.e. there is little increase in total bacteria count at 4.1^0C after 48 hours.

2.7.1.3 Effect of initial level of contamination

The initial count of fresh raw milk has a marked influence on keeping quality of raw milk (Harvey and Hill, 1967). Cooling cannot serve as substitute for proper cleaning and disinfecting of milk equipments and these indicates that milk produced under poor hygienic conditions is not satisfactory even when held at temperatures as low as 5^0C (Harvey and Hill, 1967).

Table 2.6: The effect of storage for 22 hours at different temperatures on bacterial count

Storage temperature ^{0}C	Colony count 30^0C	Keeping quality in hours	Colony count 30^0C	Keeping quality in hours
5	1900	46	41000	38
10	1720	44	48000	34
15	15100	40	110000	26
18	500000	26	2420000	18
21	700000	22	1660000	6

Source: (Gehriger, 1980)

CHAPTER THREE

3.0 MATERIALS AND METHOD

3.1 Study areas

The study was carried out in Kilimanjaro (Hai district) and in Coast (Bagamoyo and Kibaha district). Farmers studied included the traditional, small scale and large-scale producers. These areas were selected as they are potential milk producing areas and they differ in their climatic and production systems.

3.1.1 Kilimanjaro region (Hai district)

Kilimanjaro region is located on the North Eastern part of Tanzania just South of the equator having an area of 13,309 square kilometres. Kenya borders it to the North, Tanga region to the East and Arusha region to the West (Kilimanjaro Statistical Abstract, 1993). The region lies between 600m in the lowland up to 5895m at the highest peak of Mount Kilimanjaro. The annual average rainfall range from 500mm in the lowlands to 2000mm at an altitude of 1800m.

Hai district in particular lies between latitudes 02°45' and 03°31'south of the equator and longitudes 36°45' and 37°20' East of Greenwich Meridian (Mdoe and Shem, 1986). The altitude ranges from 600m to 1800m above mean sea level, which gives mild and pleasant climate (17-34^{0}C). The rainfall in Hai ranges from 500 to 1000mm per annum (Mdoe, 1985).

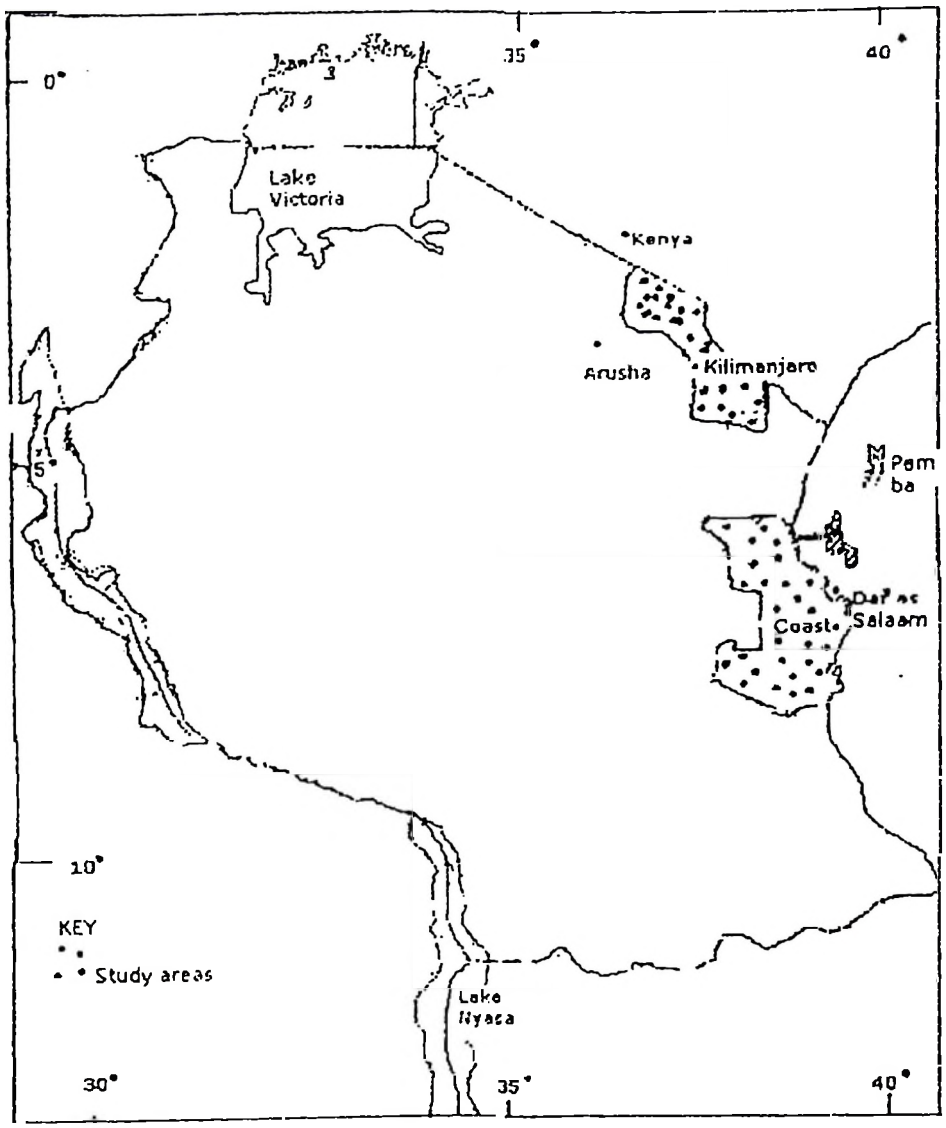

Figure 3.1: Map of Tanzania showing the study areas

Kilimanjaro region leads in Tanzania having a large number of improved dairy herds. Improved dairy herds in Kilimanjaro 113,436 totals, while the number of indigenous cattle is 309,723 (MALD, 1990). The dairy sector in Kilimanjaro region is dominated by small scale cattle keepers who practices zero grazing due to land scarcity, also there are few large scale dairy farms in this region.

3.1.2 Coast region

Coast region surrounds Dar es Salaam region in most of the parts and it covers the most of the Coastal areas. The region has five districts Kibaha, Bagamoyo, Kisarawe, Mafia and Rufiji. The region has coastal climate having an average annual rainfall of about 1000mm with two peak rainfall periods. The study was conducted in Bagamoyo and Kibaha District. Coastal region had a total of 40,490 indigenous dairy cattle.

3.1.2.1 Kibaha district

Kibaha district mainly borders Bagamoyo to the north, Kisarawe district to the south, Morogoro region to the West and Indian Ocean to the East. Most of livestock keepers reside in Kibaha town. They raise improved crossbreeds and about 50% of farmers feed their dairy cattle indoors (zero grazing).

3.1.2.2 Bagamoyo district

Bagamoyo district borders Kibaha to the south, the district is dominated by Maasai pastorals that practise traditional dairy production system. Chalinze ward has two

milk collection centres known as Enaboishu and Vigwaza milk collection centres located about 120 and 70 kilometres respectively from Dar es Salaam.

3.2 Field surveys

3.2.1 Preliminary surveys

Preliminary survey was done for two weeks, one week in Coast region and one week in Kilimanjaro region, the purpose of preliminary survey was to pre test the questionnaire and to correct the information in the questionnaire according to the findings from the field.

3.2.2 Main field survey

The survey lasted for three months and a half, two months in Kilimanjaro and one and a half month in Coast region. The aim of the survey was to identify the different dairy husbandry practices including feeds and feeding practices, milking practices and milk handling practices carried out by the different categories of milk producers.

3.3 Selection of respondents

In the study areas, the milk producer categories were divided into strata; the strata were the traditional (the Maasai pastoralists), the smallholder dairy farmers and the large-scale farmers (Snedecor and Cochran, 1989). This method was used in order to cover all the categories of producers. The samples were clearly labelled with the name of farmer or by using code numbers and records of dates and places included in standard data sheets.

3.3.1 Milk and feed sampling

Sample collection from selected farmers was done using sterilized sampling bottles with 300ml capacity. Samples collected were in duplicate from each farmer. Also feed samples were collected from farmers from the study areas the common feeds given to the animals were collected for cyanide content determination in the laboratory. The grasses collected included *Brachiaria species*, elephant grass, *Setaria species*, and Guatemala grass. Also maize bran, maize cobs and straw, were collected, furthermore banana leaves and stem, rice straw, sunflower seed cake and cotton seed cake, leucaena leaves and maize bran mixed with common salt were collected for analysis.

3.3.2 Sampling in Kilimanjaro (Hai district)

Forty farmers in Kilimanjaro region were visited whereby , 7 were traditional cattle keepers from Boma ng'ombe and KIA areas, 30 were small scale cattle keepers from Nronga, Losaa, Kalali and Foo villages. Lastly in Kilimanjaro three large scale commercial producers were visited those included Kafoi estate, Kilari farm and Sabuko farm.

3.3.3 Sampling in Coast region

A total of 40 dairy keepers were visited whereby 20 were traditional cattle keepers from Lugoba ward, 15 small scale cattle keepers from Kibaha and Chalinze, and 5 large scale dairy farmers were included in the sample *i.e* Ruvu dairy, Fresh Food farm, Khalid's farm, Mwapachu farm and Reki enterprises farm.

3.4 Sample collection and preservation

From farmers, milk samples were collected accordingly early in the morning. Two samples were sampled into two different sampling bottles of 300ml.The samples were preserved in ice-cooled boxes, while the samples for chemical analysis were preserved with Potassium dichromate (0.5 ml 4% solution in a 0.25 litre of milk). Samples from Coast region and Kilimanjaro region were taken to Sokoine University Laboratory for analysis and refrigeration.

3.5 Field quality test

In the field the following tests were done in order to test the quality of milk:

3.5.1 Organoleptic tests

The organoleptic tests were done prior the collection of milk samples from both areas. The tests comprised of smell and visual appearance. Milk samples were smelt and if it has any off flavour smell it was regarded as milk of bad quality, and for the visual test milk was judged for its appearance as milk having blood in it or having abnormal colour was graded as abnormal milk.

3.5.2 Titrable acidity

The test was done to measure the buffering power of milk plus any lactic acid produced by souring bacteria. As normal milk has an average of pH 6.6 and as it is recommended that this test be done at the farmers level, and the following procedures were followed:

- 20 mls of the sample were measured into a flask and diluted twice its volume by CO_2 free water.

- 2 mls of phenolphthalein was added and titrated with 0.1N NaOH to first persistent pink.
- Acidity was reported as % lactic acid by weight (1 ml 0.1 N NaOH = 0.009 Lactic acid)

3.5.3 Milk density

A Lactometer is an instrument that was used to detect adulteration. By the use of lactometer density of milk was determined, as lactometer test is designed to detect the change in the density of milk:

- Milk samples were mixed gently into a measuring cylinder (300 - 500 ml). Then the lactometer was allowed to sink down slowly into the milk then the last lactometer degree was taken and recorded as density and the reading was corrected by 0.2^0C as milk to be tested was having high temperature.

3.6 Laboratory quality test

In the laboratory the analysis involved the test on microbial count, thiocyanate levels in milk and the chemical composition of milk. Also the levels of cyanide in different feeds from the farmers were analysed in the Laboratory as follows:

3.6.1 Microbial counts

Total plate count, Coliform and thermoduric count were done. The exercise followed the procedure outlined in IDF standard 100:1981; FAO, 1987 and Lampert (1975).

3.6.1.1 Preparations of diluents for serial dilutions

The diluent used was peptone water, which was prepared by dissolving an equivalent weight of peptone pellets in distilled water (25g in 1 litre distilled water). Then 9 mls were pipetted in test tubes for sterilisation. Sterilisation was done in an autoclave at 121°C for 15 minutes.

3.6.1.2 Total plate count

The whole procedure was done aseptically as possible. The autoclaved agar was melted in a boiling water bath and then was cooled to 45^0C.

- Milk samples were shaken to ensure even distribution of bacteria then it was transferred with sterile pipette to 9 mls diluent
- One (1ml) of this was thoroughly mixed, dilution was added to 9ml of another sterile peptone water solution which gave a dilution of 1:100 and this procedure was repeated 1:1000 dilution.
- Plating was done on the petri dish and the dishes were labelled accordingly. The agar was then poured onto the petri dish quickly and mixed thoroughly with milk by gently rotating the dish.
- This was left for a few minutes in order to solidify before incubation at 32^0C for 48 hours.
- Counting of the colonies which had grown from the milk samples was carried by visual observation. After counting the number of bacteria in the respective milk sample was calculated using simple multiplication . i.e the

number of colonies was multiplied by the dilution factor used which was x 10^3.

3.6.1.3 Determination of Coliforms

The samples were mixed and dilutions of 10^{-1}, 10^{-2} and 10^{-3} as per standard method were applied. The plates were filled 10 to 15 mls with Mac Conkey agar to estimate coliform counts.

- Plates were left to solidify then they were turned upside down before being incubated at 32^0C for 24 hours and then colonies were counted (Mahanta, 1985).

3.6.1.4 Determination of Thermoduric bacteria

Thermoduric bacteria can survive exposure to temperatures considerably higher than the maximum temperatures for their growth. Their determination was done aseptically by transferring 5 ml of a thoroughly mixed milk sample to a test tube, and then the test tube was kept at 4^0C.

- A pilot tube containing a thermometer and 5 ml of milk was placed in the test tube rack with the other samples so that the temperatures should be monitored easily. Then the rack of tubes was placed in pasteurising bath at 63^0C.
- The closed, water tight tubes was then immersed completely or to approximately 4 cm above the level of milk for 30 minutes.
- Timing the 30 minutes holding period started when the temperature in tubes reached 63^0C.
- After that procedure milk was plated with standard agar on petri dishes, the

plates were then incubated for 48 hours at 32^0C, then the bacterial count was done and those obtained were the thermoduric bacteria as they survived pasteurisation (Mahanta, 1985).

3.6.2. Thiocynate level in milk

Thiocyanate levels in milk were determined in milk, after deproteinization with trichloroacetic acid (TCA) as the ferric complex, by measuring the absorbance at 460 nm. The minimum level of detection by this method is 1 to 2 ppm of SCN-20% of trichloroacetic acid was dissolved in 100 ml distilled water and filtered.

- Ferric nitrate reagent was dissolved in 50 ml 2M HNO_5 then diluted with distilled water to 100 ml.
- Then 4 ml of milk was mixed with 2 ml of 20% TCA then it was allowed to stand for 30 minutes and it was filtered and the clear filtrate was mixed with 1.5 ml of ferric nitrate reagent and the absorbance measured at 460 nm.
- The measurement was carried out within ten minutes from the addition of the ferric nitrate solution, as the coloured complex is not stable for any length of time.
- The concentration of thiocyanate was determined by comparison with standard solutions of known thiocynate concentration e.g.10, 15, 20 and 30 mg of thiocynate/ml.

3.6.3 Total cyanide content determination

The cyanogenic potential was determined using Essers (1988) method. A calibration solution containing 8, 16 and 32 nmoles of linamarin per ml were prepared and their

absorbances were read at 620 nM. 0.4 ml of orphosphoric was added in the tube instead of the extract.

- The samples were prepared by the addition of 0.4 of 0.1M orphosphoric buffer pH 7, followed by 0.1ml extract. 0.1 ml linamarase solution was also added then incubation of the sample was done for 15 minutes at 30^0C. 0.2ml chloramin T solution was added in samples and then was followed by incubation after 15 minutes at 25^0C.
- Linamarin calibration curve was prepared as 0.4ml linamarin solution was added followed by 2.5ml phosphate buffer (0.1M, pH 6.0).

Dry matter determination

- Dry matter and moisture content was also determined as Dry matter and moisture content determination, hot oven method was used. A sub sample of 12.5g was weighed using a top pan balance and dried overnight at (100 – 105^0C) in the oven until a constant weight was obtained. Cooling was done in a dessicator before final weighing. The following formula was used for moisture content calculation;

% Moisture content (M.C) = 12.5g – (final weight – C) x 100/12.5g

%Dry matter (D.M) = Final weight – container weight (c) x 100/ Initial weight – container weight.

- Then calculation for cyanogens levels per Kg dried sample was done as;

[CN]= C (b+a x M.C/100) x0.02605/a(1-M.C/100) x D.M/100 (In µg CN per g dry feed sample mixture). Whereby;

a= Weight of sub sample for extraction

b= volume of added extraction medium

C= nmole/tube

M.C= moisture content

D.M= dry matter content

3.6.4 Chemical composition determination

The following components were determined, percentage butter fat content, percentage total solids, percentage solids not fat and percentage protein content.

3.6.4.1 Determination of butterfat content

Volumetric Gerber Butyrometers was used to determine the content of butter fat in the milk samples collected as per IDF 105:1981, in carrying out this fresh milk at approximately 20°C was warmed to 40°C, mixed thoroughly and cooled to 20°C before testing.

- 10 ml of Gerber Sulphuric acid (ml.82g/cc) was added to the butyrometer followed by 11 ml of well mixed milk.
- Then 1 ml amyl alcohol was added then shaken.
- The butyrometer was placed in the water bath at 65^{0}C and was kept there till a set was ready for centrifuging.
- Centrifugation was done for 5 minutes at 1100 rpm, then the butyrometers was put in a water bath, and then the butteerfat ccontent was read and recorded as percentage butterfat.

3.6.4.2 Determination of total solids content

Drying and weighing method was to be used, milk samples were warmed to 24^{0}C, then 2ml of milk was pipetted into a dish with known weight and was placed in boiling water bath for 30 minutes and then dried in an oven at 104^{0}C for 2 hours. After that procedure it was cooled in a dessicator, weighed quickly and reported percentage residue as total solids (AOAC, 1990).

- The dish with dried samples was then covered and removed from the oven and allowed to cool at room temperature in the desiccators and then weighed.
- After that the samples were dried in the oven as before for one hour, cooled and reweighed. The drying was repeated until the difference in weight between two successive weighing was not more than 1 mg (O'Connor, 1995).

3.6.4.3 Determination of percentage Solid Not Fat (% SNF)

It was calculated by the difference between percentage total solids (%TS) and percentage butterfat (%BF)

%SNF = %TS - %BF.

Where, %SNF = Percentage Solids not Fat

%TS = Percentage Total Solids

%BF = Percentage Butterfat content.

3.6.4.4 Determination of percentage protein content (%CP)

The percentage protein contents of the samples were determined indirectly by determination of Nitrogen content. Nitrogen determination was done according to IDF-ISO-AOAC (1992) and the following formula was used to calculate protein content

% PROTEIN = % N x factor (6.38)

Where, N = Nitrogen content of the sample.

3.6.5 Assessment of keeping quality of raw milk

Milk samples collected were tested for its keeping quality by measuring its acidity and by bacterial count. Titrable acidity was done after 6, 12, 18, 24, 36, 48 and 72 hours consecutively while Total plate count was done after 9, 24, 36, 48 and 72 hours consecutively. Samples collected were in duplicate. One sample was stored at room temperature while its duplicate was stored in the refrigerator for cooling as the tests were going on.

3.7 Data analysis

The data collected was analysed by using the SAS (1990.) statistical package. Descriptive statistics and the general linear model was used to compare the differences of laboratory results of milk samples collected from different production system and from the two study areas having different temperatures and hence the statistical model used was:

$Yijk = X + Si + Tij + eijk$

Where as:

Yijk = General observation

X = General mean

Si = the effect of the ith system

Tij = Effect of the jth storage temperature in the ith production system

eijk = the random error.

Chi square test was performed to test if bacterial count in milk had a relation with time taken to deliver milk to the collection centre, type of milk storage vessel in use, milking place and the method used in cleaning the milking utensils. Furthermore thiocyanate content in raw milk was tested to see if it had any significant relation with the bacterial count in raw milk.

CHAPTER FOUR

4.0 RESULTS

4.1 Dairy producers

Table 4.1 shows that, a total of 80 farmers were included in the study also it shows that of the 80 farmers visited 40 were from Kilimanjaro and 40 were from Coast region. Twenty seven milk producers were from the traditional production system while 45 were from the small scale production system and only 8 were from the large scale commercial producers.

Table 4.1: Type of dairy producers from Kilimanjaro and Coast region

Area	n	TRA	SHC	LSC
Both	80(100%)	27(33.75%)	45(56.25%)	8(10%)
Kilimanjaro	40(50%)	7(17.5%)	30(75%)	3(7.5%)
Coast	40(50%)	20(50%)	15(37.5%)	5(12.5%)

Source: Field survey 2000
Note: TRA = traditional cattle keepers, SHC = smallholder dairy cattle producers, LSC = large scale commercial producers.

4.2 Cattle breeds

Table 4.2 shows that 14 milk producers from Kilimanjaro kept local breeds while 26 kept exotic breeds or crosses. Twenty three milk producers from Coast kept local breeds while 17 kept the exotic breeds and crosses. All traditional cattle keepers kept local breeds while only 7 small holder commercial producers from Kilimanjaro kept the local breeds.

Table 4.2: Dairy cattle breeds from Kilimanjaro and Coast region

Area	Production system	n	Local breeds (TSHZ)	Exotic breeds/crosses
Kilimanjaro	All	40	14(35%)	26(65%)
	TRA	7	7(100%)	0(0%)
	SHC	30	7(23.3%)	23(76.7%)
	LSC	3	0(0%)	3(100%)
Coast	All	40	23(57.5%)	17(42.5%)
	TRA	20	20(100%)	0(0%)
	SHC	15	3(20%)	12(80%)
	LSC	5	0(0%)	5(100%)

Source: Field survey 2000

Note, n = the number of dairy producers from the particular study area, TRA = traditional cattle keepers, SHC = smallholder dairy cattle producers, LSC = large scale commercial producers.

4.3 Milking practices

4.3.1 Milking method used

Table 4.3 shows that, hand milking method as the commonest method used by the dairy producers. In Kilimanjaro 95% of the dairy farmers interviewed practised hand milking while only 5% used machine for milking. In Coast region 92.5% of the dairy producers visited practised hand milking while only 7.5% used machine milking method. Only large scale commercial dairy producers practised machine milking.

Table 4.3: Milking methods practised in Kilimanjaro and Coast region

Area	Production system	n	Hand milking	Machine milking
Kilimanjaro	All	40	38(95%)	2(5%)
	TRA	7	7(100%)	0(0%)
	SHC	30	30(100%)	0(0%)
	LSC	3	1(33.3%)	2(66.7%)
Coast	All	40	37(92.5%)	3(7.5%)
	TRA	20	20(100%)	0(0%)
	SHC	15	15(100%)	0(0%)
	LSC	5	2(40%)	3(60%)

Source: Field survey 2000

Note, n = the number of dairy producers from the particular study area, TRA = traditional cattle keepers, SHC = smallholder dairy cattle producers, LSC = large scale commercial producers.

4.3.2 Milking place

Thirty eight dairy producers from Kilimanjaro were milking their cows in the kraal while only 2 did it in milking parlours. In Coast region, 37 farmers visited milked their cows in the kraal and only 3 milked in the milking parlour. All traditional and small scale dairy producers milked their cows in the kraal while 5 of large scale producers had a milking parlour.

Table 4.4: Place of milking

Area	Production system	n	In kraal	In milking parlour
Kilimanjaro	All	40	38 (95%)	2(5%)
	TRA	7	7(100%)	0(0%)
	SHC	30	30(100%)	0(0%)
	LSC	3	1(33.3%)	2(66.7%)
Coast	All	40	37(92.5%)	3(7.5%)
	TRA	20	20(100%)	0(0%)
	SHC	15	15(100%)	0(0%)
	LSC	5	2(40%)	3(60%)

Source: Field survey 2000

Note, n = the number of dairy producers from the particular study area, TRA = traditional cattle keepers, SHC = smallholder dairy cattle producers, LSC = large scale commercial producers.

4.3.3 Milking time

Table 4.5 reveals that all of the dairy producers from Kilimanjaro and Coast milked their cows twice a day except in rare cases. Thirty one dairy farmers in Kilimanjaro milked their cows in the morning around 0430 to 0530 am and the remaining milked their cows after 0530 am. In the evening 37 milked their cows around 1630 to 1730 pm while the remaining 3 (7.5%) milked their cows after 1730 pm. In Coast region 82.5% of all producers milked around 0530 to 0630 in the morning, while 15% milked around 0430 to 0530 am and one farmer milked after 0630 am. In the evening 30 dairy producers milked between 1630 and 1730 pm while 10 (25%) milked after1730 pm.

Table 4.5: Milking time

Area	Production System	n	Morning 0430-0530	0530-0630	<0630	Evening 1630-1730	>1730
Kilimanjaro	All	40	31(77.5%)	9(22.5%)	0(0%)	37(92.5%)	3(7.5%)
	TRA	7	1(14.3%)	6(85.7%)	0(0%)	4(57.14%)	3(42.8%)
	SHC	30	0(0%)	30(100%)	0(0%)	30(100%)	0(0%)
	LSC	3	0(0%)	0(0%)	3(100%)	3(100%)	0(0%)
Coast	All	40	6(15%)	33(82.5%)	1(2.5%)	30(75%)	10(25%)
	TRA	20	6(30%)	13(65%)	1(5%)	10(50%)	10(50%)
	SHC	15	0(0%)	15(100%)	0(0%)	15(100%)	0(0%)
	LSC	5	0(0%)	5(100%)	0(0%)	5((0%)	0(0%)

Source: Field survey 2000

Note, n = the number of dairy producers from the particular study area, TRA = traditional cattle keepers, SHC = smallholder dairy cattle producers, LSC = large scale commercial producers.

4.3.4 Handling vessel after milking

Table 4.6 shows that the majority of dairy farmers from Kilimanjaro used a mixture of stainless steel and aluminium vessels (82.5%). Traditional farmers used plastic vessels and gourds for milk handling. Twenty eight farmers in Coast region used plastic vessels for handling milk while only 5 farmers used aluminium cans. Traditional cattle keepers in Coast region used gourds for milk handling. From Chi square test performed on testing if there was any relation between milk handling vessel and bacterial count it was found that bacterial count in raw milk was highly significant with milk handling vessel (Table 4.7).

Table 4.6: Milk handling vessel after milking

Area	Production system	n	Plastic vessel	Stainless steel /aluminium	gourd/plastic
Kilimanjaro	All	40	0(0%)	33 (82.5%)	7(17.5%)
	TRA	7	0 (0%)	0 (0%)	7 (100%)
	SHC	30	0 (0%)	30 (100%)	0 (0%)
	LSC	3	0 (0%)	3 (100%)	0 (0%)
Coast	All	40	28 (70%)	5 (12.5%)	7 (17.5%)
	TRA	20	20 (100%)	0 (0%)	0 (0%)
	SHC	15	8 (53.3%)	0 (0%)	7 (46.7%)
	LSC	5	0 (0%)	5 (100%)	0 (0%)

Source: Field survey 2000

Note, n = the number of dairy producers from the particular study area, TRA = traditional cattle keepers, SHC = smallholder dairy cattle producers, LSC = large scale commercial producers.

Table4.7. Chi square results on association between thiocyanate content and bacterial counts in relation to milk storage vessel, time to deliver milk and place of milking.

Prod. sys	Parameter	SCN	Bacterial counts/ ml (x 10³) Obs	Exp	DF	χ^2	P
1	Thiocyanate levels in milk at 4°C	6 75	240	213			
1		10 4	62	55 2			
2		5 18	120	69	10	678	0.001
2		6 0	75	43			
3		2.5	350	180			
3		7.45	14	7			
1	Thiocyanate levels in milk at 20°C	8 6	136	78			
1		7 32	120	69			
2		5.1	800	224	10	890	0.001
2		5 9	45	12 6			
3		4.2	24	3.5			
3		5.6	40	5.7			
1	Storage vessel in relation to bacterial counts in raw milk	3.02	6800	7308			
2		5.39	4811	4707	2	4492	0.001
3		2.39	6120	4330			
1	Time taken to deliver milk to collection centre	7.6	1480	1814			
2		5.3	3360	935	4	24140	0.001
3		3.02	37230	4330			
1	Place of milking with bacterial count	2.7	1818	2629			
2		5.9	555	540	4	907	0.001
3		6.75	268	188			
1	Mode of cleaning method with bacterial count	3.02	4118	3820			
2		4 5	741	759	2	109	0.001
3		6.0	128	155			

Note. Pro. sys= Production system. Obs= Observed value. Exp=Expected value. DF= Degrees of freedom. χ^2=Chi square value and P = Probability level. Pro.sys 3= Traditional cattle keepers. 2=Smallholder dairy producers. 1= Large scale commercial producers.

4.3.5 Concentrates used for feeding the dairy cattle

Table 4.8 shows that cotton seed cake, wheat bran and sunflower seed cake were the main concentrates used by the smallholders dairy producers and large scale commercial dairy producers from both regions. The traditional cattle keepers from both regions did not use any type of concentrate for feeding the cows.

Thirty three farmers in Kilimanjaro used both cotton seed cake and sunflower seed cake while 7 dairy producers used neither of the two concentrates. In Coast region however, twelve dairy producers used a mixture of cotton seed cake, sunflower seed cake and wheat bran while the Maasai did not use any type of concentrate for feeding their cows.

Table 4.8: Concentrates used to supplement the dairy cow

			supplementation				
Area	Production system	n	none	CSC	Wheat bran/CSC	CSC/SSC	Wheat bran, CSC and SSC
Kilimanjaro	All	40	7 (17.5%)	0 (0%)	0 (0%)	33(82.5%)	0 (0%)
	TRA	7	7 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	SHC	30	0 (0%)	0 (0%)	0 (0%)	30 (100%)	0 (0%)
	LSC	3	0 (0%)	0 (0%)	0 (0%)	3 (100%)	0 (0%)
Coast	All	40	20 (50%)	2 (5%)	5 (13.5%)	12 (30%)	1 (2.5%)
	TRA	20	20 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	SHC	15	0 (0%)	2 (13.3%)	5 (33.3%)	7 (40%)	1 (6.67%)
	LSC	5	0 (0%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)

Source: Field survey 2000

Note, n = the number of dairy producers from the particular study area, TRA = traditional cattle keepers, SHC = smallholder dairy cattle producers, LSC = large scale commercial producers, CSC = cotton seed cake, SSC = sunflower seed cake.

4.3.6 Time taken before milk is delivered to the milk collection centre /selling centre

From Table 4.9, it is observed that the majority of the dairy producers from Kilimanjaro (82.5%) delivered milk in less than one hour while only 4 dairy

producers exceeded 2 hours before delivering milk to the collection centre. In Coast region all small scale dairy farmers delivered milk to the collection centre in less than one hour while all the traditional cattle keepers delivered milk after one hour to the collection centre. From Table 4.7 it is revealed that there was a strong relationship between time taken to deliver milk and bacterial count as for the test performed the χ^2 value was 24,140,000 cfu/ ml and probability level was 0.001.

Table 4.9: Time taken before milk is delivered to the collection centre /selling point

Area	Production system	n	Time to the collection centre		
			<1hour	1hour-2hours	>2hours
Kilimanjaro	All	40	33 (82.5%)	3 (7.5%)	4 (10%)
	TRA	7	0 (0%)	3(42.86%)	4 (57.14%)
	SHC	30	30 (100%)	0 (0%)	0 (0%)
	LSC	3	3 (100%)	0 (0%)	0 (0%)
Coast	All	40	20 (50%)	8 (20%)	12 (30%)
	TRA	20	0 (0%)	8 (40%)	12 (60%)
	SHC	15	15 (100%)	0 (0%)	0 (0%)
	LSC	5	5 (100%)	0 (0%)	0 (0%)

Source: Field survey 2000

Note, n = the number of dairy producers from the particular study area, TRA = traditional cattle keepers, SHC = smallholder dairy cattle producers, LSC = large scale commercial producers.

4.3.7 Preservation method used

From Table 4.10 it has been observed that the methods used in milk preservation were either boiling, refrigeration or bulk cooling tanks and the traditional method (gourd smoking). Twenty dairy producers visited in Kilimanjaro used refrigerator or bulk cooling tanks as a method of milk preservation while 4 used the traditional method (gourd smoking) as a method of preservation. In Coast region 12 traditional

cattle keepers visited used either the traditional gourd smoking or none of the preservation methods mentioned.

Table 4.10: Method of milk preservation

Area	Production system	n	Method of preservation			
			none	Gourd smoking	Boiling	Refrigerate/bulk cooling tank
Kilimanjaro	All	40	3(7.5%)	4 (10%)	13 (32.5%)	20 (50%)
	TRA	7	3(42.85%)	3 (42.85%)	1 (14.3%)	0 (0%)
	SHC	30	0(0%)	1 (3.3%)	12 (40%)	17 (56.7%)
	LSC	3	0(0%)	0 (0%)	0 (0%)	3 (100%)
Coast	All	40	9(22.5%)	15 (37.5%)	3 (7.5%)	13 (32.5%)
	TRA	20	8(40%)	12 (60%)	0 (0%)	0 (0%)
	SHC	15	1(6.7%)	3 (20%)	3 (20%)	8 (53.3%)
	LSC	5	0(0%)	0 (0%)	0 (0%)	5 (100%)

Source: Field survey 2000

Note, n = the number of dairy producers from the particular study area, TRA = traditional cattle keepers, SHC = smallholder dairy cattle producers, LSC = large scale commercial producers.

4.3.8 Milk storage vessel

From Table 4.11, it has been observed that dairy producers in Kilimanjaro used plastic, aluminium and stainless steel vessel for milk storage. The traditional Maasai cattle keepers used gourds for milk storage. In Coast region 19 traditional cattle keepers used the traditional gourds for milk storage while the small scale and large scale commercial producers used a mixture of plastic and aluminium cans for milk storage. From chi square test (χ^2) performed it was observed that there was a strong relationship ($P<0.001$) between different storage vessels and bacterial count in raw milk samples collected (Table 4.7 page 52).

Table 4.11: Milk storage vessels

Area	Production system	n	Milk storage vessel				
			plastic	plastic/ metal	aluminium	gourd	plastic/stainless steel aluminium
Kilimanjaro	All	40	11 (27.5%)	9(22.5%)	13 (32.5%)	6 (15%)	1 (2.5%)
	TRA	7	0 (0%)	0 (0%)	0 (0%)	6 (85.7%)	1 (14.3%)
	SHC	30	11 (36.7%)	8 (26.7%)	11 (36.7%)	0 (0%)	0 (0%)
	LSC	3	0 (0%)	1 (33.3%)	2 (66.7%)	0 (0%)	0 (0%)
Coast	All	40	6 (15%)	2 (5%)	3 (7.5%)	19 (47.5%)	10 (25%)
	TRA	20	0 (0%)	0 (0%)	0 (0%)	19 (95%)	1 (5%)
	SHC	15	5 (33.3%)	1 (6.67%)	0 (0%)	0 (0%)	9 (60%)
	LSC	5	1 (20%)	1 (20%)	3 (60%)	0 (0%)	0 (0%)

Source: Field survey 2000

Note, n = the number of dairy producers from the particular study area, TRA = traditional Dairy keepers, SHC = smallholder dairy cattle producers, LSC = large scale commercial producers.

4.3.9 Method used by the dairy producers in cleaning utensils and udder hygiene

Table 4.12, shows that 85% of the dairy producers from Kilimanjaro used hot water and soap in cleaning the milking utensils. None of the dairy producers used detergent for sanitizing the utensils. Six farmers from the traditional sector used cold water for cleaning their utensils.

The large scale and small scale dairy producers in Coast used hot water and soap for cleaning the milking and storing vessels while the traditional farmers used cow's urine and *Diplorhricycus condylaccarpon's* ash for cleaning the vessels. From Chi square test done, it was revealed that there was a strong relationship between mode of cleaning the milking or storage vessel with bacterial count in raw milk as the probability level was found to be significant at 0.1% ($P<0.001$).

Table 4.12: Mode of cleaning milking/ storage vessel and udder hygiene

Area	Production system	n	Cleaning milking vessels			Udder wash	
			Hot water and soap	Cow's urine and *Diplorhricycus condylaccarpon*	Cold water	Udder washing with cold water	Boiled towels and hot water
Kilimanjaro	All	40	34 (85%)	0 (0%)	6 (15%)	7(17.5%)	33 (82.5%)
	TRA	7	1 (14.3%)	0 (0%)	6 (85.7%)	7(100%)	0(0%)
	SHC	30	30 (100%)	0 (0%)	0 (0%)	0 (0%)	30 (100%)
	LSC	3	3 (100%)	0 (0%)	0 (0%)	0 (0%)	3 (100%)
Coast	All	40	20 (50%)	7 (17.5%)	13 (32.5%)	18(45%)	22 (55%)
	TRA	20	0 (0%)	7 (35%)	13 (65%)	18 (90%)	2 (10%)
	SHC	15	15 (100%)	0 (0%)	0 (0%)	0 (0%)	15 (100%)
	LSC	5	5 (100%)	0 (0%)	0 (0%)	0 (0%)	5 (100%)

Source: Field survey 2000

Note: n = the number of dairy producers from the particular study area, TRA = traditional cattle keepers, SHC = smallholder dairy cattle producers, LSC = large scale commercial producers.

Also from Table 4.12, it has been observed that traditional cattle keepers neither used hot water nor dried towels in udder washing, instead they preferred using cold water.

However, 55% of dairy cattle keepers from Coast region used boiled water and hot water for udder washing while only 45% used cold water.

4.4 Evaluation of milk quality in the field

4.4.1 Organoleptic tests

The organoleptic tests were done prior the collection of milk samples from both areas. These tests comprised of smell, visual appearance and taste. All the milk sampled was found to be of good quality by the organoleptic tests (Table 4.13).

Table 4.13: Organoleptic tests

Area	Production system	n	smell		visual	
			good	bad	normal	abnormal
Kilimanjaro	All	40	40 (100%)	0 (0%)	40 (100)	0 (0%)
	TRA	7	7 (100%)	0 (0%)	7 (100%)	0 (0%)
	SHC	30	30 (100%)	0 (0%)	30 (100%)	0 (0%)
	LSC	3	3 (100%)	0 (0%)	3 (100%)	0 (0%)
Coast	All	40	40 (100%)	0 (0%)	40 (100%)	0 (0%)
	TRA	20	20 (100%)	0 (0%)	20 (100%)	0 (0%)
	SHC	15	15 (100%)	0 (0%)	15 (100%)	0 (0%)
	LSC	5	5 (100%)	0 (0%)	5 (100%)	0 (0%)

Source: Field survey, 2000

Note: n = the number of dairy producers from the particular study area, TRA = traditional cattle keepers, SHC = smallholder dairy cattle producers, LSC = large scale commercial producers.

4.4.2 Milk density

Twenty nine milk samples collected from the dairy producers in Kilimanjaro were found to have a normal range of between 1.026 to 1.029g/cc while nine samples were having a range below 1.026g/cc and only 2 samples had a density of above 1.029g/cc.

In Coast region 39 samples collected had a normal range of 1.026 to 1.029g/cc while only one sample had a density of above 1.029g/cc and no sample had a density of below 1.022g/cc.

Table 4.14: Density of milk

Area	Production system	n	Milk density		
			1.022-1.025	>1.025-1.029	>1.029
Kilimanjaro	All	40	9 (22.5%)	29 (72.5%)	2 (5%)
	TRA	7	1 (14.3%)	6 (85.7%)	0 (0%)
	SHC	30	8 (26.7%)	20 (66.7%)	2 (6.7%)
	LSC	3	0 (0%)	3 (100%)	0 (0%)
Coast	All	40	0 (0%)	39 (97.5%)	1 (2.5%)
	TRA	20	0 (0%)	20 (100%)	0 (0%)
	SHC	15	0 (0%)	14 (93.3%)	1 (6.7%)
	LSC	5	0 (0%)	5 (100%)	0 (0%)

Source: Field survey 2000

Note; n is the number of dairy producers from the particular study area, TRA; traditional cattle keepers, SHC; means smallholder dairy cattle producers, LSC; large scale commercial producers.

4.4.3 Acidity

From Table 4.15, it has been observed that thirty five samples collected in Kilimanjaro had an acidity of between 0.18% lactic acid and 0.2% lactic acid while only 2 samples collected had an acidity of above 0.2% lactic acid, and only 3 samples were found to have an acidity below 0.18% lactic acid.

In Coast region, thirty six (90%) of the samples collected have acidity above 0.17% lactic acid while 10% of the samples collected have an acidity of below 0.18% lactic acid.

Table 4.15: Acidity of the milk samples from Kilimanjaro and Coast

Area	Production system	n	Milk acidity		
			<0.18%	0.18-0.2%	>0.2%
Kilimanjaro	All	40	3 (7.5%)	35 (87.5%)	2 (5%)
	TRA	7	3 (42.8%)	4 (57.2%)	0 (0%)
	SHC	30	0 (0%)	29 (96.7%)	1 (3.3%)
	LSC	3	0 (0%)	2 (67.7%)	1 (33.3%)
Coast	All	40	4 (10%)	36 (90%)	0 (0%)
	TRA	20	3 (15%)	17 (85%)	0 (0%)
	SHC	15	1 (6.7%)	14 (93.3%)	0 (0%)
	LSC	5	0 (0%)	5 (100%)	0 (0%)

Source: Field survey 2000

Note; n is the number of dairy producers from the particular study area, TRA; traditional cattle keepers, SHC; means smallholder dairy cattle producers, LSC; large scale commercial producers.

4.5 Evaluation of the quality of milk in the laboratory

4.5.1 Bacterial counts in raw milk

Total plate count, thermoduric count and coliform count were done on milk samples from Kilimanjaro and Coast region and the results are as shown in Table 4.16.

Table 4.16: LSMeans and SE for bacterial count in raw milk samples from Kilimanjaro and Coast region (x 10^3 cfu/ml)

Area	Production system	n	Bacterial counts/ml raw milk		
			Total plate count	Thermodurics	Coliforms
Kilimanjaro	TRA	7	500±100^b	17.7 ±.1.5^a	5.27± 0.9^a
	SHC	30	300±200^b	6 ±0.8^b	3.11±0.5 ^{a}
	LSC	3	270±200^b	5.2±1.7^c	2.45± 0.1^a
Coast	TRA	20	1900±200^a	22.3± 17 ^{a}	3.21± 0.4 ^{a}
	SHC	15	540±260^b	8± 2^b	2.43± 0.5^a
	LSC	5	1300±400^a	5.8± 0.4^c	0.92±0.3^b

Source: Field survey 2000
Note: TRA = traditional cattle keepers, SHC = smallholder commercial dairy cattle keepers and LSC = large scale commercial producers. Values within the columns having the same superscript letters means the values do not differ significantly at P>0.05

4.5.1.1 Total plate count

Table 4.16 shows that there was a significant difference (P<0.05) for total plate count on milk samples between the two areas. Milk samples from the traditional cattle keepers and the large scale producers from Kilimanjaro had significantly (P<0.01) lower bacterial counts than their counterparts in Coast region. However, milk samples from the small scale producers from both regions was found to be significantly of better bacteriological quality.

4.5.1.2 Thermodurics count

From Table 4.16 it has been observed that milk samples collected from the traditional cattle keepers from both region was having the highest thermoduric

number while milk collected from the LSC was having the lowest thermoduric count/ml of milk.

4.5.1.3 Coliform count

The results of coliform count from the milk samples collected in Kilimanjro and Coast region ranged from 2.45 ± 1.1 to 5.27 ± 0.9 cfu/ ml and 0.92 ± 0.3 to 3.2 ± 0.4 $x10^3$ cfu/ ml respectively. The difference between the two areas for coliform count in milk samples was significant ($P<0.05$). From Coast and Kilimanjaro region the LSMean for coliform count in milk samples was high in the traditional sector compared to the other production systems as shown in Table 4.16.

4.5.2 Milk compositional quality

Milk compositional quality was determined for milk samples from Kilimanjaro and Coast region and the results are as in Table 4.17.

Table 4.17: LSMeans and SE for compositional quality of raw milk samples from Kilimanjaro and Coast region

			Milk compositional quality			
Area	Production system	n	TS%	BF%	SNF%	CP%
Kilimanjaro	TRA	7	12.4±0.21^{b}	4.01±0.33^{b}	8.39±0.31^{a}	2.2±0.39^{b}
	SHC	30	12.21±0.12^{b}	4.08±0.18^{b}	8.16±0.17^{b}	3.6±0.22^{a}
	LSC	3	12.3±0.25^{b}	3.94±0.38^{b}	8.36±0.36^{a}	4.54±0.46^{a}
Coast	TRA	20	13.5±0.28^{a}	6.32±0.63^{a}	8.3±0.17^{a}	3.96±0.13^{a}
	SHC	15	12.83±0.31^{b}	4.56 ±0.37^{a}	8.3±0.2^{a}	3.31±0.16^{a}
	LSC	5	14.08±0.57^{a}	5.15±0.51^{a}	7.9±0.34^{b}	3.93±0.27^{a}

Source: Field survey 2000

Note: TRA = traditional cattle keepers, SHC = small holder commercial dairy cattle keepers and LSC = large scale commercial producers. Values within the columns having the same superscript letters means the values do not differ significantly at P>0.05

4.5.2.1 Total solids (TS%)

From Table 4.17 it has been observed that milk samples from the traditional cattle keepers and the large scale producers in Kilimanjaro had significant lower total solids values than their counterparts from Coast region. However, milk collected from the small holders from both areas was having lower total solid value. The LSMeans from Kilimajaro ranged from 12.21 ± 0.12 to 12.4 ± 0.21 while that from Coast region ranged from 12.83 ± 0.31 to 14.08 ± 0.57.

4.5.2.2 Butterfat content (BF%)

Butterfat content was significantly higher in milk samples collected from Coast region than milk samples collected from Kilimanjaro region (Table 4.17). However, there was no significant difference in butterfat content between the production systems within both areas ($P > 0.05$). The Butterfat content from both areas however ranged from 3.94 ±0.38 to 6.32 ± 0.63.

4.5.2.3 Solids not fat content in milk (%SNF)

From Table 4.17, it has been shown that, the solids not fat content in milk samples from Kilimanjaro ranged from 8.16 ± 0.17 to 8.39 ± 0.17% while that from Coast region ranged from 7.9 ± 0.34 to 8.31 ± 0.17%. From the results it can also be observed that milk from the traditional cattle keepers were having higher SNF values than milk from the small holders and the large scale producers.

4.5.2.4 Crude protein

The LSMeans for crude protein in milk samples are as indicated in Table 4.17. CP content in Coast region was high compared to the CP content in milk samples from Kilimanjaro. The LSMeans for CP content in samples from Kilimanjaro ranged between 2.22±0.39 and 4.54±0.46 while that from Coast region from 3.31±0.16 to 3.96±0.13. The CP content in milk samples from the traditional cattle keepers was high in Coast while it was very low in the same production system from Kilimanjaro.

4.5.3 Influence of thiocyanate levels in raw milk on bacterial count

From Figure 4.1 and 4.2, it has been observed that, thiocyanate levels in raw milk were negatively associated with bacterial count in raw milk, also from the results it was observed that the t–values obtained showed that there was a strong relationship between thiocyanate levels in milk and bacterial multiplications. The negative correlation between thiocyanate levels in milk and bacterial multiplications in raw milk shows that an increase in thiocyanate concentration in raw milk led to a decrease in bacterial multiplication per ml raw milk. Also from Chi square test performed (Table 4.7 page 52) on testing if thiocyanate content in milk had any relation to bacterial count it was revealed that thiocyanate content was highly significantly ($P<0.01$) related to bacterial count/ ml in raw milk.

There appears to be a relationship between the type of feed given to the animals, their cyanide content and the content of thiocyanate in milk. Data in Table 4.18 shows that milk samples from the small scale producers and the large cattle producers which were fed with concentrates containing higher CN^- level had higher SCN^- levels than milk from the traditional cattle keepers who did not feed concentrates.

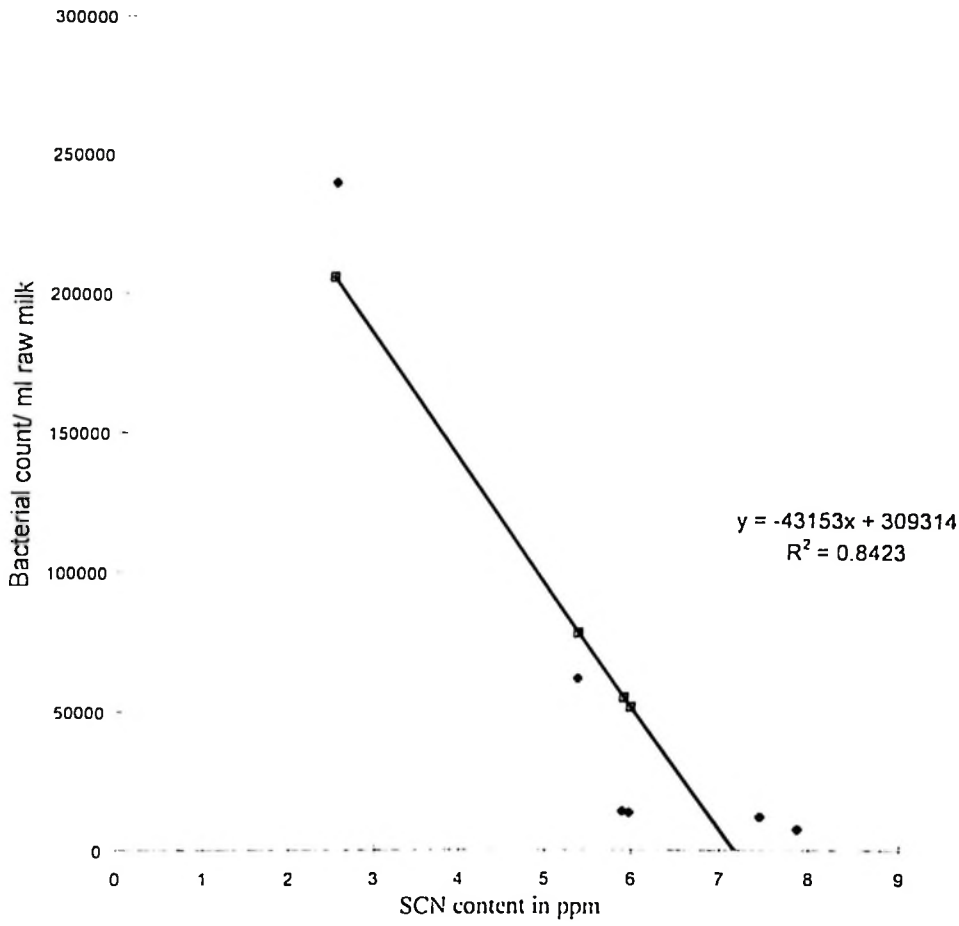

Fig. 4.1 Thiocyanate content in milk in relation to bacterial count in raw milk samples stored at 4^{0}C for 12 hours

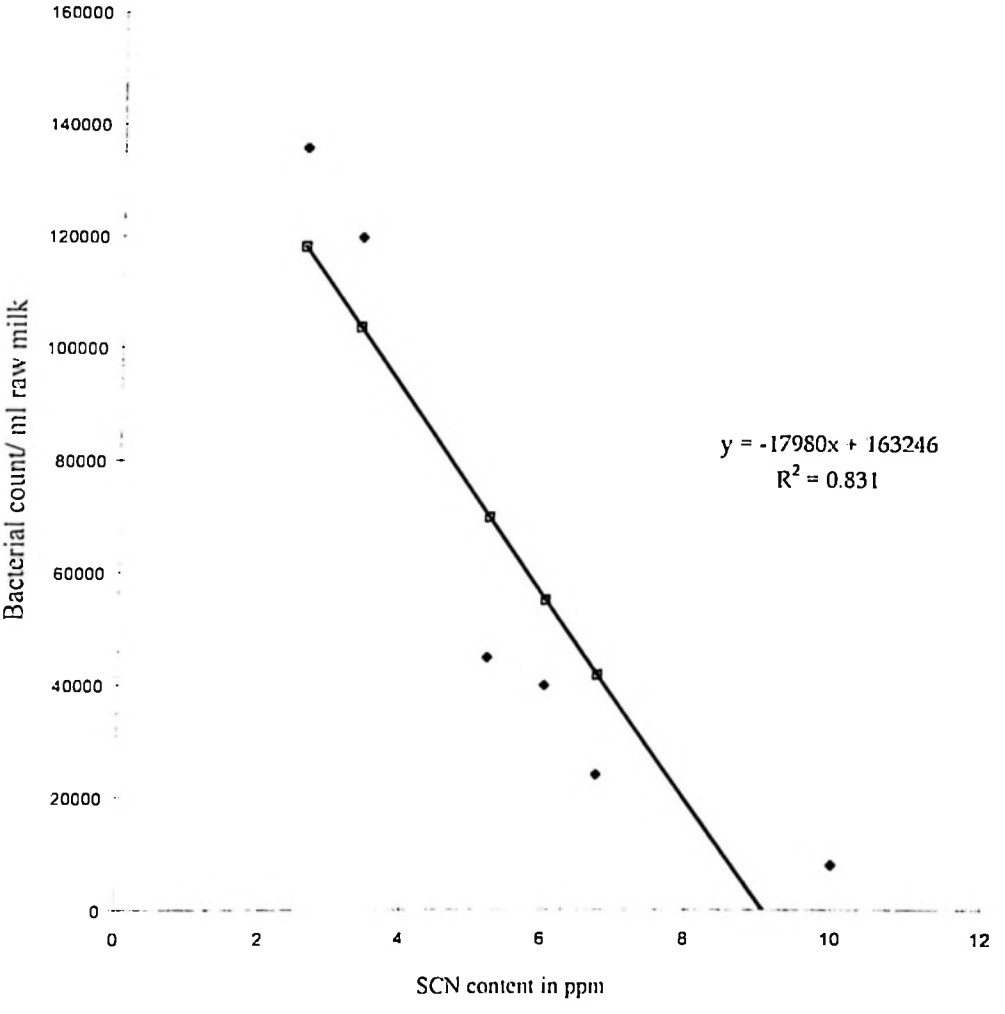

Fig. 4.2 Thiocyanate content in milk in relation to bacterial multiplication in raw milk samples stored at 20^{0}C for 12 hours

4.5.4 Cyanide content in different feed samples from Kilimanjaro and Coast region

From Table 4.18, it has been observed that the content of cyanide in different feeds was low. However, from the results it was shown that concentrate mixture was having the highest level of cyanide compared to forage.

Table 4.18: Cyanide content in different feed samples from Kilimanjaro and Coast region

Dry Feed sample	D.M (%)	CN content in µg CN/ g
Brachiaria spp	92.2	1.6
Cotton seed cake	90.6	1.9
Elephant grass	89.5	3
Maize bran	89.4	7
Cetaria spp	88.5	4
Rice straw	96	3
Maize cobs and straw	89.4	1.2
Banana leaves and stem	90.7	4.5
Guatemala grass	91	1.7
Leucaena leaves	89.2	40
Sunflower cake, maize bran mixed with Common salt	93	1700

4.6 Milk keeping quality

4.6.1 Influence of source of milk on acidity development

From Figure 4.3 and 4.4 it has been observed that raw milk samples from Kilimanjaro region stored at 20^0C turned sour after 36 hours of storage, while that from Coast region held at the same temperature turned sour just after 24 hours. Raw milk from both region stored at 4^0C had a long shelf life as, after storing for 72 hours, milk samples from Kilimanjaro was having an acidity of 0.23% while that from Coast was having an acidity of 0.27% lactic acid.

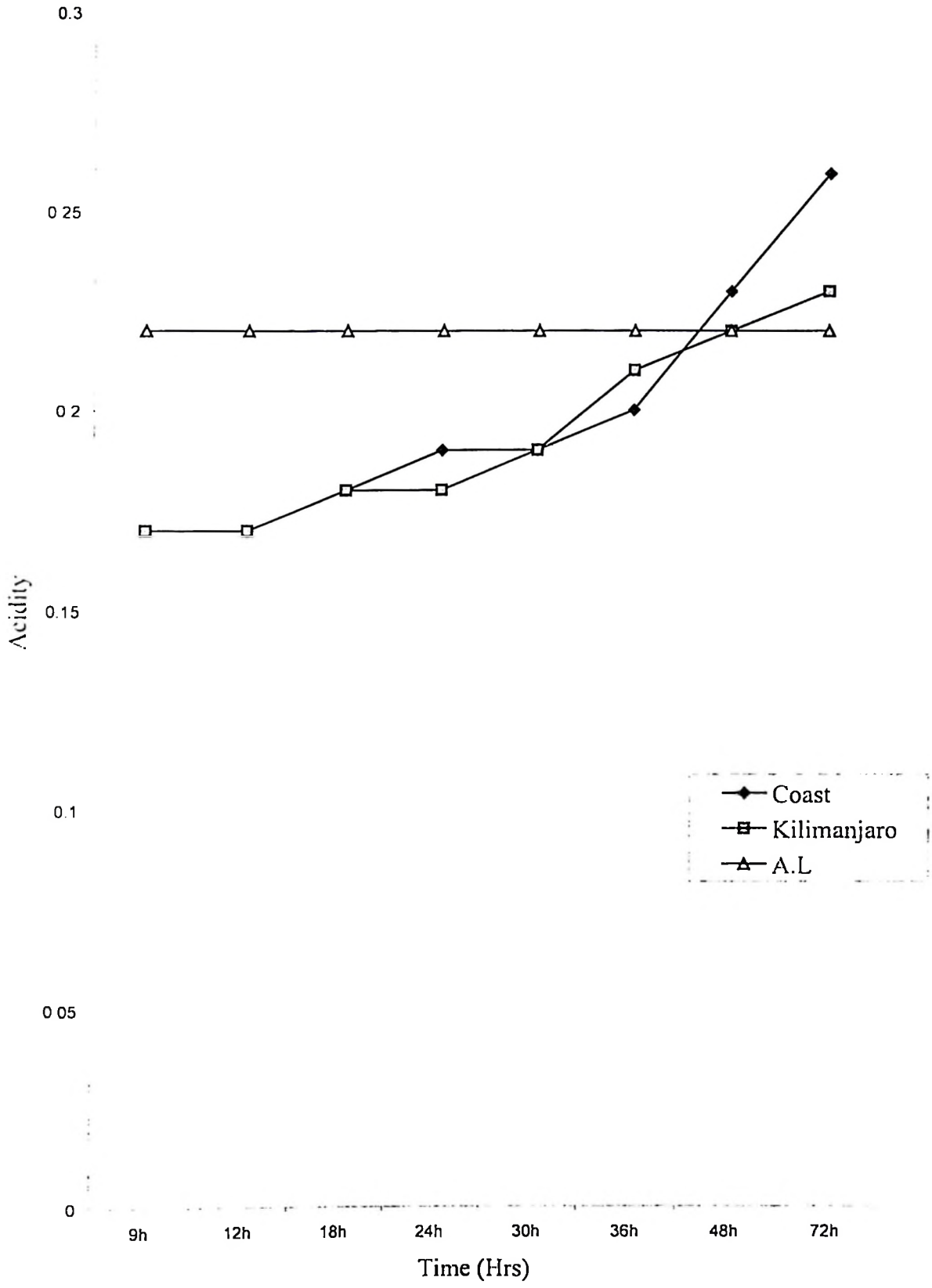

Fig. 4.3 Influence of source of milk on acidity development at refrigeration temperature (4^0C)

Note: A.L = Milk acceptable limit

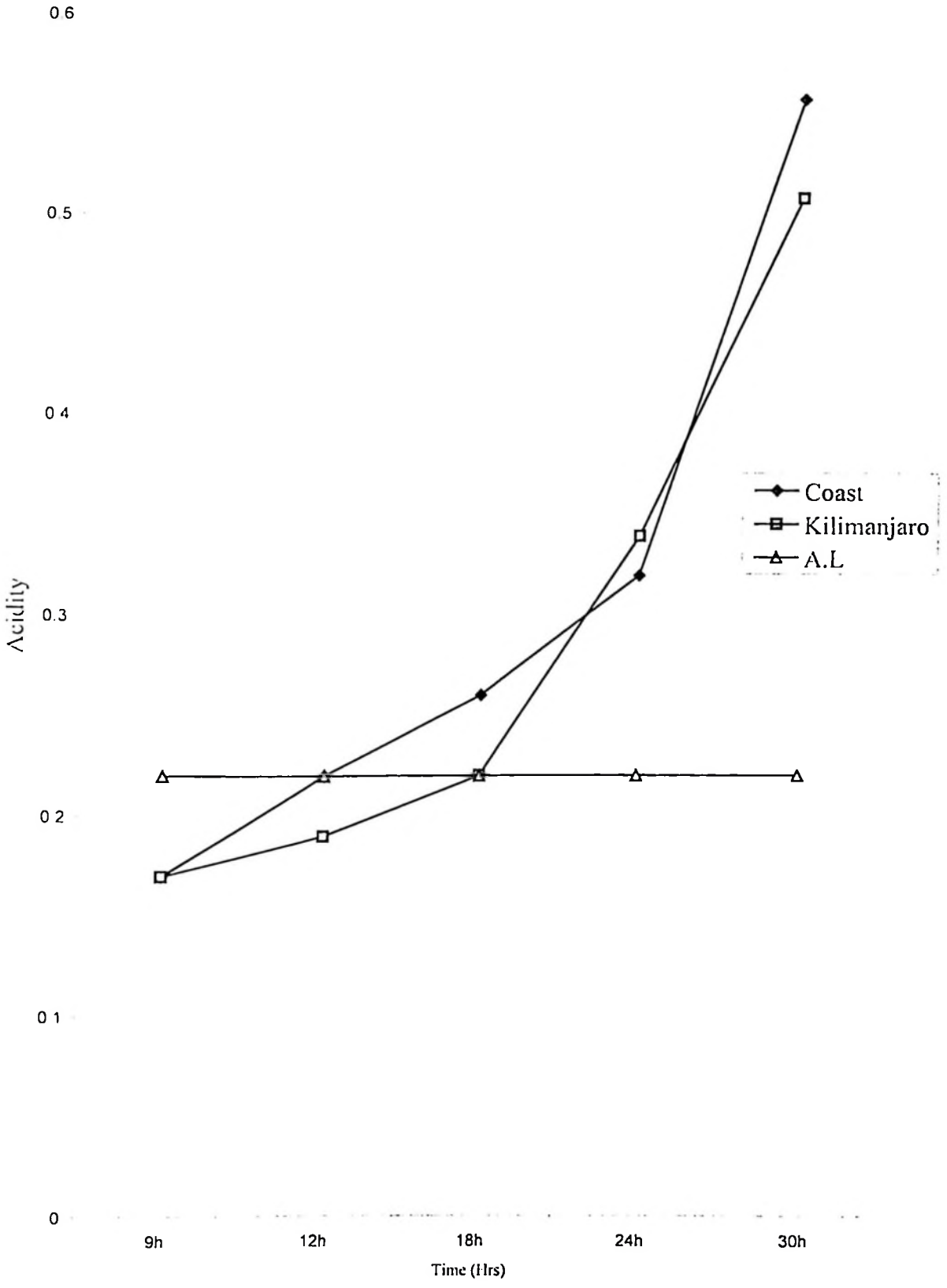

Fig 4.4 Influence of source of milk on acidity development under ambient temperature (20^0C)

Note: A.L = Milk acceptable limit

4.6.2 Influence of temperature on total plate count

4.6.2.1 Influence of storage temperature on bacterial counts on milk samples

Raw milk samples stored at 20^0C showed a rapid bacterial multiplication compared to samples stored at 4^0C. Raw milk sample having an initial bacterial count of $4x10^3$ bacteria count per ml after 9 hours had $32x10^7$ bacterial count per ml when stored at 20^0C after 72 hours of storage. Meanwhile a sample having 12×10^3 bacterial count per ml when stored at 4^0C for 72 hours was having a count of

28×10^6 bacterial count per ml.

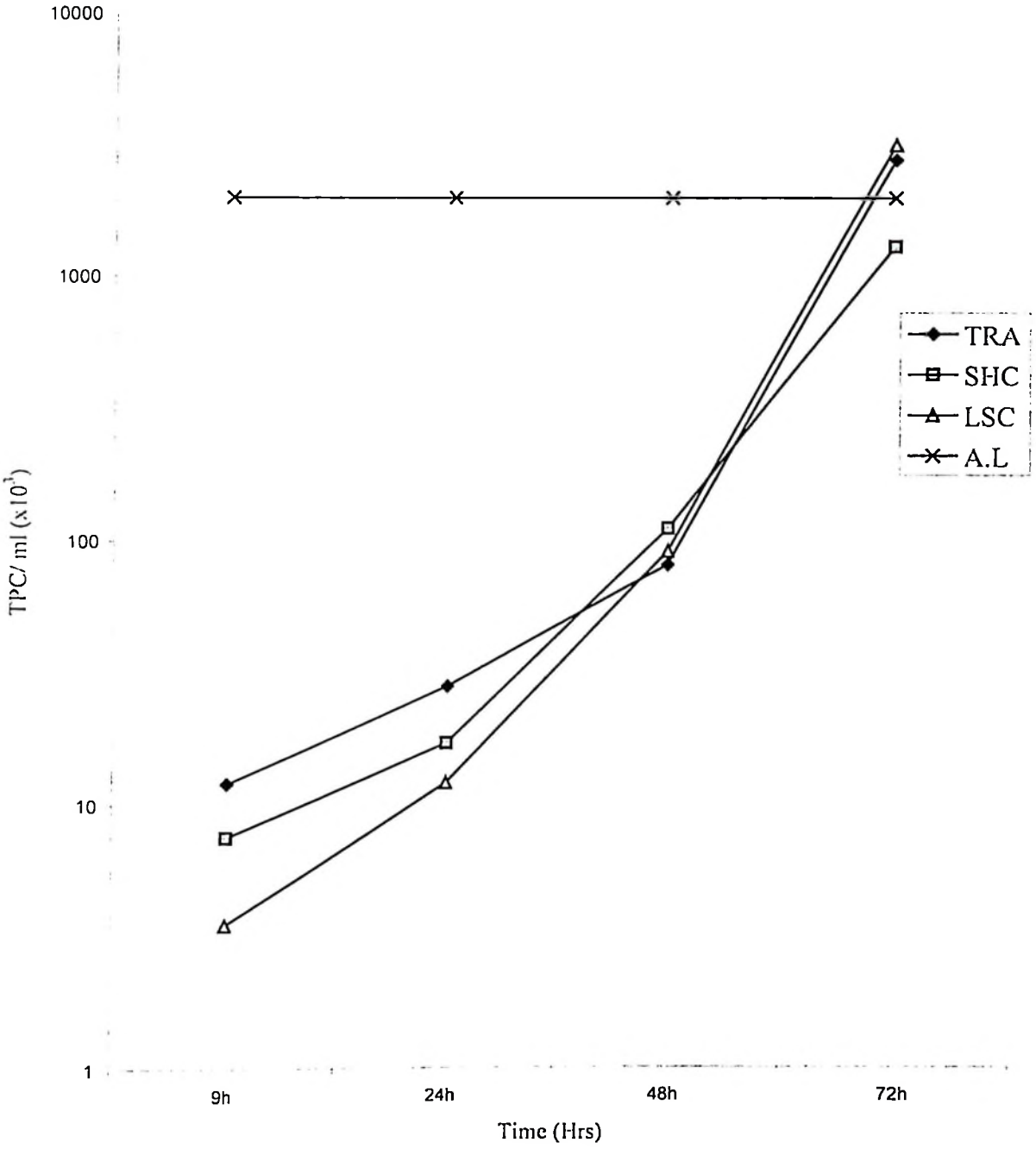

Fig.4.5 Semi Logarithmic graph for total bacterial count in raw milk samples from Kilimanjaro held at 4^0C

Note: TRA = traditional cattle keepers, SHC = small dairy cattle producers, LSC = Large scale commercial producers, A.L = Milk acceptable limit,

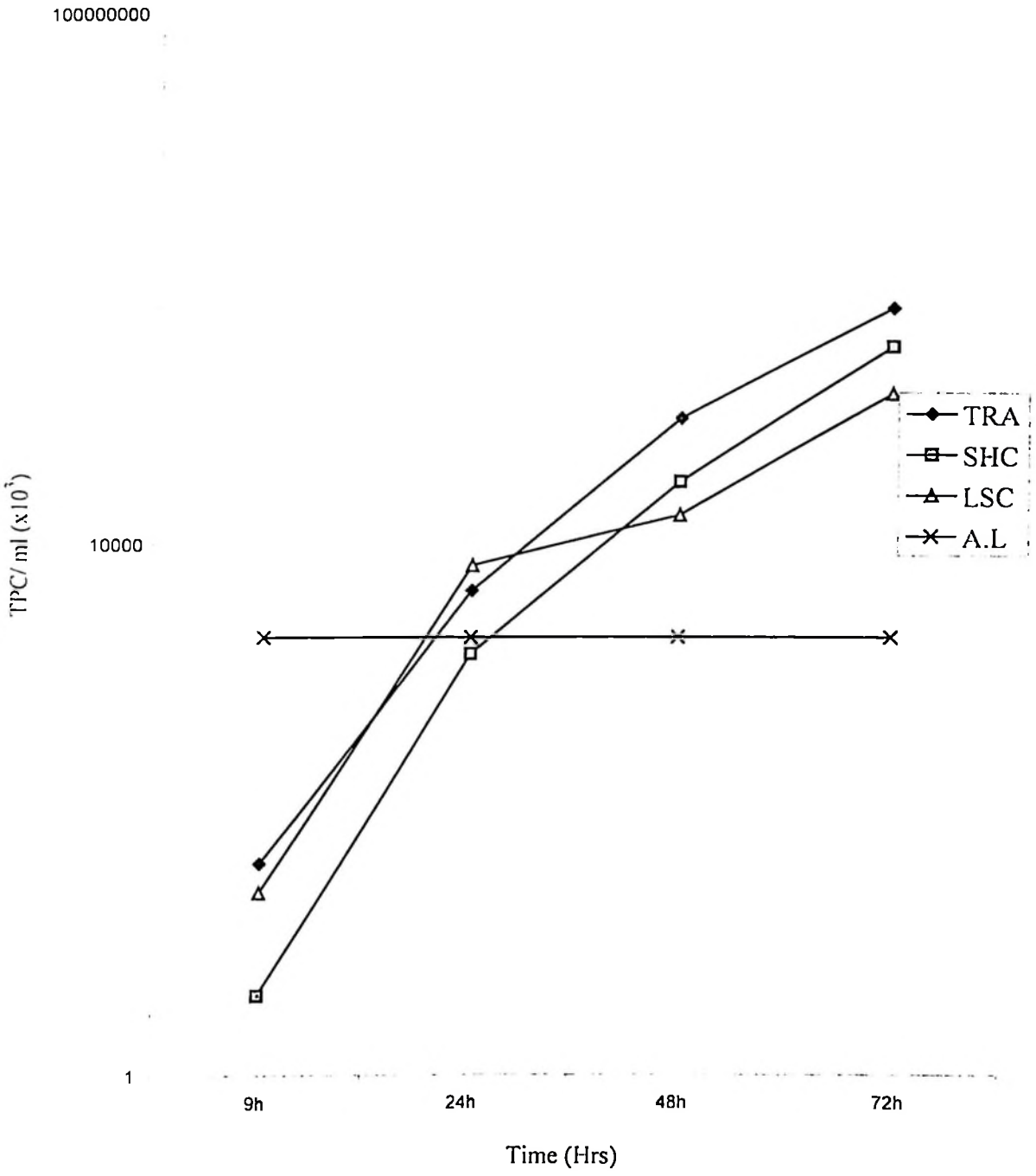

Fig. 4.6 Semi Logarithmic graph for total bacterial count of raw milk samples from Kilimanjaro held at 20^0C

Note: TRA = traditional cattle keepers, SHC = small dairy cattle producers, LSC = Large scale commercial producers, A.L = Milk acceptable limit

4.6.2.2 Influence of storage temperature on bacteria count on milk samples from Coast region

From Figure 4.7 and 4.8 it can be observed that raw milk samples from Coast region had a high rate of bacteria growth compared to raw milk samples from Kilimanjaro region. Raw milk samples which were held at 20^0C having the initial bacterial count of 136 x 10^3 cfu/ml, after 72 hours of storage at the same temperature the count has increased to 240 x 10^7cfu/ml.

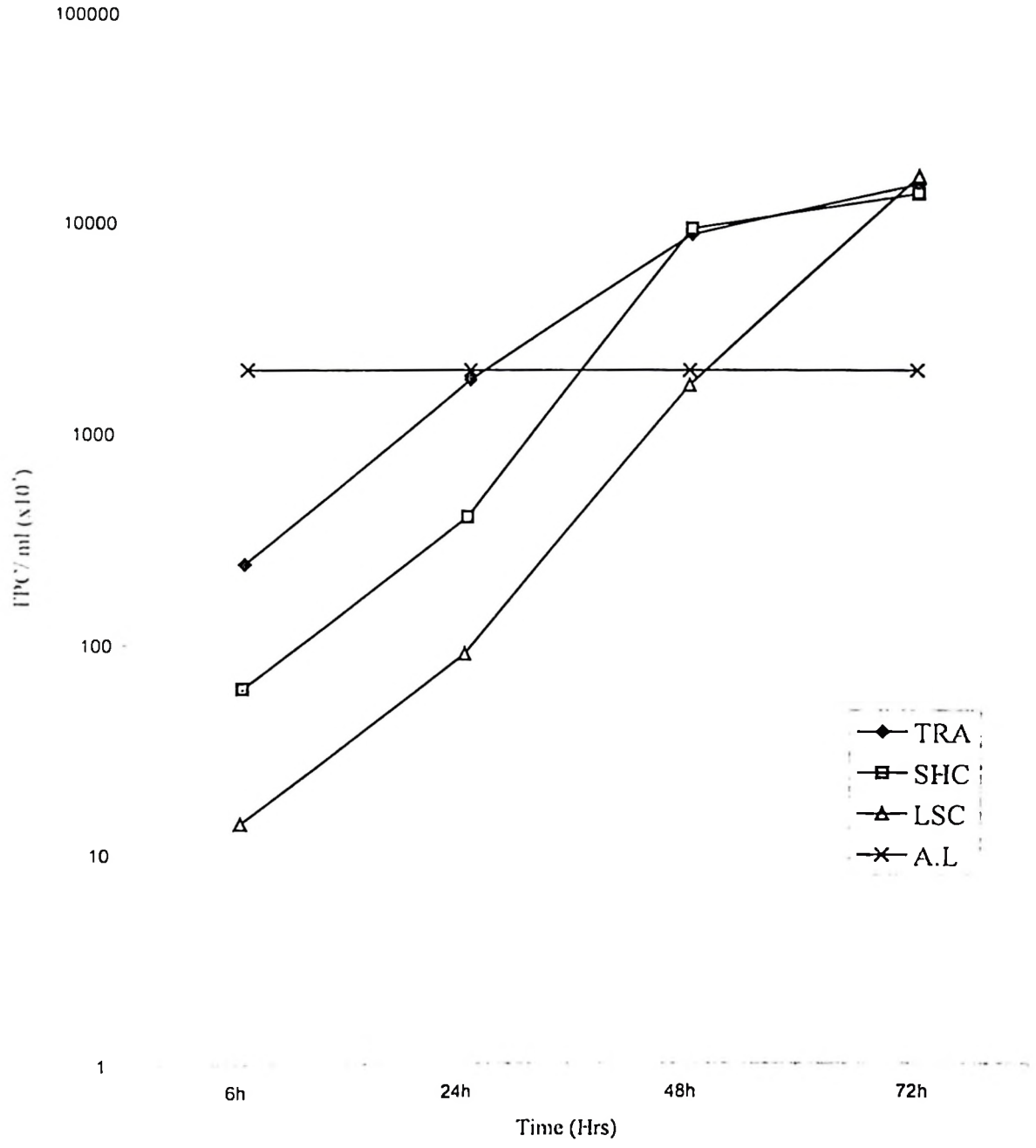

Fig.4.7 Semi Logarithmic graph for total bacterial count of milk samples from coast region held at 4^0C

Note: TRA = traditional cattle keepers, SHC = small dairy cattle producers, LSC = Large scale commercial producers, A.L = Milk acceptable limit

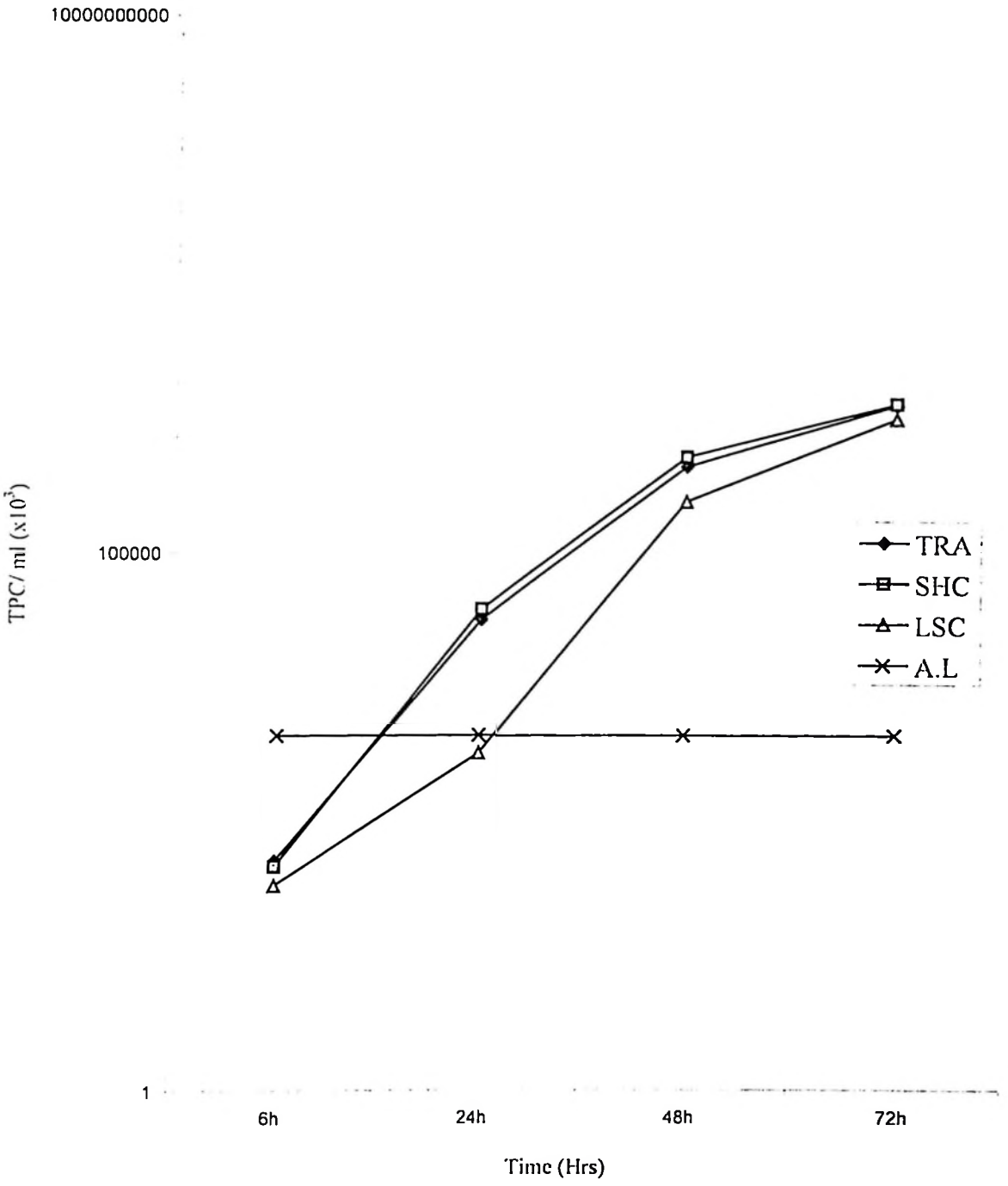

Fig.4.8 Semi Logarithmic graph for total bacterial count of milk samples from Coast region held at 20^0C

Note: TRA = traditional cattle keepers, SHC = small dairy cattle producers, LSC = Large scale commercial producers, A.L = Milk acceptable limit

CHAPTER FIVE

5.0 DISCUSSION

5.1 Milk production systems

The study aimed at evaluating different milking practices carried out in different production systems in Kilimanjaro and Coast region and their influence on the keeping quality of raw milk. From Table 4.1, it has been observed that the production systems involved in the study include traditional cattle keepers, small holder and large scale commercial dairy producers.

The traditional cattle keepers kept local breeds (Tanzania Shorthorn Zebu), while the SHC and LSC kept a mixture of exotic breeds and crosses (Table 4.2). Cattle breeds had an influence on milk compositional quality (Table 4.17). As expected milk from the local breeds had high butterfat content compared to milk from the exotic breeds. This observation agrees well with O'Connor (1995), who reports Zebu cows giving milk containing up to 7% fat.

The traditional cattle keepers keep a large number of cattle compared to the other dairy producers. The large herd size could be a reason for poor management of the cow, leading to poor quality milk. The cows were not clean, and also the environment where the cows were housed was also very dirty. This could account for the high bacteriological contamination in milk. Bodman, (1983) suggested that the body and surrounding of the cow should be kept clean as clean cows reduce milking time, labour, and bacterial contamination.

The Maasai cattle keepers from Kilimanjaro and Coast grazed their cows on rangelands. Grazed cows could have an advantage over indoor cows on udder hygiene, as it was earlier on reported by Hansen (1973) that the udder of the cows which are grazed are generally drier and cleaner during grazing period comparing to udder of the cows kept indoor, thus promoting low bacterial contamination of milk from the udder surface. This observation is supported by Joergensen (1980) as he stated that the feeding environment of the cows equally influenced a qualitative change of flora on the udder surface. He further reports that bulk milk also contained five to ten times as many anaerobic spores per ml in the housing period when silage was fed than in grazing period, even when udder of cows were washed by hypochlorite.

Also from the survey it was observed that cows were not supplemented with concentrates (Table 4.8). This could have attributed to low crude protein value obtained from milk samples collected from Kilimanjaro traditional cattle keepers. This observation is supported by Mtumwa and Mwasha (1995) as they reported that cows kept by the Maasai are fed inadequately resulting in producing small amount of milk of low quality.

From this production system it was also observed that the method used for milking the cow was hand milking (Table 4.3). Hand milking has been known to be better than machine milking if done under proper, hygienic condition. In the case of the Maasai, milking was done under unhygienic conditions, as it was observed that the Maasai milker did not even wash their hands before milking and washing of the teat

was done using cold water (Table 4.12). So, instead of improving the bacterial quality of raw milk, handmilking in the Maasai pastoralist could be a source of elevated bacterial counts in raw milk.

Another problem observed from the Maasai pastoralists was the distance from the milk collection centres. It could be observed that some villages in Coast region were about 10 km from the collection centre. This could be a reason for failure of delivery of milk on time, also it could be a reason for higher multiplication rates of bacteria in milk. The higher bacteria multiplication rate was also accerelated by temperature, as it was observed that in Coast region temperature was very high (30^0C). Therefore temperature and distance contributed to high bacteriological quality milk. This observation is supported by IDF (1961) as it is reported that most of microorganisms prefer temperature between 20^0C and 36.7^0C.

Regarding the SHC from Kilimanjaro and Coast region, it was observed that the small holders kept few cows compared to the traditional production system. From this production system it was learnt that feeding was done adequately, as it was observed that they supplemented their cows with concentrates (Table 4.8). Also it was easy for them to control the cleanliness of the cow and its environment. Clean environment and clean cow could thus improve the bacteriological quality of milk. The large scale producers kept a large herd, the difference with the Maasai is that they managed their herd very well, and they kept their cows in a clean environment and the cows were clean.

Except for LSC farms from Coast region, milk produced from the SHC and LSC from both regions were found to have low bacterial count per ml. This differentiates these systems from the Maasai pastoralist. These systems are characterised by keeping cows in cleaner condition, keeping the milking and storage equipment in clean condition and also obeying proper milking practices.

Furthermore, milking under the SHC was done by hand. The only difference with hand milking in the Maasai pastoralists was that the SHC milked the cow in cleaner environments, and also they usually washed the hands before milking. This could be a reason for low bacterial count from this system. Another difference observed from these systems when comparing them with the Maasai pastoralists is that they travelled short distances to the selling or collection centre. Also they stayed with milk for short period before delivery to the selling or collection centre (Table 4.9).

5.2 Milk bacteriological quality

From Table 4.16, it has been observed that, raw milk samples from Coast region had higher LSMean value for total plate count compared to raw milk samples from Kilimanjaro region. Despite the fact that bacterial count was higher in raw milk samples from Coast region relative to milk samples from Kilimanjaro region its quality was still good when compared to standards stipulated by TBS (1996). The highest bacterial count per ml of raw milk obtained from Coast region was $1.9x10^6$ cfu/ ml. According to TBS (1996) raw milk with bacterial count between $1x10^6$ and $2x10^6$ cfu/ml is considered as good quality milk. Also according to standards stipulated by TBS (1996) milk having bacterial count below $1x10^6$cfu/ ml is

considered to be of very good quality, so milk samples from Kilimanjaro region was of very good quality as the bacterial count ranged from $2.7x10^5$ to $5x10^5$ cfu/ ml.

Regarding thermoduric count, it was observed that milk samples from the traditional cattle keepers had the highest LSMeans value compared to samples collected from other production systems in Kilimanjaro and Coast region (Table 4.16). However, milk samples from Coast region were found to have high counts of thermodurics than samples from Kilimanjaro region. The high count of thermodurics in milk indicates that milk was produced or processed in unclean surroundings or under poor sanitary procedures (Lampert, 1975). Also the high count of thermodurics might be contributed by dirty milking equipments as it was earlier on mentioned by Kurwijila (1994) that nonspore forming thermodurics originates from dirty milking eqiuipments while the spore forming thermodurics originates from feeds, barn dust or soil.

Also from Table 4.16, it was observed that milk samples from the traditional cattle keepers in both area produced milk having high coliform count per ml compared to other production systems. The count per ml from the traditional cattle keepers from Kilimanjaro region at 37^0C for 24 hours was $5.3x10^3$ cfu/ ml. According to TBS (1996), milk with coliform counts between $1x10^3$ and $50x10^3$ cfu/ ml is regarded as good quality milk. In this case milk from Kilimanjaro traditional cattle keepers was regarded as good quality milk. This case was also true for milk samples from Coast region, from the same production system as milk samples had $3.2x10^3$ cfu/ ml and thus it was categorised as good quality milk. As coliform count is used to test the

general level of hygienic practices taken to avoid contamination of every kind rather than contamination of faecal origin (Kurwijila, 1994) from the result it was obvious that milk samples from the traditional cattle producers had undergone a high level of bacterial contamination leading to high coliform count/ ml.

From the above observation, it is concluded that milk samples from the traditional cattle keepers had the highest levels of total plate count, thermodurics and coliform count compared to milk samples from SHC and LSC. The following factors might have been the source of variations in bacterial counts in raw milk samples from the different production systems

Milking place has been regarded as a source of bacteria contamination in raw milk. From the study done it was found out that the kraal was commonly used by most of the dairy producers as about 93.75% of the dairy producers milked in the kraal. From this study (Table 4.4) it was also observed that all the traditional dairy producers were milking in the kraal. Also from Chi square test performed (Table 4.7) milking place was highly significant at 0.1% to bacterial count obtained in milk collected from different production systems. This observation is supported by Loth (1998) who reported that all milking in Maasai pastoralists was carried out in the kraal. Also Nell (1990) supports this observation as it was reported from his study that Maasai pastoralists were normally milking their cows in the kraal, which was constantly dirty, which is likely to contaminate milk during milking. Regarding coliform count/ ml, which was high in Coast region comparing to Kilimanjaro region, it can be deduced that, some coliform organisms were from faecal microbial

indicating unsanitary handling during milking. Therefore from the study it can be suggested that the high bacterial counts from all production systems might be highly contributed by milking place, which through dung, dust and improper milk handling could contaminate milk with bacteria.

Time taken before milk is delivered to the collection centre or selling point has been regarded as a factor contributing to bacteria multiplication in raw milk. Table 4.9 indicates that most of the dairy producers (82.5%) from Kilimanjaro stayed with milk for less than an hour before delivering it to the collection centre, while 20 dairy producers in Coast region took the same time before milk was delivered to the collection Centre. Time taken before milk is delivered to the selling point is one of the major factors affecting milk bacteriological quality (Van den Berg, 1988). From Chi square test (χ^2) (Table 4.7) performed it was observed that there was a significant association ($P< 0.01$) between time taken to deliver milk to the collection centre and bacterial counts in milk samples from different producers. As milk from the traditional cattle keepers took more than one hour to reach the selling point, this might have contributed to higher bacterial counts to milk from this production system, as raw milk was not cooled though it stayed long before reaching the selling centre. From Van den Berg (1988), it is advised that milk should be cooled soon after milking if milk has to be transported over long distances to reach the collection centre. Schmidt and Van Vleck (1974) also recommended that milk should be cooled to 4^0C within two hours after milking to maintain the flavour and extend the keeping quality of raw milk, as this temperature keeps bacterial growth to the minimum phase.

However, from the survey done, it was observed that most of dairy producers from Kilimanjaro and Coast region used plastic and aluminium vessels for handling and storage of milk. In contrast, the traditional cattle keepers used gourds for milk handling and storage. This observation is supported by Loth (1998) who reported that the majority of dairy producers from Morogoro, Coast and Dar es Salaam, used plastic utensils for milk handling and storage. Furthermore, he reported that all traditional dairy producers used gourds and plastic utensils for milk handling and storage. Chi square test (χ^2) done revealed that type of handling vessel contributed a lot to the higher levels of bacteria count from different producers (Table 4.7). From the test it was found that there was a significant difference ($P<0.01$) between milk handling vessel and bacterial count. Milk handled in gourds and plastic equipments had a high bacterial counts compared to milk handled in aluminium cans. From Henderson (1971), it is recommended that equipment surface should preferably be of seamless, stainless steel fabrication to reduce to the minimum the effect of undesirable flavour and bacteriological quality of milk. Atherton and Newlander (1977) has recommended the use of aluminium cans to plastic and gourds, it has also been reported that milk should not come into contact with copper or iron because they can induce oxidised flavour in milk. Plastic are only recommended if they are washed by using hot water and detergent to sanitize and thereafter hanged to dry.

Despite the above factors mode of cleaning milking or storage vessels and udder hygiene are also major factors contributing to high levels of bacterial counts in raw milk samples from different production systems. From the survey done it was observed that the majority (85%) of the dairy producers from Kilimanjaro used hot

water and soap for cleaning the milking and storage utensils. In Coast region only 50% of the dairy producers used hot water and soap in cleaning the milking vessels. The traditional cattle keepers from Kilimanjaro used cold water while most of the traditional cattle keepers from Coast used cows urine and ash from *Diplorhricycus condylaccarpon* tree for cleaning the milking utensils.

From Henderson (1971), it has been reported that the production of quality milk requires the use of smooth utensils that are clean and sanitized to minimize the presence of bacteria. Also it has been reported that moist utensils associated with partial removal of milk solids from the surface provides an ideal environment for microbial growth (Atherton and Newlander, 1977). The use of cold water has been restricted as it is said that cold water itself is a source of microbial contamination. Therefore, higher bacterial counts observed in milk samples from traditional milk producers and some from SHC and LSC dairy producers could be attributed by poor cleansing of milking and storage utensils.

From Table 4.12, it was also observed that, the majority of traditional cattle keepers (92.6%) did not wash the teat before milking. This observation is supported by Loth (1998) who reported from his study that all Maasai pastoralists did not wash the teat before milking. From Rasmussen *et al.* (1990) it was reported that because teats come into contact with milk during milking, teat washing prior to milking lowers bacterial count in milk. So as the Traditional cattle keepers did not wash the teats this might also have contributed to higher bacterial counts in raw milk samples collected.

5.3 Milk organoleptic and compositional quality

The quality of raw milk at the point of collection was good. From Table 4.13, it has been shown that, from the organoleptic tests done all milk samples collected had good smell and had normal appearance. These findings agree well with the findings by Loth (1998) who reported that milk collected from different dairy producers had low bacterial count and had no abnormality by organoleptic test.

Also from the results it was observed that eighty nine percent of the milk samples collected had normal density range 1.026 to 1.029g/cc while only 11% of milk samples collected had density below 1.026g/cc (Table 4.14). The density obtained from the majority of the milk sampled agrees well with the earlier findings by Van den Berg (1988) who reported that, density of normal milk should be around 1.029g/cc.

As milk is considered to be adulterated if the density is lower than 1.026g/cc, from the study it was assumed that nine dairy producers (11.25%), whose milk had a density of below 1.026g/cc might have added water to milk. Another reason for lower density levels might be the feeding regime as it is reported from Schmidt and Van Vleck (1974) that when an animal goes off feed there is a decrease in density of milk. The decrease in density produces the same characteristics as if water were added to milk. Loth (1998) found from the study done in Morogoro, Coast and Dar es Salaam that the majority of the samples collected were having a density between 1.025 and 1.029g/cc. Also, these observations are supported by Ombui *et al.* (1995) in a study done in Kiambu district, as they reported that the majority of samples in

their studies had a density of normal unadulterated cows milk ranging between 1.026 and 1.032g/cc.

Lastly these observations agree well with the finding by Kurwijila *et al.* (1988) in their report on the composition of cow's milk and goat's milk at Magadu dairy farm in Morogoro as they reported that, all types of milk regardless of species or breed to have density of above 1.026g/cc.

Milk acidity for milk samples collected from Kilimanjaro and Coast region had normal range of below 0.2% lactic acid (Table 4.14). This observation agrees well with findings from Van den Berg (1988) who stated that although the acidity of milk varies slightly between species, variations within species are sometimes greater and thus the titratable acidity of cow's milk normally varies between 0.16 and 0.2% lactic acid respectively. Furthermore, O'Connor, (1995) stated that normal fresh milk in which no lactic acid has been produced normally exhibits an initial acidity of 0.16% lactic acid.

However milk physical chemical properties are as shown in Table 4.17, the LSMeans value for milk compositional quality were ranging within the normal range except for a slight difference in butterfat content, total solids and crude protein. Also, it has been observed that milk components obtained from all production systems and from both regions were similar to the other reported values for milk collected from other places (Henderson, 1971; IDF, 1980; Ryoba and Hansen, 1988; O'Connor, 1995 and Loth, 1998).

The LSMeans for total solids was high in milk samples collected from Coast region as compared to milk from Kilimanjaro region. This observation might be due to the nutritive values of feeds taken by the lactating cow, as it was mentioned by Massae (1993) that in Kilimanjaro there is inadequate availability of feed resource and the feed available is of poor nutritive value and hence resulting in poor quality milk. Also from the study, it has been observed that milk samples from Coast region was having higher BF content compared to milk from Kilimanjaro ranging from 4.56±0.37 to 6.32±0.63. The high BF content in milk samples might be due to breed influence as it has been reported by O'Connor (1995) that Zebu cows give milk containing up to 7% butterfat, also Tasker, (1955), Scheineder *et al.* (1948) supports this observation as they report butterfat percentage among Zebu cattle to be in the range of 5 percent to 7 percent. In contrast to this milk from Zebu, in Kilimanjaro was having low butterfat content, the reason for the low BF content might be the feeding regime, as underfeeding have been known to reduce fat content and also fat content is influenced by more roughage intake (O'Connor, 1995).

Except for the low solids not fat value in milk samples from LSC producer from Coast region, the means for SNF from the study in both areas were consistent to the standards stipulated by Tanzania Bureau of Standards (TBS) (1996) for raw milk (8.5% SNF). The low SNF mean value from Coast region might be caused by the influence of temperature as Henderson (1971) regards temperature as largely responsible for the decline in SNF content in milk. Emery (1978) reports that SNF percent tends to decrease as environmental temperature rises above 19^0C. From the study it was observed that milk samples from the traditional cattle keepers in

Kilimanjaro were found to have the lowest LSMean value of 2.2±0.39. The low CP value from this production system might be due to breed of the cow or unusual rations given to the cow.

Therefore the slight differences in milk compositional quality from both areas might be due to environmental, physiological and genetical factors (IDF, 1970; Henderson 1971; Lampert, 1975; Van den berg, 1988 and Loth, 1998). The environmental factors includes nutritional, milk handling, season of calving and general management. While physiological factors are general animal disease and mastitis and the genetic factors, which are most important, are the breed differences and their influence in milk composition alteration.

5.4Thiocyanate content in relation to bacterial multiplication

From the study (Figure 4.1 and 4.2) it was observed that there was a strong relationship between thiocyanate levels in raw milk and bacterial multiplication. The negative correlation shown in Figure 4.1 and 4.2 reveals that, the higher the thiocyanate level in raw milk the lower the bacterial number in raw milk samples. This is probably because natural bacteriostatic effect of natural LP system is proportional to the SCN^- concentration. This is supported by Björk (1978) who reported that the natural antibacterial system in milk enhances the bacteriostatic properties of milk and thus milk stays long without spoilage. Also it has been found out that many gram positive bacteria such as lactic acid *Streptococci* and Lactobacilli are inhibited (Oram and Reiter, 1966., Hoogendoorn,1976) while many gram negative bacteria such as *Escherichia coli*, *Pseudomanas spp*,

Salmonella spp are killed (Reiter *et al.*, 1976., Björk *et al.*, 1975)

5.5 Cyanide content in feed samples

From Table 4.18, it was observed that cyanide levels in feed samples collected from Kilimanjaro and Coast region were having low levels of cyanide. The levels of cyanide in μg/g of dry feed sample varied from 1.2 in maize stem and cobs to 1700 in concentrate mixture. From the study it was revealed that there was a relationship between CN^- content in feed and the thiocyanate content in milk as it was learnt that milk from the traditional cattle keepers who did not feed concentrates was having low levels of SCN^- compared to milk from the LSC and SSC who fed their animals with feeds rich in CN^- content. From Sorbo (1975) it has been reported that in conversion of cyanide into thiocyanate, sulphur containing amino acid are important and thus for cyanide to be converted to thiocyanate, the protein content must be considered otherwise any diet given to lactating cow must be supplemented with protein in order to increase the cyanide concentration. Also glucosinalate containing feedstuffs such as mustard cake, cauliflower, cabbage and mustard fodders are known to increase the levels of thiocyanate in milk (Siha and Singhal, 1993).

5.6 Milk keeping quality

From the study done in Kilimanjaro and Coast region it has been shown that the important part of bacterial action considered was the development of acidity (lactic acid). Lactic acid development has been regarded as one of the properties of bacteria affecting keeping quality of raw milk stored at different temperatures (Harvey and Hills, 1967). Raw milk samples from Kilimanjaro and Coast region stored at 4^0C

after 72 hours of storage had acidity of 0.23% lactic acid and 0.31% lactic acid respectively. Temperature has been regarded as a major factor contributing to lactic acid development in raw milk. Lampert (1975) pointed out that when held at room temperature raw milk sours much more quickly than when held in refrigerator, for the bacteria that cause the development of acid grow much faster around 21^0C than at lower temperature. This case is true in the study as milk stored at 20^0C behaved differently as after 36 hours of storage, milk samples had coagulated and was having acidity of above 0.35% lactic acid.

Raw milk samples from Coast region developed acidity rapidly compared to raw milk samples from Kilimanjaro. Hence from the study done it was revealed that raw milk from Kilimanjaro had a better keeping quality than milk samples from Coast region. From IDF (1961) it is reported that souring of milk results from lactic acid bacteria activity on milk as they grow rapidly at temperatures exceeding 15^0C with an optimum temperature of 30^0C. Growth is very much reduced at temperatures below 10^0C and thus cooling of milk immediately after production is very important in order to prolong the milk shelflife. From the same author it is reported that at 26.7^0C the number of microorganism in milk samples doubled in about one and a half hours, at 15.6^0C. More than four hours are needed to double the number originally present, at 10^0C about eight hours are required and if milk was held at 4.4^0C about 39 hours are required for the number to double the initial count.

From the study done by Macha (1985) on milk keeping quality, it was reported that there is a linear relationship between total bacterial count and milk keeping quality.

Thus the more raw milk is contaminated the poor the keeping quality and *vice versa*. This is reflected well in the study as milk samples from Coast region kept at 20^0C had high bacterial count and as a result it had poor keeping quality while samples from Kilimanjaro kept under the same temperature had a better quality and thus had a better shelflife. Having high bacterial counts attributed to poor keeping quality

From IDF (1961) it is reported that souring of milk results from lactic acid bacteria activity on milk as they grow at temperatures exceeding 15^0C, so the rapid multiplication of bacteria due to high ambient temperature led to poor keeping quality of raw milk.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

From the study done in Kilimanjaro and Coast regions it can be concluded that:

(a) Raw milk samples from the traditional cattle keepers had higher bacterial counts compared to milk samples from LSC and SHC production systems. However, the higher bacteriological counts were contributed by the poor hygienic practices.

(b) Raw milk samples collected from Kilimanjaro and Coast regions had normal milk physical chemical properties except for slight differences. However the observed differences in milk components were due to genetic difference and nutritional factors.

(c) Levels of thiocyanate in milk had a strong relationship with natural bacteriostatis as milk with high levels of thiocyanate had lower bacterial counts and *vice versa*.

(d) Cyanide levels in feeds was not directly related to the levels of thiocyanate in milk.

6.2 RECOMMENDATIONS

(a) Proper feeding regime should be stressed to SHC and LSC dairy producers in order to improve the compositional quality of milk they produce. As from the study it was observed that nutritional factors contributed to low values in milk butterfat, crude protein.

(b) All dairy producers should be educated on the possible methods of improving the keeping quality of raw milk. The following things should be stressed;

i) Producing milk having low initial bacterial count, through following general cleanliness during milking and after milking.

ii) Cooling milk where possible should be done as rapidly and to lower temperature as possible.

iii) Feeding the animals with concentrates in order to increase the thiocyanate concentration in milk and thus activating the lactoperoxidase system, which acts against a wide range of bacteria that are important in milk keeping quality.

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APPENDICES

APPENDIX I: QUESTIONNAIRE ON MILK PRODUCTION

SECTION A. BACKGROUND INFORMATION.

1. Respondent's name

2. background

Village	ward	district	Sex of respondent	Age of respondent	Milk sales area	Source of financing	Prevailling weather condition	Producer category

CODES.

Village	Ward	District	Sex	Source of financing	Other occupation	Weather condition	Producer category
1 = Machame	1=Machame magharibi	1 = Hai	1 = Female	1 = Savings	1 = None	1 = Hot	1 = Traditional
2 = Vigwaza	2 = Vigwaza	2 = Kibaha	2 = Male	2 = credit	2 = Farming	2 = Cold	2 = Smallholder
3 = Lugoba	3 = Lugoba	3 = Bagamoyo		3 = Others (specify)	3 = salaried	3 = Dry	3 = Large scale producer
					4 = Retired	4 = Wet	
						5 = businessman/woman	
						6 = Others (Specify)	

SECTION B. MILKING PRACTICES

2. Practices

Source area District	period in business	Milking method	Place where milking is done	Time of milking	Type of handling vessels	Type of concentrates used when milking

CODES.

District	Period in business	Milking method	Place where milking is done	Type of handling vessel
1 = Hai	1 = One year	1 = Hand milking	1 = In the boma	1 = Plastic
2 = Kibaha	2 = Two years	2 = Machine milking	2 = In the pen	2 = metal
3 = Bagamoyo	3 = Three years		3 = In open air	3 = Glass
	4 = More than three years		4 = In a milking parlour	4 = Stainless steel
				5 = copper
				6 = Others (specify)

SECTION C. MILK HANDLING PRIOR TO SALE

3) Milk handling

Longest period milk stays before sale (hrs)	Do you process milk?	Major sales products	How do you wash the udder	Method of preservation	Type of milk storing can	Mode of cleaning containers	Amount left over and fate

CODES

Process milk ?	Major sales product	Method of preservation	Type of milk storing can	Udder washing	Mode of cleaning containers	Fate of left over milk
1= No	1=fresh milk	1 = Not treated	1 = Plastic	1= using cold water only	1 = Cold water only	1 = Thrown away
2 = Yes	2 = Maziwa lala	2 = Boiling	2 = Metal	2= using hot water only	2= Hot water only	2 = Used by family when raw
	3 = Yoghurt	3 = Refregirating/chilling	3 = Glass	3= hot water and drying	3 =Cold water and soap	3 = Unboiled. naturally fermented
	4 = Milk shake	4 = Cold water bath	4 = Plastic and metal	4=with a dry towel	4 = Hot water and soap	4 = Given to animals
	5 = Cheese	5 = Antibiotic added	5 = Copper cans		5 = Detergent and water	5 = Processed into mala cultured)
	6 = Butter/cream	6 = Hydrogen peroxide/ Lactoperoxidase added	6 = Stainless steel can		6 = Others (specify)	6 = Others (specify)

SECTION D. INFORMATION ON MILK PROCUREMENT

4. Milk procurement

District	Ward	Source type	Organization of collection	Time of collection	Unit of measure	Purchase price	Quality control before receiving
1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3

CODES

Source type	Organization of collection	Quality control measures before receiving milk	Unit of measure
1 = Individual farmer	1 = Farmer(s) deliver to a collection point	1 = Non	1 = Litre
2 = Dairy co-operative society	2 = Trader(s) deliver to a collection point	2 = visual test	2 = Kilogram
3 = private processor	3 = Farmer(s) deliver to trade premises	3 = Alcohol test	3 = Treetop bottle (750 ml)
4 = Self help group	4 = Trader(s) deliver to trading premises	4 = Boiling	4 = Soda bottle (350 ml)
5 = traders/hawkers		5 = Others (specify)	5 = Large cap (500 ml)
6 = Own farm			6 = Others (specify)

Appendix 2: Quality of milk collected from different production systems in Kilimanjaro and Coast region

Env	Prod.sys	TPC	Thermo	Coli	BF	TS	Acidity	Lact	CP	SNF	SCN
1	3	80000	6000	1200	3.65	11.88	0.19	1.0283	2.7	8.26	7.45
1	3	100000	7200	1400	4.2	12.46	0.18	1.0275	3.85	8.3	2.27
1	3	120000	8000	2800	4.15	12.45	0.21	1.0272	4	8.7	7.87
1	2	90000	3200	3500	4.5	13.2	0.21	1.0277	4.19	8.59	10.37
1	1	118000	10000	2000	3	11.59	0.18	1.0295	3.71	8.07	2.5
1	1	380000	19000	2000	3.95	12.02	0.17	1.0265	6.2	8.48	2.89
1	1	248000	15000	1500	4.3	12.78	0.16	1.0278	3.81	8.61	3.02
1	2	290000	5000	1000	2.75	11.36	0.18	1.0298	3.82	8.23	5.41
1	2	270000	4000	2800	3.65	11.88	0.17	1.0283	4.6	8.26	4.2
1	2	220000	6500	1000	4.2	12.46	0.16	1.0275	4	8.69	3.12
1	1	110000	35000	8000	4.55	13.24	0.18	1.0276	4.32	8.01	4.66
1	2	80000	12000	2000	4	12.01	0.19	1.0262	3.2	8.58	2.09
1	2	140000	6000	300	3.5	12.08	0.18	1.0285	3.15	8.31	3.02
1	2	110000	7000	1000	4.65	12.96	0.16	1.0268	3.17	7.67	4.78
1	1	40000	20000	9700	5.5	13.17	0.18	1.0234	4.16	7.63	5.34
1	2	45000	2000	0	4.7	12.33	0.18	1.024	3.67	7.55	3.32
1	2	24000	4000	3300	5.75	13.3	0.19	1.0227	7.6	8.26	5.4
1	2	60000	7800	5000	4	12.26	0.18	1.0272	3.32	8.46	3.43
1			10000	2000	3.5	11.96	0.18	1.0285			

1	2	3500000	5000	2000	3.9	12.85	0.21	1.0271	3.21	7.53	3.1
1	2	391000	3000	0	5	12.53	0.19	1.0246	3.7	8.55	5.97
1	2	40000	13000	8000	4.3	12.85	0.2	1.0268	4.3	7.45	6.49
1	2	1010000	4000	1200	5.4	12.85	0.19	1.0232	3.87	6.19	5.12
1	2	60000	5000	2000	5.4	11.59	0.2	1.0232	3.2	10.24	3.45
1	2	50000	2500	500	3	13.24	0.18	1.0295	2.67	5.53	4.51
1	2	50000	6000	1700	5.72	11.25	0.21	1.0226	5.4	9.11	3.1
1	2	880000	3000	9700	2.23	11.34	0.19	1.032	3.4	8.87	5.63
1	2	62000	4000	7000	2.75	11.62	0.18	1.0297	4.6	10.65	6.75
1	2	170000	10200	7200	2.13	12.78	0.2	1.034	3.17	7.45	2.7
1	2	390000	3000	1600	4.3	11.75	0.19	1.0278	3.15	7.94	2.7
1	2	1010000	5800	2000	3.9	11.84	0.2	1.026	3.44	7.75	7.01
1	2	168000	9800	7600	5	12.75	0.19	1.0242	3.81	7.75	2.01
1	2	1450000	12500	6000	3.6	12.6	0.2	1.027	2.49	9	5.9
2	1	800000	6000	12500	6.5	14.6	0.2	1.029	3.82	8.1	2.87
2	1	1000000	31500	8000	3.6	12.6	0.19	1.027	2.49	9	5.9
2	1	2300000	27500	13500	5.9	13.5	0.18	1.028	4.54	7.6	6
2	1	1900000	14000	5200	4.2	12.7	0.18	1.029	3.46	8.5	7
2	1	2640000	26500	5200	5.9	13	0.19	1.029	4.07	7.1	8.9
2	1	1600000	32000	400	7	14.5	0.19	1.029	3.82	7.5	5.9
2	1	3500000	15000	1200	4.2	13	0.2	1.029	4.94	8.8	5.1
2	1	3300000	10000	2600	3.4	11.9	0.18	1.029	3.72	8.5	6.75
2	1	3600000	24500	3500	6.3	14.6	0.18	1.029	3.53	8.3	4.5
2	1	2100000	37500	2700	5.2	13.8	0.19	1.029	3.68	8.6	6.4
2	1	3800000	12000	900	3.4	12.7	0.17	1.029	4.03	9.3	5.2
2	1	2900000	20000	1500	4.1	12.14	0.17	1.029	3.76	8.04	13.4
2	1	3200000	13000	2600	6.9	14.8	0.18	1.026	3.96	7.9	7.6
2	1	600000	37000	3150	7.2	14.9	0.2	1.027	3.64	7.7	11.2
2	1	1270000	19500	1350	4.9	13.7	0.19	1.029	4.36	8.8	5.6

2	1	3000000	42000	2250	4.65	13.34	0.2	1.026	5.82	8.69	8.2
2	1	1000000	21000	4200	6.5	14.6	0.16	1.028	4.22	8.1	4.9
2	1	720000	9000	1700	6.6	14	0.16	1.029	4.7	7.4	14
2	1	930000	32500	2000	4.9	13.6	0.18	1.026	3.89	8.7	7.5
2	1	55000	21000	4750	3.8	13.4	0.16	1.026	3.59	9.6	5.6
2	2	85000	7500	1500	3.6	11.9	0.18	1.0261	3.2	8.3	5.63
2	2	70000	18000	7300	4.4	12.5	0.19	1.0283	2.8	8.1	3.28
2	2	810000	9000	1900	5.4	13.5	0.19	1.026	3.2	8.5	8.2
2	2	1700000	12000	7800	4.3	12.8	0.19	1.029	3.3	8.5	5.85
2	2	700000	6000	1200	2	11.1	0.2	1.026	3.3	9.1	4.925
2	2	80000	5800	1700	3.1	8.9	0.18	1.028	4	5.8	5.63
2	2	230000	9700	3400	3.8	11.3	0.2	1.029	1.9	7.5	11.08
2	2	890000	6800	2000	4.9	14	0.18	1.0287	3.1	9.1	5.97
2	2	720000	2500	700	4.2	13.1	0.2	1.029	3.7	8.9	7.01
2	2	1010000	1250	700	5.7	14.6	0.18	1.027	3.4	8.9	7.87
2	2	1050000	9800	1700	1.8	11	0.19	1.029	3.2	9.2	6.52
2	2	700000	10000	2600	8.2	15.3	0.19	1.027	3.4	7.1	5.26
2	2	80000	9700	1900	5.9	13.8	0.2	1.029	3.6	7.9	3.02
2	2	120000	3500	800	4.2	13.1	0.18	1.027	3.4	8.9	1.56
2	2	30000	7000	800	6	14.7	0.18	1.027	4.1	8.7	3.69
2	3	2500000	8700	1500	7.2	14.9	0.2	1.027	3.64	7.7	8.9
2	3	1700000	2500	800	5.9	13	0.2	1.029	4.07	7.1	8.8
2	3	1200000	6000	1200	6.6	14	0.19	1.028	4.22	8.1	4.9
2	3	720000	1200	3000	5.9	13.8	0.18	1.029	3.6	7.9	3.02
2	3	460000	7000	8000	6	14.7	0.18	1.027	4.1	8.7	3.7

Note; Env= Environment, Prod.sys= production system, TPC= total plate count, Thermo= thermodurics, BF= Butter fat content, TS= total solids, Lact= Lactometer reading, CP= Crude protein, SNF= Solids not fat, SCN- = Thiocyanate content.

Appendix 3: GLM procedure for laboratory data for raw milk samples from Coast region

Dependent Variable: TPC

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	15986459047619.00000	7993229523809.52000	8.25	0.0011
Error	37	35826750952380.90000	968290566280.56600		
Corrected Total	39	51813210000000.00000			

Dependent Variable: THERM

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	2319987235.11904000	1159993617.55952000	17.94	0.0001
Error	37	2392312702.38095000	64657100.06435000		
Corrected Total	39	4712299937.50000000			

Dependent Variable: COLI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	22345761.90476190	11172880.95238090	2.73	0.0780
Error	37	151158238.09523800	4085357.78635779		
Corrected Total	39	173504000.00000000			

Dependent Variable: BF

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	11.58793750	5.79396875	2.95	0.0648
Error	37	72.68300000	1.96440541		
Corrected Total	39	84.27093750			

Dependent Variable: TS

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	6.76655190	3.38327595	2.07	0.1404
Error	37	60.44303810	1.63359562		
Corrected Total	39	67.20959000			

Dependent Variable: CP

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	3.75941940	1.87970970	5.28	0.0096
Error	37	13.18375810	0.35631779		
Corrected Total	39	16.94317750			

Dependent Variable: SNF

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	0.72419655	0.36209827	0.62	0.5419
Error	37	21.50718095	0.58127516		
Corrected Total	39	22.23137750			

Dependent Variable: SCN

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	27.39714973	13.69857487	2.08	0.1392
Error	37	243.61237464	6.58411823		
Corrected Total	39	271.00952437			

Appendix 4: GLM procedure for laboratory data for raw milk samples from Kilimanjaro region

Dependent Variable: TPC

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	424334321153.8450000	212167160576.9220000	0.51	0.6030
Error	37	15310406653846.1000000	413794774428.2740000		
Corrected Tot	39	15734740975000.0000000			

Dependent Variable: THERM

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	881491512.82051300	440745756.41025600	23.67	0.0001
Error	37	688899487.17948700	18618905.05890500		
Corrected Total	39	1570391000.00000000			

Dependent Variable: COLI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	35555903.84615380	17777951.92307690	2.30	0.1139
Error	37	285403846.15384600	7713617.46361747		
Corrected Total	39	320959750.00000000			

Dependent Variable: BF

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	0.10434417	0.05217208	0.06	0.9414
Error	37	31.89763333	0.86209820		
Corrected Total	39	32.00197750			

Dependent Variable: TS

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	0.15959385	0.07979692	0.22	0.8034
Error	37	13.40944615	0.36241746		
Corrected Total	39	13.56904000			

Dependent Variable: CP

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	5.42568135	2.71284067	2.17	0.1282
Error	37	46.20849615	1.24887827		
Corrected Total	39	51.63417750			

Dependent Variable: SNF

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	0.42955801	0.21477901	0.28	0.7568
Error	37	28.30937949	0.76511836		
Corrected Total	39	28.73893750			

Dependent Variable: SCN

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	17.55193878	8.77596939	2.50	0.0956
Error	37	129.70929872	3.50565672		
Corrected Total	39	147.26123750			