

**ASSESSMENT OF MILK QUALITY AND THE POTENTIAL OF A QUALITY BASED
PAYMENT SYSTEM IN SMALL HOLDER FARMS IN LIMURU AND ELDORET,
KENYA.**

Kevin Kinyua Kabui, BVM (University of Nairobi).

**A thesis submitted in partial fulfillment of requirements for the degree of Master of
Veterinary Public Health (MVPH) in the University of Nairobi.**

DEPARTMENT OF PUBLIC HEALTH, PHARMACOLOGY AND TOXICOLOGY.

FACULTY OF VETERINARY MEDICINE

2012.

DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

Signature: _____ Date: _____

Kevin Kinyua Kabui, BVM.

Department of Public Health, Pharmacology and Toxicology

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

Signature: _____ Date: _____

Prof. S.M. Arimi, BVM, MSc, PhD.

Department of Public Health, Pharmacology and Toxicology

Signature: _____ Date: _____

Prof. E.K. Kang'ethe, BVM, MSc, PhD.

Department of Public Health, Pharmacology and Toxicology

Signature: _____ Date: _____

Dr. Amos Omore, BVM, MSc, PhD.

International Livestock Research Institute (ILRI)

DEDICATION

This thesis is dedicated to my family and friends for their never-ending and overwhelming support through the length of my work. Thank you all for believing in me.

ACKNOWLEDGEMENT

I would like to thank my supervisors, Professors S.M Arimi, E.K. Kang'ethe and Dr. Amos Omore for their invaluable inputs towards the completion of this work. I would also like to thank the University of Nairobi for granting me a scholarship, the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), Kenya Agricultural Research Institute (KARI), International Livestock Research Institute (ILRI) and East Africa Dairy Development project (EADD) for availing funds towards the completion of this work.

Secondly, my heartfelt gratitude goes to all the staff at the Department of Public Health, Pharmacology and Toxicology and in particular, Mr. Nduhiu, Mr. Mainga, Mr. Macharia, Ms. Nduati, Mr. Marimba, Mr. Njoroge, Ms. Leah and Ms. Mercy for their overwhelming support. I extend my thanks to the management and staff of Limuru Dairy Cooperative Society and Metkei Dairy Farmers Limited and to my field assistants, Mr. Wairagi, Ms. Wanja, Mr. Chui, and Mr. Koima for their invaluable assistance.

A big thank you goes to my family, friends and colleagues who have encouraged me through the course of the work. To the farmers I extend my sincere gratitude for your invaluable input without which this work would not have been completed. Thank you so much and keep up the good work.

To all those whom I have not mentioned by name and who, in one way or another, contributed to the success of this work, receive my sincere thanks.

Last but not least I thank the almighty God for giving me the grace, strength and endurance throughout the length of the study.

TABLE OF CONTENTS

DECLARATION.....	i
DEDICATION.....	ii
ACKNOWLEDGEMENT.....	iii
TABLE OF CONTENTS.....	v
LIST OF TABLES.....	xii
LIST OF FIGURES.....	xiii
LIST OF APPENDICES.....	xiv
ABSTRACT.....	xv
CHAPTER ONE.....	1
1.0 INTRODUCTION.....	1
CHAPTER TWO.....	4
2.0 LITERATURE REVIEW.....	4
2.1 Milk and its components.....	4

2.2 Physicochemical Properties of Milk.....	6
2.2.1 Hydrogen ion Concentration (pH).....	6
2.2.2 Oxidation Reduction Potential of Milk (Eh)	6
2.2.3 Density / Specific Gravity	7
2.2.4 Freezing Point.....	7
2.3 Developments in Kenya’s dairy sector	8
2.4 Milk production in Kenya.....	9
2.5 Marketing of milk in Kenya.	12
2.6 Milk quality in Kenya.....	13
2.7 Milk Payment Methods	13
2.8 Methods of testing for Bacteriological Quality of Milk.	14
2.8.1. Clot on Boiling (C.o.B) Test	14
2.8.2 The Alcohol Test	17
2.8.3 Dye reduction tests	17

2.8.4 Total Bacterial Count.....	18
2.8.5 Coliform Counts	19
2.9 Testing Compositional Quality.....	19
CHAPTER THREE	20
3.0 MATERIALS AND METHODS	20
3.1 Study area	20
3.2 Study design	21
3.3 Sample size	23
3.4 Sample collection	25
3.5 Laboratory Tests	25
3.5.1 Compositional Analysis.....	25
3.5.2 Sample preparation	26
3.5.3 Total Plate Count.....	26
3.5.4 Coliform Count.....	27

3.5.5 One Hour Resazurin Test	27
3.5.6 Titratable Acidity.....	28
3.6 Farmer Practices Questionnaire.....	28
3.7 Data Analysis.....	28
CHAPTER FOUR	30
4.0 RESULTS	30
4.1 Bacteriological analysis.....	30
4.1.1 Total Bacterial Count.....	30
4.1.2 Coliform count.....	30
4.1.3 Resazurin test.....	35
4.1.4 Titratable acidity.....	35
4.2 Compositional analysis results	35
4.2.1 Fat content	35
4.2.2 Density.....	36

4.2.3 Freezing point	36
4.2.4 Protein content	36
4.2.5 Solids Not Fat (SNF)	37
4.2.6 Added Water	37
4.2.7 pH	37
4.3 Details of the household	38
4.3.1 Age.....	38
4.3.2 Farming experience	38
4.3.3 Training	38
4.3.4 Milk testing.....	39
4.3.5 Grazing system	39
4.4. Dairy farmer practices	39
4.4.1 Hand washing	39
4.4.2 Udder washing	40

4.4.3 Teat dipping.....	40
4.4.4 Milk containers	40
4.4.5 Water source	41
4.4.6 Distance and time taken to the milk collection centre.....	41
4.4.7 Transport to the milk collection centre.....	42
4.4.8 Housing cows	42
4.4.9 Drugs withdrawal period after treatment of the cows.	43
4.4.10 Milk composition parameters	43
4.4.11 Milk tests	43
4.4.12 Payment on quality	43
4.4.13 Cattle feeding.....	44
4.5 Correlation between the microbiological tests.	44
4.6 Regression analysis.....	47
CHAPTER FIVE	48

5.0 DISCUSSION.....	48
CHAPTER SIX.....	54
6.0 CONCLUSION	54
6.1 RECOMMENDATIONS.....	54
CHAPTER SEVEN	56
7.0 REFERENCES	56
CHAPTER EIGHT	65
8.0APPENDICES	65

LIST OF TABLES

Table 1: Gross composition of bovine milk in grams per 100 ml	5
Table 2: Bacterial Quality Grading in Denmark	15
Table 3: Somatic cell quality grading in Denmark.....	16
Table 4: Number of registered members and samples taken per collection centre in Limuru and Eldoret	24
Table 5: The percentage of samples with various Total counts/ml from Limuru.	31
Table 6: The percentage of samples with various Total counts/ml from Eldoret.....	32
Table 7: The percentage of samples with various Coliform counts/ml from Limuru.	33
Table 8: The percentage of samples with various Coliform counts/ml from Eldoret.	34
Table 9: Correlation between direct and indirect microbiological test results of the milk from Limuru.	45
Table 10: Correlation between direct and indirect microbiological test results of the milk from Eldoret.	46

LIST OF FIGURES

Figure 1: Annual milk production in Kenya.....	11
Figure 2: Milk delivery chain in Limuru and Eldoret.	22

LIST OF APPENDICES

Appendix 1: Dairy farmer practices questionnaire.....	65
Appendix 2: Limuru Milk Composition Parameters.....	73
Appendix 3: Eldoret Milk Composition Parameters	74

ABSTRACT

The dairy sub-sector in Kenya accounts for 14% of the agricultural gross domestic product (GDP) and 3.5% of the national GDP. The sub-sector is mainly made up of small scale dairy farmers who are scattered in high and medium potential areas of the country (USAID report, 2008). These small scale farmers account for approximately 75% of the milk produced which is currently estimated to be more than four billion liters (FAO stat, 2011). Most of this milk is informally marketed and paid for based on quantity. Public health concerns have been raised on the quality of this milk and considering that consumers were found willing to pay more for improved milk safety and quality attributes, the safety and quality of the milk produced by small scale dairy farmers who are the predominant players in the dairy industry has to be guaranteed in order to enable them retain and access convectional markets. This study was conducted in Limuru and Eldoret to determine the quality of milk produced by small scale farmers and their perceptions on a quality based milk payment system.

The study design was cross sectional where 297 individual and 10 bulk milk samples were systematically sampled and 252 questionnaires administered at the household level for both study areas. Direct and indirect bacteriological analysis was done using the total count, coliform count, titratable acidity and resazurin tests. Compositional analysis was done by testing for the fat content, solids not fat (SNF), density, protein and added water using a milk analyzer (Lactoscan).

A questionnaire on farmer practices was administered at the household level to assess knowledge on milk hygiene aspects and perceptions on quality based milk payment system. The results

obtained from the assessment of the bacteriological and compositional quality were judged against the Kenya Bureau of Standards (KeBS) bench marks.

Of the milk samples collected in Limuru, 78% and 91% were of good quality based on total counts (≤ 2 million cfu/ml) and coliform counts ($\leq 50,000$ cfu/ml) respectively. From Eldoret, 78% and 92% of the milk samples were of good quality based on the same benchmarks for total and coliform counts, respectively. Analysis using the resazurin test indicated that 77% and 83% of the samples from Eldoret and Limuru respectively had readings ranging from 4-6 on the Lovibond comparator indicating that the milk was of good acceptable quality. Eighty percent of the samples from Limuru were found to have acidity levels within the acceptable range of 0.16 ± 0.02 and therefore judged to be of good quality for the titratable acidity test.

The compositional analysis results from Limuru showed that the average pH was 6.63, fat 3.8%, density 1.027 g/ml, protein 3.1%, freezing point -0.541° C, added water 3.42% and solids not fat 8.2%. The average pH, fat and the freezing point were within the recommended ranges while the SNF, protein and density were below the recommended ranges. Added water was above the limit set indicating presence of adulteration.

The compositional analysis for Eldoret samples showed that the average pH was 6.64, fat was 4.28%, density was 1.028, protein was 3.64%, freezing point was -0.556 , added water was 1.88% and solids not fat was 9.23%. The average pH, fat, density, protein and freezing point were within the recommended levels while added water was above the limit due to adulteration.

A correlation analysis between the direct and indirect bacteriological tests showed that there was a significant positive correlation between the resazurin test and the total count ($r = 0.70$; $p < 0.05$ and $r = 0.25$; $p < 0.05$) and coliform count ($r = 0.55$; $p < 0.05$ and $r = 0.23$; $p < 0.05$) in both study areas.

Results from the questionnaire survey revealed that most farmers (84 % in Limuru and 98% in Eldoret) would accept a system of payment on quality provided there was appropriate incentive. Most farmers (82%) were also found to be adhering to recommended dairy hygiene practices such as washing the milk cans with hot water and soap. Regression analysis at a significance level of 5% showed that none of the independent variables investigated contributed significantly to the quality of the milk.

The overall milk quality from both study areas could be termed as acceptable based on the KeBS benchmarks. This could have been related to good dairy farmer practices that were observed such as hand washing, timely removal of manure, proper cleaning of milk cans and use of recommended bedding material. Continued application of these practices would help in improvement of the quality of milk and decrease losses due to rejected milk.

The study concludes that it is possible to introduce a system of milk payment on quality where the resazurin test can be introduced as a screening test for the bacteriological quality at the milk collection centre level. It is recommended that a pilot study be conducted to test the applicability of such a system

CHAPTER ONE

1.0 INTRODUCTION

Agriculture has been the backbone of the Kenyan economy for many years. Currently, the sector accounts for 30% of the gross domestic product (GDP) and 80% of the national employment, mainly in the rural areas (Price Waterhouse Coopers, 2010; Muriuki *et al*, 2001). The dairy sub-sector accounts for 14% of the agricultural GDP and 3.5 % of national GDP. Smallholder dairy farmers approximated to be more than 1.8 million (National Dairy Master Plan, 2010) and scattered in high and medium potential crop-livestock systems comprise the largest group of the dairy players (USAID report, 2008). They also account for approximately 75% of the total milk that is produced in the country, which is estimated at more than 5 billion litres (Kenya Dairy Board, 2011; FAO Stat, 2011).

The dairy sub- sector in Kenya has evolved over the years from predominantly large scale herds that were mainly kept by white settler farmers in the earlier years of the last century to small scale herds which were started after 1954 when the Swynnerton plan allowed indigenous Kenyans to engage in commercial agriculture (Omore *et al*, 1999). However, the major shift in the dairy sector was seen after its liberalization in 1992, which led to a stimulated increase in small scale trading in fresh milk (Owango *et al*, 1998). This contributed to what is currently the largest dairy subsector in Eastern and Southern Africa accounting for over 70% of the dairy cattle population (Muriuki *et al*, 2001; Thorpe *et al*, 2000) with an estimated average milk per capita consumption of 145 liters per year (ILRI annual report, 2007). The amount of milk produced has

also increased over the years apart from a decline in 2008 which was mainly attributed to the post election violence that affected some of the high milk potential areas especially in the Rift Valley Province (Zvomuya, 2008).

Ninety percent of the milk produced in Kenya is informally marketed; 42% of which is sold raw directly to consumers, about 24% is sold through dairy cooperatives, 2% sold directly to processors, 17% sold to mobile traders and 15% sold through milk bars and kiosks (Omore *et al*, 2002; Omore *et al*, 2005). Most of this marketed milk is paid for based on quantity as opposed to payment based on compositional and microbiological quality which is mainly practiced in most countries of the developed world.

In a study done by Mwangi *et al* (2000), public health concerns were raised about the quality of milk produced in Kenya. It was concluded that a huge percentage of milk that reached the consumers from both informal and formal agents was below the Kenya national standards with 60-80% of samples collected from various market pathways, including pasteurized milk, failing to meet standards set by the Kenya Bureau of Standards.

Adoption of a quality based milk payment system can help improve the overall quality of the milk produced as shown by a study done by the International Dairy Federation (IDF) where 82% of the countries in Europe participating in a milk improvement program achieved their objectives (FOSS analytical, 2005). Another study done by Pirisi *et al* (2006) in sheep and goat milk in France, found out that the bacteriological count declined by up to 10.8% per year within a period of 10 years after the introduction of a payment on bacteriological quality system.

The safety and quality of the milk produced by small scale dairy farmers who are the predominant players in the dairy industry has to be guaranteed in order to enable them retain and access convectional markets; putting into consideration that consumers were found willing to pay more for improved milk safety and quality attributes (Makokha and Fadiga, 2009).

To address this issue therefore, a study was conducted with the broad objective of assessing the milk quality and quality based payment system in small holder farms in Limuru and Eldoret.

The specific objectives of the study were:

- To determine the bacteriological and the compositional quality of milk samples collected from individual farmers at milk collection centres in the study areas and identify the most appropriate test for use under laboratory conditions.
- To evaluate farmers' perceptions and practices associated with good and bad quality milk as basis for benefitting from quality based payment system.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Milk and its components

Milk is one of the oldest foods known to man and is defined as the normal, clean and fresh secretion, without any addition or subtraction, extracted from the udder of a healthy cow, and free from colostrum, i.e. excluding that which is got during the first seven days after calving (Draft East African standards on raw milk, 2010).

Milk is a complex mixture of fats, proteins, carbohydrates, minerals, vitamins and other miscellaneous constituents dispersed in water (Harding, 1999). Apart from milk being important for nutrition of the young, milk borne biologically active compounds such as casein and whey proteins have been found to be increasingly important for physiological and biochemical functions that have crucial impacts on human metabolism and health (Gobbetti *et al*, 2002). These compounds have been found to be useful in guarding humans against pathogens and illnesses (Park, 2009).

Milk composition varies between species, breeds and individual animals depending on the management systems.

Table 1: Gross composition of bovine milk in grams per 100 ml

	Maximum	Minimum	Average
Water	90.5	80.5	87.2
Fat	8.2	1.7	3.7
Proteins	5.5	1.4	3.5
Lactose	6.1	2.5	4.9
Ash	1.2	0.4	0.7

Adapted from Park, 2009.

2.2 Physicochemical Properties of Milk

2.2.1 Hydrogen ion Concentration (pH)

The pH or the hydrogen ion concentration of milk gives a measure of the acidity of milk. In normal cow milk, the pH ranges from 6.6 to 6.8. The pH value can be lower than 6.6 due to development of acidity even though milk has normal acidity range of 0.1- 0.16%, which is mainly attributed to the phosphates, citrates and carbon dioxide present in milk (Draft East African standards on raw milk, 2010). The pH value can be greater than 6.8 mainly due to mastitis.

Milk pH can be determined indirectly or directly. Direct measurement is through the use of indicator dyes, titratable acidity or use of pH meters. Indirect measurement is done through the clot on boiling and alcohol tests.

2.2.2 Oxidation Reduction Potential of Milk (Eh)

The oxidation- reduction potential (Eh) is the balance between oxidized and reduced forms of the chemical substances in milk. The Eh of normal milk falls within +0.2 to + 0.3 volts (Bundelkhand University, Institute of Food Technology website <http://www.iftbu.org/milk.htm> on 12th May, 2011.)

The test for the Eh is more accurate than boiling or alcohol test in judging the keeping quality of milk and is also a measure of the degree of spoilage.

2.2.3 Density / Specific Gravity

The specific gravity of milk is the ratio of the density of milk to density of water. The specific density should range between 1.028 g/ml – 1.036g/ml. The reading is done using a lactometer.

The specific gravity in milk is lowered by addition of water and cream and is increased by addition of skim milk or removal of fat (Draft East African standards on raw milk, 2010; Bundelkhand University, Institute of Food Technology website, <http://www.iftbu.org/milk.htm> on 12th May, 2011.)

2.2.4 Freezing Point

This is the most constant physical property of milk and is determined by the number of solute particles present. Milk freezes at a lower temperature than normal water with its freezing point lying between -0.525 °C and -0.565 °C. Presence of soluble constituents lowers the freezing point. The freezing temperature can be determined using a cryostat (Draft East African standards on raw milk, 2010; Bundelkhand University, Institute of Food Technology website, <http://www.iftbu.org/milk.htm> on 12th May, 2011) and also through the use of electronic milk testing devices e.g. the lactoscan (Lactoscan website, http://www.lactoscan.com/usefull_info/english/freezepoint.html accessed on 29th January 2012.)

2.3 Developments in Kenya's dairy sector.

The market-oriented dairy farming with exotic cattle in Kenya started when European settlers introduced dairy cattle breeds from their native countries (Omore *et al*, 1999; Conelly, 1998). Most of these settlers occupied the most agriculturally productive highland areas in central parts of Rift Valley and Central Provinces. Cross-bred cattle dairy production by Africans started after 1954 when a colonial policy paper, the Swynnerton Plan of 1954, allowed them to engage in commercial agriculture. By 1963, when Kenya attained independence, the dairy herd had expanded to about 400,000 exotic cattle and their crosses with the local East African zebu (Thorpe *et al*, 2000).

The smallholder herds started expanding after independence followed by the exit of the settlers who sold most of their land to African smallholders. However, the most significant change in the Kenyan dairy subsector came with the liberalization of milk marketing in 1992 (Omore *et al*, 1999).

The major impact has been a rapid growth of the formal and informal private sector which provides input and output services, and a redistribution and increase of the overall social and economic benefits of market-oriented dairying to smallholder producers, market agents and consumers in Kenya (Thorpe *et al*, 2000).

2.4 Milk production in Kenya

Kenya has one of the largest dairy industries in sub-Saharan Africa with a well developed production and processing capacity based on more than five million improved cattle. The dairy herd in Kenya is the largest such herd in Africa with more dairy cattle than the rest of the countries in Eastern and Southern Africa combined (Staal *et al*, 2008).

Milk production in Kenya has been rising steadily from the early years of the twenty-first century (Fig 1). The growth has been mainly driven by increases in yields per cow which still remains below international standards. South Africa and Argentina have yields ranging between 2500 and 3500 kilograms per year (East African Dairy Development (EADD), 2008) while the yields in Kenya have been reported to be up to 1,500 kilograms per year mainly due to low level of supplementation, limited access to production services and the level of management (Zvomuya,2008).

Most of the dairy production is concentrated in Rift Valley and Central provinces. Fifty three percent of dairy cattle are found in the Rift Valley and 25% in Central Province. Milk from these two provinces is sold mainly to urban areas within these provinces while some of it makes it to Nairobi (EADD, 2008).

According to the projections by the Ministry of Livestock Development (MoLD) and the Kenya Dairy Board (KDB), milk supply is bound to grow by at least 4.5% per annum in the next four

years from an estimated 4.2 billion litres currently to almost 5 billion litres by 2014. The country then is likely to face a surplus of up to 17% which translates to an increase in exports.

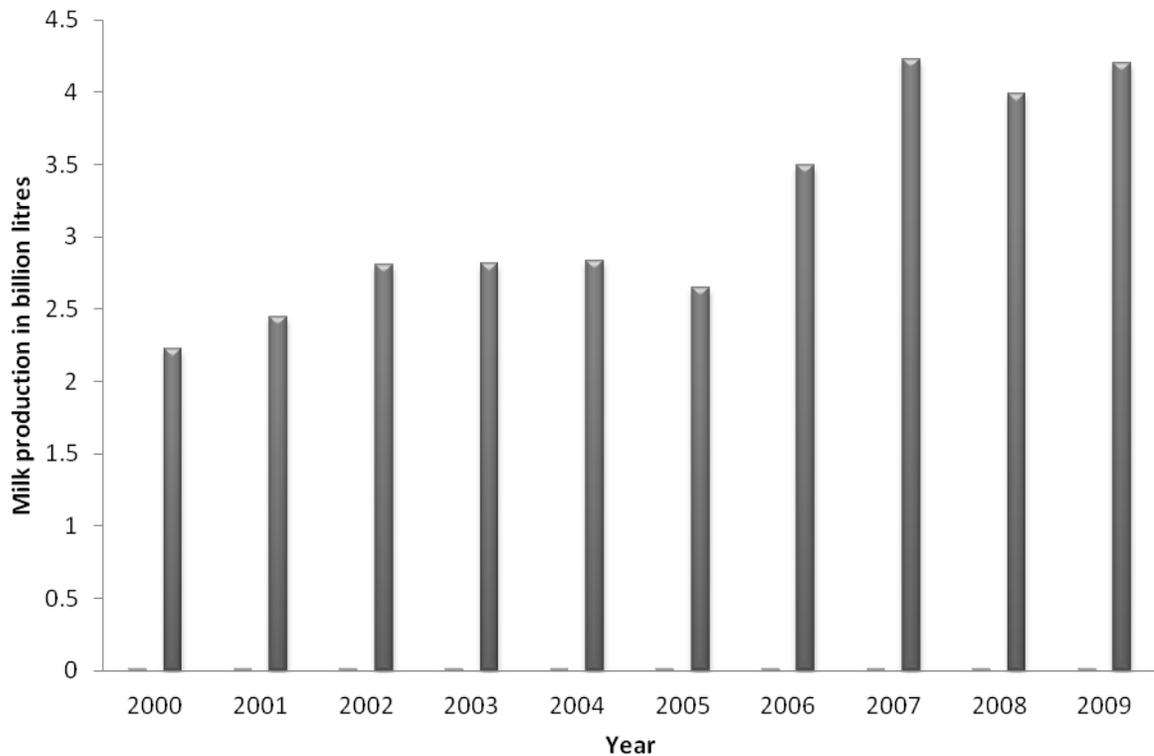


Figure 1: Annual milk production in Kenya (Data adapted from Kenya dairy website accessed at www.Kenyadairy.com on 30th May 2011; FAO Stat, 2011.)

The fall in production in 2008 was mainly attributed to the post-election violence of 2007-2008 which led to loss of dairy animals and displacement of small scale dairy farmers especially in the Rift valley (Zvomuya, 2008).

The general upward trend in milk production over the years has been attributed to among other things a change in policy in the dairy industry in 2004 and increases in yield per cow (EADD, 2008; Wambugu *et al*, 2011).

2.5 Marketing of milk in Kenya.

Before the liberalization of the dairy sector, the Kenya cooperative creameries (KCC) marketed most of the milk produced in the country. Thirty four percent of the milk supplied was from large scale producers, 54% from small scale producers through their cooperatives and 12% from individual farmers who supplied directly (Staal *et al*, 2008).

The smallholder herds account for 70% of the milk production in Kenya and 80% of the marketed milk (Omore *et al* 1999). From the annual smallholder dairy herd production, approximately 36% is consumed on farm and the rest (64%) is marketed as surplus, either through direct sales to individual consumers, co- operatives, self-help groups and traders or through sale to private processors.

Marketing infrastructure is most advanced in Central Province, especially in Kiambu District, where dairy co-operatives play a major role, while direct sales from producers to consumers are common in Coast, Southern Rift Valley and Western Kenya. Sales of processed milk by KCC and private dairies comprise only 19% of marketed milk, most of which is sold in Nairobi (Omore *et al*, 1999).

The main participants in informal marketing are dairy cooperatives, milk bars, traders/ middlemen and farmers. Dairy cooperatives have played a critical role in milk procurement systems in some areas of Kenya where there are significant local milk surpluses that small scale

informal markets cannot handle. They also provide a functional means to access larger formal markets (Staal *et al*, 2008).

2.6 Milk quality in Kenya.

In a study done by Mwangi *et al*, (2000), it was concluded that a huge amount of milk that reached the consumers from both informal and formal agents was below the Kenya national standards on milk with 60-80% of samples collected from various market pathways, including pasteurized milk, failing to meet the minimum standards set by the Kenya Bureau of Standards (KeBS). The study also found out that bacterial counts were already high by the time the milk reached the informal market which partly could have been attributed to the general lack of a cold chain. On the contrary, milk from dairy co-operatives was found to be of better quality most likely due to higher hygiene standards and better handling (e.g. testing for adulteration, use of aluminum containers and chilling equipment).

However, according to Omore *et al*, 2000, health risks from bacterial contamination are already judged to be low because of the common consumer practice of boiling milk before consumption and this may decrease the need for strict implementation of regulations preventing raw milk marketing.

2.7 Milk Payment Methods

Milk payment is made based on quantity measure (volume or weight), the compositional quality or the hygienic quality. Milk payment system in Kenya is based on the quantity measure.

The percentage fat and solids in milk form the basis of most payment systems that are based on compositional quality while payment on hygiene depends on the tests used to determine milk hygiene accompanied by a grading structure. The payments are usually bonuses/penalties or other incentives e.g. feed (Draaiyer *et al*, 2009). Most European countries have adopted milk payment systems based on quality for example Denmark, where the price of milk may be determined by the protein and fat composition in milk or the bacteriological quality as shown in Tables 2 and 3. The system outlines the maximum deductions and the minimum prices to be paid for the milk supplied. To grade the quality of milk, a sample is taken from individual farmers on a weekly basis and tested for bacteriological, cell count and added water (FOSS analytical, 2005)

2.8 Methods of testing for Bacteriological Quality of Milk.

2.8.1. Clot on Boiling (C.o.B) Test

This is one of the oldest tests for abnormal acidity levels in milk, which is brought about by too much acid in milk ($\text{pH} < 5.8$). The test is performed by boiling a small amount of milk in a spoon, test tube or any other suitable container. If there is coagulation or precipitation, the milk fails the test. The test is not sensitive to slightly sour milk (O'Connor, 1995; Draaiyer *et al*, 2009).

Table 2: Bacterial Quality Grading in Denmark

	Class limit cfu /ml	Recommended price adjustment
Class 1 extra	$\leq 30,000$	+1%
Class 1 B	30,001 to $\leq 50,000$	0
Class 2	50,001 to $\leq 200,000$	-4%
Class 3	$> 200,000$	-10%

Adapted from FOSS analytical report (2005).

Table 3: Somatic cell quality grading in Denmark.

	Class limit cells/ml	Recommended price adjustment
Class 1 S	$\leq 200,000$	2%
Class 1 extra	200,001 to $\leq 300,000$	1%
Class 1	300,001 to $\leq 400,000$	0
Class 2	400,001 to $\leq 500,000$	-4%
Class 3	$> 500,000$	-10%

Adapted from FOSS analytical report (2005).

2.8.2 The Alcohol Test

The test is quick, simple and is used as a screening test. It is based on instability of the proteins when the levels of acid and/or rennet are increased and acted upon by the alcohol. Also increased levels of albumen (colostrum milk) and salt concentrates (mastitis) results in a positive test.

The test is done by mixing equal amounts of milk and 68% ethanol (usually 2ml) in a small bottle or test tube. If the tested milk is of good quality, there will be no coagulation, clotting or precipitation upon shaking (O'Connor, 1995, Draaiyer *et al*, 2009).

2.8.3 Dye reduction tests

The tests are based on the changes of certain dyes (put in milk) within a time frame due to oxidation reduction changes resulting from the metabolism of the organism present in the milk; it is an indirect measure of the number of microorganisms present in the milk. These tests include the resazurin and the methylene blue reduction tests.

It is generally assumed that the greater the number of bacteria in milk, the quicker the oxygen will be consumed, and in turn the sooner the color will disappear. Thus, the time of reduction is taken as a measure of the number of organisms in milk (O'Connor, 1995; Draaiyer *et al*, 2009).

2.8.4 Total Bacterial Count

2.8.4.1 Standard Plate Count (SPC)

Standard plate count is the official regulatory test used for estimating bacterial populations of raw milk and milk products (Ruegg and Reinemann, 2002).

A high standard plate count is indicative of a milk quality problem usually caused by errors in cooling milk or cleaning milk equipment. Rarely, a high bacteria count can be associated with sub-clinical mastitis, especially by *Streptococcus* species (Hayes *et al*, 2001)

The test is performed by pipetting standard dilutions of milk (usually tenfold) into petri dishes, adding standard plate count agar and incubating the plates at 32°C for 48 hours. Bacterial colonies are then counted using a variety of methods depending upon the colony types present. The standard plate count is computed based on the dilution and the number of colonies present (Ruegg and Reinemann, 2002).

2.8.4.2 Alternative Methods of Total Bacteria Determination

The bactoscan method is a technologically advanced method that uses epifluorescent microscopy to count bacterial cells that have been stained with acridine orange. This method has compared favourably to traditional bacteriologic methods and is considered less variable and more reproducible (Lachowsky *et al*, 1997).

2.8.5 Coliform Counts

These counts are performed by culturing dilutions of raw milk on selective indicator media such as Violet Red Bile agar and incubated at 37°C for 24 hours. The counts are indicative of the effectiveness of cow hygienic preparation procedures during milking and cleanliness of the cow's environment (Davidson *et al*, 2004)

2.9 Testing Compositional Quality

Compositional characteristics are the features of raw milk related to natural composition that has special importance in processing e.g. fat content and total solids.

Simple but time consuming tests have been developed over the years to determine the composition of milk. These tests require laboratories with relatively costly equipment, materials and staff. More recently user-friendly, low-cost and rapid automatic milk analyzers have been developed and successfully introduced for small-scale as well as large-sale applications. These units require minimal space and give virtually instant results (Draaiyer *et al*, 2009).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study area

The study was carried out in Limuru District in zones that supply Limuru Dairy Cooperative Society with milk and in Eldoret in zones that supply Metkei Multipurpose Dairy Limited. The two areas were chosen because they had established dairy cooperatives and because the study was to be a follow up on another done by Makokha and Fadiga (2009) in the same areas to determine the quality attributes that consumers looked for in milk and meat products.

Limuru Dairy Cooperative has over seven thousand registered members but as of August 2010, only 2580 members were active. The Dairy Society had 32 milk collection centres spread out in five administrative zones. The zones and the number of collection centres per zone were as follows; Limuru- 7, Murengeti- 3, Ndeiya- 10, Ngecha- 7 and Rironi-5. The collection centres from which milk was sampled were conveniently selected based on ease of accessibility and the number of farmers who supplied milk to the centres. The centres, number of registered farmers and samples taken per centre are as shown in Table 4.

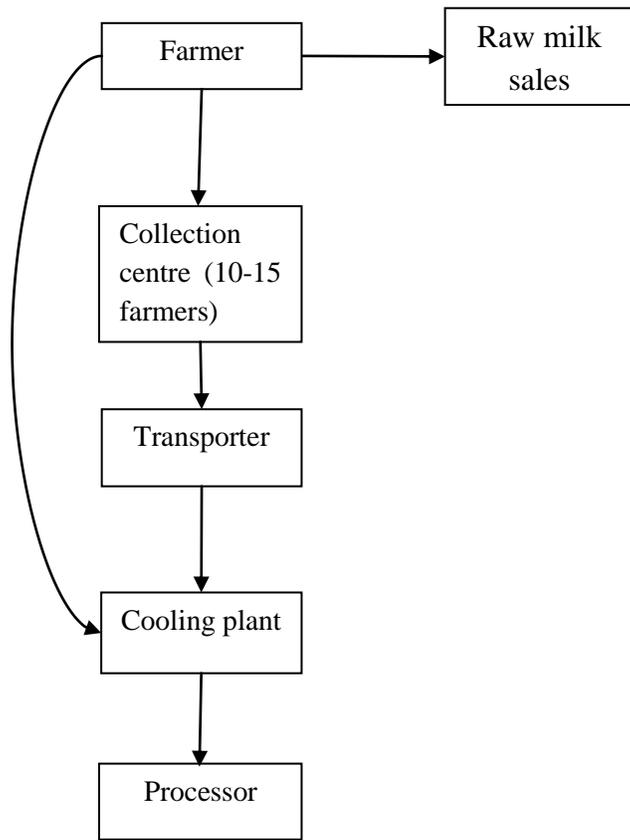
Metkei Multipurpose Dairy Limited is a company that has a milk cooling facility that serves four Dairy Cooperatives in Keiyo South district namely; Metkei, Kipsaos, Tulwobei and Kapkitony. The milk collection centres serving the dairy were made up of a maximum of 15 farmers unlike in Limuru Dairy where they were made up of more than fifty farmers (Figure 2).

Milk from the collection centres, which were located at farm gates, was bulked by contracted transporters and delivered to the cooling plant and thereafter sold to processors. Some farmers delivered their milk directly to the cooling plant. Sampling was done before bulking from systematically selected farmer's cans at the collection centres.

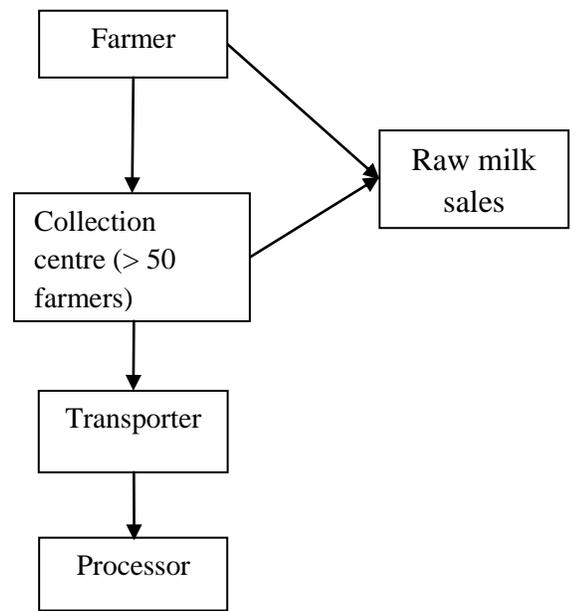
3.2 Study design

This was a cross sectional study where milk samples were collected from systematically selected dairy farmers at the dairy collection centers.

Structured dairy practice questionnaires were administered at the household level to the same farmers whose milk had been sampled to determine those practices that may affect the quality of milk and also to establish farmers' views on a system of payment based on grading and payment of a premium on milk with low counts delivered to the cooperative.



Milk delivery chain in Eldoret



Milk delivery chain in Limuru

Figure 2: Milk delivery chain in Limuru and Eldoret.

3.3 Sample size

The calculated sample size was based on a study done by Ombui *et al* (1994) on total counts and coliform counts in cooperative dairy farmers' cans in selected dairies in Kiambu district.

The sample size was calculated using the formula from Martin *et al*, 1987.

$$n = \frac{Z\alpha^2 Pq}{L^2}$$

Where:

$Z\alpha$ is 1.96, P is the proportion of milk deliveries that meet quality standards from farmers' milk cans taken to be 80%, q is 1-p, L is precision at 0.05

The calculation gave a sample size of 246 samples.

Ninety five (95) individual and 10 bulk milk samples and 202 individual samples were collected from selected collection centres and transporters in Eldoret and Limuru respectively. The disparity in the number of samples taken in the two study areas was occasioned by limited funds for the study in Eldoret.

Table 4: Number of registered members and samples taken per collection centre in Limuru and Eldoret

Zone	No of registered members/ zone	Collection centres sampled from	No. of samples taken
Limuru	267	Kwambira	29
Murengeti	253	Murengeti	29
Ndeiya	696	Tiekunu	42
Ngecha	890	Ngecha	29
		Kabuku	23
		Nyathuna	10
Rironi	474	Rironi	10
		Gatimu	10
		Muguga	20
Eldoret	225	Metkei	53
	150	Kipsaos	42
		Bulk milk	10
		Total	307

3.4 Sample collection

The milk samples were collected from individual farmers who brought milk to the collection centres. They were systematically sampled by assigning raffle tickets to every third person on the queue before weighing and pooling of milk was done.

The milk was aseptically sampled using an aluminium ladle that was first flamed and cooled before being used to thoroughly mix the milk and then collect approximately 100 ml which were then distributed into two sample bottles. One bottle was for milk designated for microbiological analysis while the other bottle was for milk designated for compositional analysis. All the sample bottles were properly labelled, stoppered and transported to the laboratory in an ice packed cooler box. The bulk milk samples were collected from various milk transporters using the same procedure.

3.5 Laboratory Tests

Laboratory tests were carried out at the Department of Public Health, Pharmacology and Toxicology, the Central Veterinary Laboratories, Kabete, the Regional Veterinary Laboratories, Eldoret and the Metkei Multipurpose Limited laboratory, Eldoret.

3.5.1 Compositional Analysis

The analyses were carried out using a lactoscan which was able to give the fat content, solids non fat, added water, density, freezing point and the protein content of the milk.

3.5.2 Sample preparation

A test sample to determine dilutions to be used for the Total count and Coliform count was prepared by making two preparations of 1 ml dilutions in saline (0.85% NaCl) of the sample from 10^{-1} to 10^{-7} . The two preparations were plated and incubated in plate count agar at 32° C for 48 hours and violet red bile agar at 37°C for 24 hours for Total counts and Coliform counts respectively. Plates with counts between 30-300 for Total counts and 15-150 for Coliform counts were selected. From the two preparations of the test sample, it was determined that dilutions 10^{-1} to 10^{-4} were to be used for the Coliform count while dilutions 10^{-3} to 10^{-7} were to be used for the Total count.

3.5.3 Total Plate Count

The samples were examined for Total plate count as per Houghtby *et al.* (1992) where 1ml of dilutions 10^{-3} to 10^{-7} was placed into labelled sterile petridishes and molten standard plate count agar (PCA) (Oxoid®) which had been prepared and maintained in a water bath at 50 ° C added, mixed well and left to solidify. The petridishes were then incubated at 32° C for 48 hours after which petridishes with colonies ranging from 30-300 were selected for counting using a colony counter.

The results were interpreted as per the Kenya Bureau of Standards (KeBS) / proposed East African guidelines on Total counts where samples with less than 2 million cfu/ml were acceptable.

3.5.4 Coliform Count

The coliform count was done as per Christen *et al.* (1992) where 1 ml of dilutions 10^{-1} to 10^{-4} was placed into sterile labelled petridishes and molten sterile violet red bile agar (VRBA) (Oxoid[®]) which had been maintained in the same temperatures as the PCA added. Mixing was then done and the media left to solidify. Incubation was done at 37°C for 24 hours after which typical red coliform colonies were identified and petridishes with colonies ranging 15-150 were selected for counting.

The results were interpreted as per the Kenya Bureau of Standards (KeBS) / proposed East African guidelines on Coliform counts where samples with less than 50,000 cfu/ml were acceptable.

3.5.5 One Hour Resazurin Test

The resazurin test was done as per Draaiyer *et al.*, (2009) where the resazurin tablet (Surechem) was completely dissolved in 50 ml of sterile distilled water according to the instructions of the manufacturer. One millilitre of the resulting solution was transferred into 10 ml of the milk sample in a test tube and mixed, incubated at 37° C for 1 hour in a water bath. The samples were then read using a Lovibond comparator 2000+ (Tintometer ltd) for colour change and designated numerical score value that ranged from 1-6. A milk sample without the resazurin dye was similarly treated and used as the blank in the comparator.

3.5.6 Titratable Acidity

The titratable acidity test was done as per Draaiyer *et al*, (2009) where ten millilitres of the milk sample were put in a beaker stood on a white tile. Four drops of 1.6% phenolphthalein pH indicator were added into the milk sample and mixed. Titration was done using 0.9 N sodium hydroxide with constant shaking of the milk until an observable permanent colour change (pink) was noticed. The amount of sodium hydroxide used was then recorded and the acidity of the milk calculated by dividing the amount of base used by the volume of the milk sample. This was then expressed as lactic acid percent.

3.6 Farmer Practices Questionnaire

A questionnaire on farmer practices was administered to farmers at the house hold level to assess knowledge on milk hygiene aspects and also to get their attitude towards payment based on composition and hygienic quality (Appendix 8.1)

3.7 Data Analysis

A database was created in Microsoft Excel (2007) for the laboratory and questionnaire data analysis. The data was then exported to STATA 12[®] where summary descriptive statistics and correlation analysis between the indirect (resazurin and titratable acidity) and the direct (total count and coliform count) bacteriological tests was done.

Regression analysis was also performed to investigate whether certain identified factors i.e. Hand washing, udder washing, water source, distance from farm to the collection centre, time taken to collection centre, housing of the animals, type of bedding and frequency of manure removal contributed to the microbiological quality of the milk. The coliform and total counts were transformed by converting them to Log_{10} values to normalise their distribution. Dummy variables were created for each of the categorical variables where the factor under investigation was assigned a value of 1 while the rest were assigned a value of 0 e.g. in the case of water source which had several categories - piped water, rain water, community pump water, private pump water and river/stream water, if a value of 1 was assigned to piped water, the other sources of water would be assigned 0.

Linear regression analysis using the forward and backward options was carried out between the identified factors and the Log_{10} coliform and total counts from both study areas. Reference categories were identified and not included in the regression model to avoid over specification.

CHAPTER FOUR

4.0 RESULTS

4.1 Bacteriological analysis

4.1.1 Total Bacterial Count

In Limuru, 157/ 202 (78%) had counts equal or less than 2,000,000 colony forming units(cfu) per ml while in Eldoret, 78% of the individual samples (74/95 milk samples) and 50% (5/10) of the bulk samples had counts equal or less than 2,000,000 cfu/ per ml.

The rest of the milk samples 45/202(22%) from Limuru and 21/95(22%) from Eldoret, had counts over 2,000,000 cfu/ per ml (Table 5 and 6).

4.1.2 Coliform count

In Limuru, 184/202(91%) had counts less than 50,000 coliforms/ ml while in Eldoret, 87/95 (92%) of the individual samples and 100% (10/10) of the bulk samples had counts less than 50,000 coliforms/ ml. The rest of the milk samples, 18/202 (9%) and 8/95 representing 8% had counts more than 50,000 coliforms/ ml (Table 7 and 8).There was no significant difference between the identified factors and the coliform quality of milk from both study areas.

Table 5: The percentage of samples with various Total counts/ml from Limuru.

Location	No. of samples analysed	Samples with $\leq 10^3$ cfu/ml	Samples with $> 10^3 - \leq 2 \cdot 10^5$ cfu/ml	Samples with $> 2 \cdot 10^5 - \leq 10^6$ cfu/ml	Samples with $> 10^6 - \leq 2 \cdot 10^6$ cfu/ml	Samples with $> 2 \cdot 10^6$ cfu/ml
Muguga	20	3 (15%)	8 (40%)	5 (25%)	0 (0%)	7(35%)
Gatimu	10	0 (0%)	4 (40%)	3 (30%)	0 (0%)	3(30%)
Kabuku	23	0 (0%)	14 (61%)	5 (22%)	1 (4%)	3(13%)
Kwambira	29	0 (0%)	7 (24%)	6 (21%)	2 (7%)	14(48%)
Rironi	10	0 (0%)	8 (80%)	1 (10%)	0 (0%)	1(10%)
Tiekunu	42	1 (2%)	31 (74%)	6 (14%)	2 (5%)	4(10%)
Nyathuna	10	0 (0%)	8 (80%)	0 (0%)	1 (10%)	1(10%)
Murengeti	29	2 (7%)	19 (66%)	2 (7%)	1 (3%)	7(24%)
Ngecha	29	1 (3%)	12 (41%)	11 (38%)	1 (3%)	5(17%)
Total	202	7 (3%)	111 (55%)	38 (19%)	8 (4%)	45(22%)

KeBS recommended standards

0-1,000,000 cfu/ml	Very good quality
1,000,000- 2,000,000 cfu/ml	Good quality
>2,000,000 cfu/ml	Bad quality

Table 6: The percentage of samples with various Total counts/ml from Eldoret.

Location	No. of samples analysed	Samples with. $\leq 10^3$.cfu/ml	Samples with $> 10^3$ - $\leq 2*10^5$ cfu/ml	Samples with $> 2*10^5$ - $\leq 10^6$ cfu/ml	Samples with counts $> 10^6$ - $\leq 2*10^6$ cfu /ml	Samples with $> 2*10^6$ cfu/ml
Metkei	53	0 (0%)	31 (59%)	8 (15%)	0 (0%)	14(26%)
Kipsaos	42	2 (5%)	31 (74%)	4 (10%)	0 (0%)	7(17%)
Total	95	3 (3%)	62 (65%)	12 (13%)	0 (0%)	21(22%)

KeBS recommended standards

0-1,000,000 cfu/ml	Very good quality
1,000,000- 2,000,000 cfu/ml	Good quality
>2,000,000 cfu/ml	Bad quality

Table 7: The percentage of samples with various Coliform counts/ml from Limuru.

LOCATION	No. of samples analysed	Samples $\leq 10^1$ Coliform count	Samples with $>10^1 \leq 10^3$ counts/ml	Samples with $> 10^3 - 5 \cdot 10^4$ coliforms counts/ml	Samples with $> 5 \cdot 10^4$ coliforms / ml
Muguga	20	0 (0%)	10 (50%)	6 (30%)	4 (20%)
Gatimu	10	0 (0%)	5 (50%)	5 (50%)	0 (0%)
Kabuku	23	1 (4%)	13 (57%)	10 (43%)	0 (0%)
Kwambira	29	0 (0%)	17 (59%)	10 (34%)	2 (7%)
Rironi	10	0 (0%)	8 (80%)	2 (20%)	0 (0%)
Tiekunu	42	1 (2%)	21 (50%)	15 (36%)	6 (14%)
Nyathuna	10	1 (10%)	9 (90%)	1 (10%)	0 (0%)
Murengeti	29	2 (7%)	18 (62%)	6 (21%)	5 (17%)
Ngecha	29	1 (3%)	17 (59%)	11 (38%)	1 (3%)
Total	202	6 (3%)	118 (58%)	66 (33%)	18 (9%)

KeBS recommended standards

0-1,000 cfu/ml	Very good quality
1,000 – 50,000 cfu/ml	Good quality
>50,000 cfu/ml	Bad quality

Table 8: The percentage of samples with various Coliform counts/ml from Eldoret.

location	No. of samples analysed	Samples with $\leq 10^1$ Coliform count	Samples with $>10^1 \leq 10^3$ counts/ml	Samples with $> 10^3 - 5 \cdot 10^4$ counts/ml	Samples with $> 5 \cdot 10^4$ coliforms / ml
Metkei	53	7 (13%)	32 (60%)	14 (26%)	7 (13%)
Kipsaos	42	11 (26%)	33 (79%)	8 (19%)	1 (2%)
Total	95	18 (19%)	65 (68%)	22 (23%)	8 (8%)

KeBS recommended standards

0-1,000 cfu/ml	Very good quality
1,000 – 50,000 cfu/ml	Good quality
>50,000 cfu/ml	Bad quality

4.1.3 Resazurin test

Out of the samples analyzed from Limuru and Eldoret using this test, 83% (168/202) and 77% (73/95) of the individual milk samples and 80% (8/10) of the bulk milk samples respectively had readings ranging from 4-6 on the comparator indicating the milk was of good acceptable quality. Seventeen (34/202) and 23% (22/95) of the individual samples taken in Limuru and Eldoret respectively and 20% (2/10) of the bulk milk taken from Eldoret had readings ranging from 1-3 on the comparator indicating that the milk was of poor unacceptable bacteriological quality.

4.1.4 Titratable acidity

Out of the 202 samples that were analyzed using this test in Limuru, 80% of the samples were found to have acidity levels within the range of 0.16 ± 0.02 and therefore judged to be of good quality. The rest (20%) had lactic acid levels greater than 0.18 indicating poor quality.

4.2 Compositional analysis results

4.2.1 Fat content

The average fat content of the milk from Limuru was 3.8%. Gatimu collection centre had the lowest average fat content at 3.5% while Ngecha had the highest average at 3.9%. In Eldoret, the average fat content was 4.3% with areas serving Metkei dairy having the highest average of 4.3%.

4.2.2 Density

The average milk density for Limuru was 1.027 g/ml. Kwambira had the lowest average density of 1.026 g/ml for the individual milk collection centres while Nyathuna had the highest average density of 1.028 g/ml. The average milk density for the areas sampled in Eldoret was 1.028 g/ml.

4.2.3 Freezing point

The average freezing point of the milk samples from Limuru was -0.541°C . The highest recorded average freezing point was in Kwambira with -0.522°C while the lowest average recorded freezing point was in Nyathuna with -0.549°C .

The average milk freezing temperature for the areas sampled in Eldoret was -0.556°C . Milk from Kipsaos had a freezing point of -0.576°C while that from Metkei was -0.539°C .

4.2.4 Protein content

The average milk protein content for Limuru was 3.1% with Kwambira having the lowest (3.01%) and Nyathuna the highest (3.16%). The average milk protein content for the areas sampled in Eldoret was 3.64%.

4.2.5 Solids Not Fat (SNF)

The average SNF for Limuru was 8.2%. Kwambira area had the lowest average (7.9%) while Nyathuna had the highest (8.37%). In Eldoret, the average SNF for the two areas sampled was 9.23%.

4.2.6 Added Water

Milk from the nine collection centres in Limuru had an average added water of 3.42%. Of the areas sampled, Kwambira had the highest average added water percentage (6.79 %) while Tiekunu had the lowest (2.1%). In Eldoret, the average added water for the two areas sampled was 1.88% with Metkei having a higher percentage of 2.25% while Kipsaos had a low of 1.4%.

4.2.7 pH

The nine milk collection centres in Limuru had an average milk pH of 6.63. All the areas sampled recorded average pH readings within the acceptable limits. In Eldoret, the average pH was 6.64 with the areas sampled recording readings within the range of 6.6-6.7.

4.3 Details of the household

4.3.1 Age

Forty six percent of the farmers sampled in Limuru were aged 60 years and above; 44% were aged between 40-59 years while only 10% were aged below 40 years. In Eldoret, 25% of the farmers sampled were aged 60 years, 42% between 40- 59 years and 32% less than 40 years.

4.3.2 Farming experience

Majority of the farmers (50%) interviewed in Limuru had kept dairy cows for between 0- 20 years. Twenty four percent had kept dairy animals between 21- 30 years while 26% had kept dairy animals for more than 30 years. In Eldoret, 75% of those interviewed had kept dairy animals for between 0- 20 years, 4% had practiced dairy farming for between 21- 30 years while 19% had kept dairy animals for more than 30 years.

4.3.3 Training

In Limuru, 30.5% of the farmers interviewed had undergone some training in milk hygiene with a majority (26%) having undergone training of up to one month and 4 % having training of more than one month. In Eldoret, 40% of the farmers interviewed had undergone some form of training in dairy farming with a majority (24%) having undergone training for a maximum period of one month;16% of those interviewed had undergone more than one month's training.

4.3.4 Milk testing

Sixty two percent (62%) of the farmers in Limuru were aware of one or more of the tests conducted at the milk collection centre while 38% of the farmers were not aware of any tests done on milk. In Eldoret, a majority of the farmers (99%) were aware of one or more tests conducted in milk. A majority of those farmers who were aware mentioned the lactometer test and alcohol test as some of the tests done.

4.3.5 Grazing system

Most of the farmers in Limuru (88%) practiced zero grazing, 11% practiced semi extensive grazing while 1% practiced extensive grazing. In Eldoret, most of those interviewed practiced semi extensive grazing (78%) with the rest (22%) practicing extensive grazing.

4.4. Dairy farmer practices

4.4.1 Hand washing

All the farmers interviewed in Limuru reported that they washed their hands before milking; 58% washed their hands using water and soap while the rest (42%) used water only. Majority of the farmers (94%) who washed their hands dried them using re-usable cloths with the rest not drying their hands. In Eldoret, majority of the interviewed farmers (99%) washed their hands with 67% using soap and water and the rest using water alone. Of those who washed their hands, 68% dried them using a re-usable cloth with the rest (32%) not drying their hands.

4.4.2 Udder washing

Most of the farmers in Limuru (99%) washed their cow's udder, with majority (88%) washing before milking, and 11% washing the udder before and after milking. Most of those who washed the udder used udder cloths (99%) though only a few (29%) used a separate udder cloth per cow.

In Eldoret, 97% of the farmers washed their cows' udder with 51% washing before milking and 46% washing before and after milking. Seventy one percent of those who washed the udder used an udder cloth but only 40% used a separate udder cloth per cow.

4.4.3 Teat dipping

Ninety two percent and 90% of the respondents in Eldoret and Limuru respectively did not perform teat dipping after milking.

4.4.4 Milk containers

All the farmers interviewed in Limuru used aluminum milk containers to transport milk to the collection centres. Seventy four percent washed the milk containers after use while 22% washed the containers before and after use.

Eighty two percent of the farmers washed their containers with hot water and soap while 16% used water and detergent. A few farmers, 2%, washed their milk containers with cold water and soap.

Sixty four percent of the farmers stored their container on rafts after washing, 34% hang them while 2% stored them on the ground.

In Eldoret, 95% of the farmers transported milk using aluminium and stainless steel containers while 5% used plastic containers. Forty seven percent of the farmers washed their containers before use while 49% washed before and after use. Ninety four percent washed their containers with hot water and soap, 2% used hot water alone while 1% used cold water. Sixty four percent of the farmers dried their containers on rafts while 34 % chose to hang them. None of the farmers interviewed cooled their milk before sale.

4.4.5 Water source

Most of the farmers interviewed in Limuru (80%) had water piped to their homes while 7% got their water from community and private pumps. One percent of those interviewed got their water from rain catchment, rivers and streams while the rest got their water from more than one source.

In Eldoret, 57% of the farmers interviewed got their water from private pumps while 6% had piped water. Twenty percent of those interviewed got their water from more than one source.

4.4.6 Distance and time taken to the milk collection centre

Most of the farmers in Limuru (73%) lived within a kilometer or less of the milk collection centre while the rest lived more than a kilometer from the centre. Majority of the farmers in Limuru (82%) took less than half an hour to reach the collection centre while the rest took between 30-45

minutes. In Eldoret, a majority of the farmers (44%) lived more than a kilometer from the cooling plant; 25% and 29% lived less than and within a kilometer from the cooling plant, respectively. Fifty seven percent of the farmers took less than an hour to the collection centre while 19% took more than an hour. The rest took between 30-60 minutes.

4.4.7 Transport to the milk collection centre

In Eldoret, 60% of the respondents transported the milk to the cooling plant on foot while 37% had their milk transported to the plant using motor cars. The rest either transported using bicycles or donkey carts.

4.4.8 Housing cows

A majority (98%) of the farmers in Limuru housed their cows; most of the sheds (56%) had concrete floor. Thirty five percent of the farmers had the floor of their sheds made of stones.

A majority of the farmers who housed their animals (36%) used wood shavings as bedding; 32% used soil, while 21% didn't use any bedding. Seventy nine percent of the farmers removed the manure daily while 14% removed manure weekly.

In Eldoret, 84 % of the farmers did not house their cows. Of the 16% who housed their animals, 9% had their floor shed made of stones and preferred grass bedding material.

A majority of those who housed their cows (9%) preferred to remove the manure on a weekly basis.

4.4.9 Drugs withdrawal period after treatment of the cows.

Majority of the respondents in Limuru (90%) were aware of the antibiotic withdrawal period and 87% of them observed the withdrawal period. Similarly in Eldoret, 94% of the respondents were aware and observed the antibiotic withdrawal period.

4.4.10 Milk composition parameters

In Eldoret, 35% of the respondents were aware of milk compositional parameters; however, only 15% of them were aware of how to influence these parameters.

In Limuru, 43% of the respondents were aware of milk compositional parameters while only 33% were aware of how to influence these parameters.

4.4.11 Milk tests

Only 1% and 5% of the respondents from Eldoret and Limuru, respectively tested milk before delivery. The most common test done was the clot on boiling.

4.4.12 Payment on quality

Most of the respondents in Limuru (84%) and Eldoret (98%) reported that they would accept a system of payment based on the quality of milk delivered.

4.4.13 Cattle feeding

Eighty four percent of the respondents from Eldoret fed their animals on a mixture of concentrates and other feed besides letting them out to graze. In Limuru, 97 % of the respondents fed their animals on a mixture of concentrates and other feed with the rest letting their animals out to graze.

4.5 Correlation between the microbiological tests.

Tests for correlation were conducted between the standard microbiological test (Total count and Coliform count) and the Resazurin and Titratable acidity tests. There was a significant ($p < 0.05$) positive correlation between the Resazurin test and the Total count and Coliform count tests in Limuru and Eldoret as shown in Table 9 and 10 respectively. No significant correlation was found between the Titratable acidity and Total counts and Coliform counts. There was significant fair and strong correlation of the resazurin test results to the standard microbiological test results in Limuru and Eldoret, respectively

Table 9: Correlation between direct and indirect microbiological test results of the milk from Limuru.

Indirect tests		Direct tests	
		Total Count	Coliform Count
Resazurin	Pearson Correlation	0.251**	0.231**
	Significance level	.000	.001
	Number of samples	202	202
Titrateable acidity	Pearson Correlation	.002*	.055*
	Significance level	.974	.433
	Number of samples	202	202

**There was a significant ($p < 0.05$) fair correlation between the resazurin test and the total count and coliform count.

*There was no significant ($p > 0.05$) correlation between the titrateable acidity test results and the total and coliform counts.

Table 10: Correlation between direct and indirect microbiological test results of the milk from Eldoret.

Indirect test		Direct tests	
		Total Count	Coliform Count
Resazurin	Pearson Correlation	0.704**	0.552**
	Significance level	.000	.000
	Number of samples	95	95

**There was a significant ($p < 0.05$) strong positive correlation between the resazurin test and the coliform count test.

NB: The Titratable acidity test was not performed in Eldoret due to lack of appropriate equipment to conduct the test.

4.6 Regression analysis

None of the independent variables investigated were significant at 5% significance level.

CHAPTER FIVE

5.0 DISCUSSION

The overall bacteriological quality of the milk supplied by farmers in Limuru and Eldoret can be termed as good. From the results, 78% and 91% of the milk samples from Limuru were of acceptable Total count and Coliform count quality respectively as per the Kenya Bureau of Standards guidelines of $\leq 2,000,000$ cfu/ml and $\leq 50,000$ cfu/ml, respectively. Similarly, 78% and 92 % of the milk samples from Eldoret were of acceptable Total count and Coliform count quality, respectively.

These results are consistent with a study done by Ombui *et al* (1994) in Kiambu district which showed that 89.5% of samples from farmers milk cans were considered to be of good quality with no more than 50,000 cfu/ ml of milk for coliform counts. The analysis of the bulk milk showed that all samples collected were within the acceptable KeBS limits for coliform counts while half were within the KeBS limits for total counts. The quality of bulk tank milk is reported to be affected by poor hygiene either during equipment cleaning and sanitation, during milking, or between milkings or by intramammary infections (NMC website, <http://www.nmconline.org/articles/bulktank.htm>)

The quality of raw milk has been shown to be directly affected by the handling and storage methods utilized by farmers and transporters (Karuga, 2009). Furthermore, bacterial contamination of raw milk has been reported to mainly occur from the following four sources:

within the udder, outside the udder, surrounding environment and the surface of the equipment used for handling and storage (Wallace, 2009; Kurwijila, 2006). The generally good quality of the milk from the two study areas could be attributed to some of the dairy farmer practices that were observed i.e. hand washing, udder washing, proper cleaning of milk containers, daily removal of manure and use of appropriate bedding material.

All the farmers interviewed in Limuru transported milk using aluminum cans while some farmers in Eldoret used plastic containers. Aluminum containers are recommended because they don't have adhesive properties and therefore easy to clean when compared with plastic containers (Karuga, 2009). The study also established that there was no significant correlation between the container used and the bacteriological quality of the milk as determined by the coliform and total counts.

Most of the farmers in the two study areas also washed their containers with hot water and soap and either hang them out to dry or placed them on specially erected racks, a practice which also contributed to the good quality of the milk because this leads to the destruction of harmful bacteria (Kurwijila, 2006).

The distance or time between milking, transportation and collection has been noted as a contributor to the microbiological quality of the milk sold by milk traders (Milk training guide, 2004). This was however not so in this study given that none of the variables were found to be significant in the regression analysis. This could be due to very short duration and time spent between the farm and the collection centre where samples were taken. It is also likely that

farmers delivered milk soon after milking, thus reducing the time for observable differences in bacterial growth, given the various practices studied. Bacterial growth in milk is most rapid after 2-3 hours post milking when they enter the log phase of rapid growth (FAO 1979). Most milk samples were collected within less than 2 hours in this study. In a study conducted on the microbiological quality of milk in a region of Nepal by Dahal *et al* 2010, the high total bacterial count was attributed to the distance between the milk collection units and the milk plants. From this study, it was noted that most farmers in Limuru (73%) lived within a kilometer or less of the milk collection centers which significantly reduced the time taken to transport milk from the farm to the center and reduced spoilage. In Eldoret, most of the milk was collected at conveniently located centres near farmers' homesteads and was thereafter bulked and transported to a cooling facility before being collected by the processor; however, some farmers took their milk directly to the cooling plant. It was also noted that some of the milk transporters took long before collecting and transporting milk to the cooling centre. It has been reported that milk spoils within 3-4 hours after milking especially in hot environmental temperatures. Cooling of milk therefore is advocated to help in significantly reducing the multiplication of bacteria and in turn reducing spoilage (Hygienic milk handling and processing guide).

Among the sources of microbial contamination of milk is the exterior environment of the udder (Dahal *et al* 2010, Wallace, 2009). This is brought about by soiling of teats with manure, mud, feeds or bedding; organic bedding has been shown to harbor large numbers of microorganisms which often exceed 10^8 to 10^{10} organisms per gram of bedding (Wallace, 2009). The study found out that majority of the farmers in the study sites used some form of organic bedding (mostly

wood shaving). This practice could have potentially led to the introduction of environmentally associated microorganisms in the milk. However, it has also noted that wood products such as shavings which have a much larger particle size, do not tend to cling to teat skin and support slower growth of bacteria (Wallace, 2007). Practices such as washing of hands with soap and warm water before milking, the washing of the udder using an udder cloth and daily removal of manure from the dairy shed were done by majority of the farmers and this could have contributed to the good quality of the milk. This observation is collaborated by Wallace (2009) who reported that thorough cleaning of the udder followed by drying with a clean cloth was effective in reducing the number of bacteria in milk contributed from soiled teats. A study on the impact of hygiene measures on raw milk by Abdalla and Elhagaz (2011) in Khartoum state, Sudan showed that there was a significant effect on application of hygiene practices prior to milking in total count and coliform count.

In Eldoret, majority of the farmers interviewed (84%) did not house their animals and this greatly reduced chance of contamination by organic bedding and manure. Most of those who housed their animals had the floors of the shed made of stones and removed the manure weekly, factors that could have also contributed to the low bacterial counts.

Most of the compositional quality parameters were within the acceptable range apart from the presence of added water in both study sites and low SNF and protein content in Limuru. The adulteration of milk with water was found to be a common practice by some farmers from the study sites. This practice has been reported to not only decrease the quality of the milk but also to

introduce chemical and microbial health hazards (Small Dairy Project Policy Brief 4). The low SNF and protein content of the samples from Limuru could have been attributed to a variety of factors including the feed, genetics, season of the year, stage of lactation and disease (Harris and Bachman, 1988; Wattiaux, 2012)

The Plate count test has been reported to be generally accepted as the most accurate and informative method of testing the bacteriological quality of milk (Kurwijilla *et al*, 1992; Godefay and Molla, 2000) while the Coliform test has been used to test for the effectiveness of cleaning procedures during milking. Test for correlation among the bacteriological tests done was conducted and the one hour Resazurin test was found to have a fair and strong correlation ($p < 0.05$) with the Plate count ($r = 0.25$ and $r = 0.70$) and Coliform count ($r = 0.23$ and $r = 0.55$) tests in Limuru and Eldoret, respectively. The significant correlation means that the Resazurin test could be used as an indirect indicator of the bacteriological quality of milk at the collection centres.

Most of the farmers in both study areas were optimistic about the introduction of a payment on quality system as a way of improvement on milk quality, provided that there was an incentive. Moon *et al* (2000) reported that application of a milk quality payment system based on total bacterial counts and somatic cell counts of raw milk was effective in improving raw milk quality in Korea. They reported that the proportion of herds in the first grade of total bacterial counts ($< 100,000$ c.f.u./ml) after application of the milk payment system improved from 26.7% to 85.4%, and decreased from 54.6% to 6.1% in third and fourth grade of total bacterial counts ($> 250,000$ c.f.u./ml), respectively. The New Kenya Cooperative Creameries (KCC) has also been

reported to be interested in a payment on quality system to help improve the quality of milk produced by small scale dairy farmers in Kenya (In 2 Africa website, 2011). It was also noted during the study that the Cooperative societies from the two study sites had started investing in equipment (mainly lactoscans) that would enable them test the compositional quality of the milk at the collection centre level.

CHAPTER SIX

6.0 CONCLUSION

The apparent overall good quality of the milk and the willingness of a majority of the farmers (84% and 98% for Limuru and Eldoret, respectively) to be paid on quality provided that there was incentive is a good indicator that it is possible to introduce payment on quality system in Kenya. The fair and strong correlation between the resazurin and the standard microbiological tests results indicates that the resazurin test can be used as an indirect indicator for microbiological quality at the collection centres.

6.1 RECOMMENDATIONS

- i. Training of dairy farmers on how to influence the compositional and bacteriological quality of milk needs to be done before a system of payment on quality is implemented.
- ii. Milk testing structures that are in place in the Cooperative societies need to be strengthened to avoid cases of adulteration. This should include introduction of antibiotic and aflatoxin testing.
- iii. There is need to introduce microbiological and compositional milk testing at the collection centre for individual farmers to avoid losses that resulted in rejection of pooled milk at the factory level.

- iv. A pilot study with a group of farmers on incentive based milk quality payment system needs to be conducted where the Resazurin test (10 minute) could be introduced as a screening test for bacteriological quality.
- v. The problem of added water needs to be investigated further to find out how it occurs and come up with measures of stopping it.

CHAPTER SEVEN

7.0 REFERENCES

Abdalla, M.O.M., and Elhagaz, F.M.M., (2011): The impact of applying some hygiene practices on raw milk quality in Khartoum state, Sudan. *Research Journal of Agriculture and Biological Sciences*. **7 (2):**169-173.

Bundelkhand University, Institute of Food Technology. Accessed at <http://www.iftbu.org/milk.htm> on 12th May, 2011.

Christen, G.L., Davidson, P.M., McAllister, J.S. and Roth, L.A., (1992): Coliform and other indicator bacteria. *Standard Methods for the Examination of Dairy Products*. Edited by Marshall, R.T. American Public Health Association, 16th Edition, Washington D.C.: 247-267

Conelly, W.T., (1998): Colonial era livestock development policy; introduction of improved dairy cattle in high potential farming areas of Kenya. *World development*. **26:**1733-1748.

Dahal, L.R., Dainik, B., Nepali, K., and Ramashish, S., (2010): Total bacterial counts of raw milk in Eastern Terai of Nepal. *The Journal of Agriculture and Environment*.**11:**46-50.

Davidson, P. M., Roth, L. A., and Gambrel-Lenarz, S. A., (2004): Coliform and other indicator bacteria. *Standard Methods for the Examination of Dairy Products*, 17th edition. American Public Health Association.187–226.

Draaiyer, J., Dugdill, B., Bennett, A., and Mounsey, J., (2009): Milk Testing and Payment Systems Resource Book; a practical guide to assist milk producer groups. Food and Agriculture Organization (F.A.O).

Draft COMESA/ East Africa Dairy Standards on raw milk. Accessed at <http://www.dairyafrika.com/EAS%2067%20raw%20milk%20cleaned.document> on 10th June 2010.

East African Dairy Development report, (2008): The Dairy Value Chain in Kenya. A report by TechnoServe Kenya.

Food and Agricultural Organization, (1979): Manuals of Food Quality Control. 4. Microbiological Analysis. FAO, Rome.

FAO STAT -<http://faostat.fao.org/site/339/default.aspx>. Accessed on 29th November 2011.

FOSS analytical, (2005): The key to high quality products lies in your raw milk supply: Influence the composition, volume and hygienic quality of your raw milk through payment systems. 3.

Gobbetti, M., Stepaniak, L., De Angelis, M., Corsetti, A., and Di Cagno, R., (2002): Latent bioactive peptides in milk proteins: proteolytic activation and significance in dairy processing. *Critical Reviews in Food Science and Nutrition*. **42:** 223 – 239.

Godefay, B., and Molla, B., (2000): Bacteriological quality of raw milk from four dairy farms and milk collection centres in and around Addis Ababa. *Berl. Münch. Tierärztl. Wschr.* **113**:1-3.

Harding, F., (1999): Milk quality. Chapman and Hall Food Science Book, first edition. Aspen Publishers, Incorporated Gaithersburg, Maryland, Edited by Harding, F.: 3-23.

Harris, B., and Bachman, K.C., (1988): Nutritional and management factors affecting solids not fat, acidity and freezing point of milk. University of Florida, Institute of food and agricultural sciences. Accessed at www.feedbarnstore.com/animalscience/dairy/ds-25.pdf on 20th February 2012.

Hayes, M.C., Ralyea, R.D., Murphy, S.C., and Carey, N.R., (2001): Identification and characterization of elevated microbial counts in bulk tank raw milk. *Journal of Dairy Science*: **84**:292-298.

Houghtby, G.A., Maturin, L.J., and Koenig, E.K. (1992): Microbiological counts methods. Standard Methods for the Examination of Dairy Products. Edited by Marshal, T.R. American Public Health Association, Washington, DC, U.S.A.

Hygienic milk handling and processing. Accessed at <http://www.fao.org/ag/againfo/resources/documents/MPGuide/mpguide1.htm> on 18th February 2012.

ILRI annual report (2007): Markets that work - making a living from livestock. Accessed at <http://cgspace.cgiar.org/handle/10568/567> on 20th February 2012.

In 2 East Africa website: www.in2east africa.net. Kenya: Quality-based milk payment to make life tougher for farmers. Accessed on 5th May 2011.

Karuga, S. (2009): Draft report on dairy chain analysis, Timau milk shed. Micro enterprise support program trust.

Kenya Dairy Board. Accessed at <http://www.kdb.co.ke/> on 30th May 2011.

Kenya dairy website. Accessed at www.Kenyadairy.com on 30th May 2011.

Kurwijila, L.R., (2006). Hygienic milk handling, processing and marketing; Reference guide for training and certification of small-scale milk traders in East Africa. Sokoine University of Agriculture, Tanzania. Accessed at [http:// mahider.ilri.org/ bitstream/ handle/10568/1697/ TrainerGuideVol-1_C.pdf](http://mahider.ilri.org/bitstream/handle/10568/1697/TrainerGuideVol-1_C.pdf).

Kurwijila, R. L., Hansen, K. K., Macha, I. E., Abdallah, K. and Kadigi, H. J. S. (1992): The bacteriological quality of milk from hand and machine milked dairy herds in Morogoro, Tanzania. *African Livestock Research*. **2**: 59-67.

Lachowsky, W.M., Mc Nab, W.B., Griffiths, M., and Odumeru, J., (1997): A comparison of the bactoscan 8000s to 3 cultural methods for enumeration of bacteria in raw milk. *Food research international*. **30**:273-280.

Lactoscan: http://www.lactoscan.com/usefull_info/english/freezepoint.html. Accessed on 29th January 2012.

Makokha, S. and Fadiga, M.L. (2009): Exploiting markets for dairy and meat products' quality and safety: A Kenyan case study. Research report 24 on Demand for livestock products in developing countries with a focus on quality and safety attributes: Evidence from Asia and Africa.

Martin, S. W., Meek, A.H., and Willeberg, P.,(1987): Veterinary epidemiology: Principles and methods. First edition. Iowa State University Press.

Milk training guide for small scale informal traders in Kenya (2004): Improve the quality of your milk and please your customers-.accessed at <http://www.ilri.org/Link/Publications/Publications/MilkHygieneGuide-Trader.pdf>.

Moon, J. S., YiSeok, J., SukKyung, I., BokGyeong, K., HyunMi, K., GumChan, J., JongMan, K., and OkKyung, K.,(2000): Effects on improvement of milk quality after application of payment system by hygienic quality of raw milk from dairy cow in Korea. *Korean Journal of Veterinary Public Health*. **24(3):** 223-229.

Muriuki, H. G., Mwangi, D. M., and Thorpe, W., (2001): How Smallholder Dairy Systems in Kenya Contribute to Food Security and Poverty Alleviation: Results of recent collaborative studies. Paper presented at the 28th Tanzania Society of Animal Production Conference, Morogoro, 7th –9th August 2001: 9.

Mwangi, A., Arimi, S.M., Mbugua, S., Kang’ethe, E.K., and Omore, A.O., (2000): Assurance of marketed milk in Kenya. Faculty of veterinary medicine biennial conference. 30-31st August 2000. University of Nairobi.

National Dairy Master Plan (2010): Action plan and implementation strategy, Volume II.

NMC website, <http://www.nmconline.org/articles/bulktank.htm>. Accessed on 21st November 2012.

O’Connor, C.B., (1995): International Livestock Research Institute (ILRI) Training manual 1. Rural dairy technology. International Livestock Research Institute Addis Ababa, Ethiopia. Accessed at [192.156.137.110/website/html/training Mat/Manual.pdf](http://192.156.137.110/website/html/training%20Mat/Manual.pdf) on 12th August 2011.

Ombui, J.N., Kaburia, H.F.A., Macharia, J.K., and Nduhiu, G., (1994): Coliform counts and *Escherichia coli* in raw commercial milk from dairy farmers in Kiambu district Kenya. *East African Medical Journal.* **71(10):** 635-639.

Omore, A., Lore, T., Staal, S., Kutwa, J., Ouma, R., Arimi, S.M., and Kang’ethe, E., (2005): Addressing the public health and quality concerns towards marketed milk in Kenya. Accessed at <http://www.smallholderdairy.org/collaborative%20res%20reports.htm>.

Omore, A., Muriuki, H., Kinyanjui, M., Owango, M., and Staal, S., (1999): The Kenyan dairy subsector: a rapid appraisal. Small holder dairy research and development project. Accessed at <http://www.smallholderdairy.org/collaborative%20res%20reports.htm>.

Omore, A.O., Arimi, S. M., Kang'ethe, E.K., and McDermott, J.J., (2000): Analysis of public health risks from consumption of informally marketed milk in Kenya. Accessed at <http://www.smallholderdairy.org/collaborative%20res%20reports.htm>.

Omore, A.O., Arimi, S.M., Kang'ethe, E.K., Mcdermott, J.J., and Staal, S., (2002): Analysis of milk borne public health risks in milk markets in Kenya. Presented at annual symposium of the animal production society of Kenya, Kenya Agricultural Research Institute (KARI)- Naivasha.

Owango, M., Lukuyu, B., Staal, S.J., Kinyanjui, M., Njubi, D., and Thorpe, W., (1998): Dairy cooperatives and policy reforms in Kenya: Effects of livelihood and market liberalization. *Food policy*. **23(2):**173-185.

Park, Y. W., (2009): Bioactive components in milk and dairy products. First edition. Wiley-Blackwell publishers.

Pirisi, A., Lauret, A., and Dubeuf, J.P., (2006): Basic and incentive payments for goat and sheep milk in relation to quality. *Small ruminant research*. **68(1-2):** 167-178.

Price water house coopers website. www.pwc.com/ke/en/industries/agriculture.jhtml. Accessed on 4th June 2010.

Ruegg, P.L., and Reinemann, D.J., (2002): Milk Quality and Mastitis Tests. *The Bovine Practitioner*.**36:** 41-54.

Smallholder Dairy Project (SDP) brief 4. Public Health issues in Kenyan milk markets.

Accessed at <http://www.smallholderdairy.org/milk%20and%20public%20health.htm> on 20th February 2012.

Staal, S., Pratt, A., and Jabbar, M., (2008): Dairy Development for the Resource Poor; A Comparison of Dairy Policies and Development in South Asia and East Africa. Rome, Italy: Pro-Poor Livestock Policy Initiative.

Thorpe, W., Muriuki, H.G., Omore, A., Owango, O., and Staal, S., (2000): Development of small holder dairying in Eastern Africa with particular reference to Kenya. Paper presented at the UZ/RVAU/DIAS/DANIDA-ENRECA Project Review Workshop 10-13 January 2000, Bronte Hotel, Harare, Zimbabwe

United States Agency for International Development- Quarterly progress report, May- July 2008.

Wallace, R.L., (2007): Bedding choices: Mastitis control and cow comfort. Accessed on 19th June 2012 at [http:// www.livestocktrail.illinois.edu/uploads/dairynet/papers/2007%20dd%20Bedding%20Choices.pdf](http://www.livestocktrail.illinois.edu/uploads/dairynet/papers/2007%20dd%20Bedding%20Choices.pdf)

Wallace, R. L., (2009): Bacteria count in raw milk. Accessed on 19th June 2012 at <http://www.livestocktrail.illinois.edu/uploads/dairynet/papers/Bacteria%20Counts%20in%20Raw%20Milk%20DD%202008.pdf>.

Wambugu, S., Kirimi, L., and Opiyo, J., (2011): Productivity trends and performance of dairy farming in Kenya. Tegemeo Institute of Agricultural Policy and Development.

Wattiaux, M.A.,(2012): Milk composition and nutritional value. Accessed at babcock.wisc.edu/sites/default/files/de/en/de_19.en.pdf

Zvomuya, F., (2008): Dairy mail Africa; Focus on Kenya supplement, October 2008.

CHAPTER EIGHT

8.0 APPENDICES

8.1 Dairy farmer practices questionnaire.

District.....Division.....Location.....

Sub-location.....Name of milk collection centre.....

Name of DFBA

Weather on date of sample collection: hot/cold/dry/wet.....

1= Hot 3= Dry

2=Cold 4= Wet

A) General information

1. Name of RespondentDate of interview.....

Respondent's position in the household [_____] (code)

1 = Head	3 = Daughter	5 = Hired manager/employee
2 = Spouse	4 = Son	6 = Other (specify)_____

House hold head details

Sex [code: 1 = Male, 2 = Female]	[_____]
Age (years)	[_____]
Years of farming experience (years)	[_____]
Number of years of schooling (years)	[_____]

2. Is there anyone in the household who has had any training on milking and/or milk hygiene/handling/testing?

Yes.....No.....

If yes, what is the duration of the training on milking hygiene/ handling/ testing?

- 1) No training
- 2) Up to one month of training
- 3) Between one month and 6 months of training
- 4) More than 6 months of training

3. Where and in what year did the training take place?.....

4. Who does the milking?

1 = Head	3 = Daughter	5 = Hired manager/employee
2 = Spouse	4 = Son	6 = Any of options 1-5

5. If the milking is done by someone other than the household head, provide the following information about the milker

Sex [code: 1 = Male, 2 = Female]	[_____]
Age (years)	[_____]
Years of farming experience (years)	[_____]
Number of years of schooling (years)	[_____]

6. Specify milking and/or milk hygiene/handling/testing that you are aware of.....

1. = None
2. = Organoleptic test

- 3. = Lactometer
- 4. = Alcohol test
- 5. = Boiling
- 6. = Hygiene Management
- 7. = Dairy Standards
- 8. = Clean milk handling
- 9. = Milk preservation
- 10. = Others (Specify)_____

B) Herd information

7. Herd size.....

Number of lactating cows in the herd.....

Number of Heifers in the herd.....

Number of calves in the herd.....

Number of dry cows in the herd.....

8. Number of milkings/day.....

C) Cows' productive performance

9. For each cow in a herd, of up to 3 cows, fill a column. [If number of cows are more than 3 then from each breed, including local breed and dairy animals, select one cow.

		COW		
Breed (code)		[__]	[__]	[__]
Age (Years)		[__]	[__]	[__]
Number of Calvings		[__]	[__]	[__]
Age at 1st calving (Months)		[__]	[__]	[__]
Pregnant Now? 1=Yes 0=No		[__]	[__]	[__]
Last calving date MM/YY		[_]/[_]	[_]/[_]	[_]/[_]
TOTAL DAILY MILK PRODUCTION (Morning plus evening milk) in liter	At Calving (initial milk production)	[__]	[__]	[__]
	Yesterday	[__]	[__]	[__]
Cattle breeds				
1 =Hostein-Friesian (pure) 2 =Hostein-Friesian (cross) 3 =Ayrshire (pure) 4 =Ayrshire (cross) 5 = Jersey (pure) 6 = Jersey (cross)		7 = Guernsey (pure) 8 = Guernsey (cross) 9 =Sahiwal 10 = Boran 11 = Local Zebu 12 = Other (specify)		

10. Grazing system:

(1)Zero grazing..... (2)Extensive grazing..... (3)Semi extensive grazing.....

(4) Other (specify).....

C) Hygiene information

11. Do you wash your hands before milking? (1)Yes..... (2)No.....

If you wash, what do you use?

(1)Water alone; (2) Water + soap/disinfectant; (3) other (specify) _____

12. If you wash your hands, do you dry them before milking? (1) Yes..... (2) No.....

If you dry your hands, what do you use?

(1)Newsprint; (2) Disposable paper towels; (3) Re-usable cloth; (4) other, specify _____

13. Do you wash your cow's udder before milking? (1) Yes..... (2) No.....

If yes, when do you wash it?

(1) Cleaned before milking only (2) cleaned after milking only (3) cleaned both before and after milking

14. If you clean the udder, what do you use (1) Udder cloth..... (2) Disposable towels.....

15. If the answer in udder cloth, do you use a separate one for each cow? (1)Yes.... (2)No.....

16. If you use the udder cloth, how often do you wash it?

(1)Daily..... (2)Weekly..... (3) Never.....

17. How do you wash the udder cloth?

(1) With warm water..... (2) With warm boiled water..... (3) With cold unboiled water..... (4) With cold boiled water.....

18. Do you use a sanitizer when washing the udder cloth? (1)Yes.... (2)No.....

If yes, what type of sanitizer do you use? (1) Hypochlorite..... (2) Iodophore
..... (3) Other (specify).....

19. Do you use milking cream? (1) Yes..... (2) No.....

20. Do you use teat dipping after milking to prevent mastitis? (1) Yes..... (2) No

21. What type of milk container do you use?

(1)Plastic..... (2)Aluminum..... (3)Other.....

22. How often do you wash the container?

(1)Before every use (2) After every use (3), before and after every use

23. How do you clean the container?

(1)With cold water alone.....(2)With hot water alone.....(3)With cold water and
soap.....(4)With hot water and soap.....(5)With detergent and
water.....(6)Others (specify).....

24. What is your source of water?

(1)Piped/ tap.....(2)River/ stream.....(3)Community ground pump...(4)Roof catchment (rain
water).....(5)Private ground pump/well.....(6)Other (specify).....

25. How do you store the milk containers after cleaning?

(1) On rafts..... (2) Hanging them..... (3) On the ground..... (4) Other
(specify).....

26. Do you cool the milk before sale? (1)Yes.... (2)No.....

27. How much milk do you:

a) Keep in a day?.....

b) Give out in a day?.....

c) Sell in a day?.....

28. How far is the milk collection centre?.....

29. How long does it take you to transport the milk to the collection centre/ dairy processing centre?(1)< 30 minutes..... (2) 30-45 min..... (3) 45- 60 min..... (4) > 1 hour.....

30. Do you house your cows? (1)Yes.... (2)No.....

If yes, what is the floor of the cow shed made of?.....

1= Dirt 3 = Wood 5= Other (Specify)

2= Concrete 4= Stones

31. Does your cow shed have bedding? (1)Yes.... (2)No.....If yes, what type of bedding?.....

1= Straw 3= Wood shavings 5= Soil

2= Grass 4= Dry Maize Stalks 6= other (Specify).....

32. How often do you clean/ remove manure from the shed?.....

1= Daily 3= Monthly

2= Weekly 4= Other (specify).....

D) Milk composition and hygienic quality

33. Have you ever used antibiotics to treat your animals? (1)Yes.... (2)No.....

If yes, are you aware of the antibiotic withdrawal period? (1)Yes.... (2)No.....

If yes, did you observe this period? (1)Yes.... (2)No.....

34. Are you aware of some of the compositional parameters in milk? (1)Yes.... (2)No.....

If yes, are you aware of how to influence the compositional quality of milk? (1)Yes....

(2)No.....

35. Are you aware of how the quality of your milk compares to others? (1)Yes.... (2)No.....

If yes, is it (1) above average (2) average (3) below average?.....

36. If the cooperative introduced higher payments for those delivering milk of high bacteriological and compositional quality, would you support this? (1)Yes.... (2)No.....

37. Does your milk get spoilt before delivery? (1)Yes.... (2)No.....

If yes, how many times has it spoilt in the last week?

38. Has your milk been rejected by the cooperative in the last one month? (1)Yes.... (2)No.....

If yes, why was it rejected?.....

1= Low fat 3=Abnormal colour 5=Failed Alcohol test 7. Other (Specify)

2. = Low Density 4= Abnormal smell 6= Dirt

39. Do you do any milk test before delivering milk to the collection centre?

(1)Yes.... (2)No.....

If yes, which are these tests?.....

1= Alcohol test 3=Density Test

2= Clot on boiling test 4. Other (Specify).....

40. What type of feed do you give your animals?.....

1= Concentrates Only 4= Grass and other forage

2= Napier only 5= Mixture of Concentrate and other Feed

3= Free range

8.2 Limuru Milk Composition Parameters.

Milk composition parameters								
LOCATION	NO.	pH	FAT	SNF	DEN	AWM	FP	PROTEIN
Gatimu	10	6.71	3.51%	8.10%	1.027	4.87%	-0.533 ° C	3.06%
Kabuku	23	6.61	3.84%	8.33%	1.027	2.31%	-0.547 ° C	3.15%
Kwambira	29	6.65	3.76%	7.97%	1.026	6.79%	-0.523 ° C	3.02%
Muguga	20	6.63	3.83%	8.28%	1.027	3.42%	-0.543 ° C	3.13%
Murengeti	29	6.60	3.77%	8.24%	1.027	3.32%	-0.541 ° C	3.11%
Ngecha	29	6.63	3.89%	8.29%	1.027	2.90%	-0.544 ° C	3.16%
Nyathuna	10	6.70	3.80%	8.38%	1.028	2.56%	-0.549 ° C	3.16%
Rironi	10	6.71	3.75%	8.26%	1.027	2.62%	-0.543 ° C	3.12%
Tiekunu	42	6.61	3.84%	8.36%	1.027	2.19%	-0.549 ° C	3.16%
Average	202	6.63	3.80%	8.25%	1.027	3.42%	-0.541 ° C	3.12%

Milk Component	KeBS Recommended Standards
AWM- Added Water	0% added water
FAT- Fat content	Not less than 3.25%
SNF- Solids Not Fat	Not less than 8.50%
DEN- Density	Between 1.028 g/ml – 1.036 g/ml
FP- Freezing Point	Between -0.525 ° C to -0.550 ° C
PROTEIN- Protein content	Not less than 3.5%
pH	Between 6.6-6.8

8.3 Eldoret Milk Composition Parameters

Milk composition parameters								
LOCATION	NO.	pH	FAT	SNF	DEN	AWM	FP	PROTEIN
Kipsaos	42	6.64	4.23%	9.24%	1.281	1.43%	-0.576 ° C	3.64%
Metkei	53	6.64	4.32%	9.23%	1.280	2.25%	-0.539 ° C	3.64%
Average	95	6.64	4.28%	9.24%	1.281	1.88%	-0.556 ° C	3.64%

Milk Component	KeBS Recommended Standards
AWM- Added Water	0% added water
FAT- Fat content	Not less than 3.25%
SNF- Solids Not Fat	Not less than 8.50%
DEN- Density	Between 1.028 g/ml – 1.036 g/ml
FP- Freezing Point	Between -0.525 ° C to -0.550 ° C
PROTEIN- Protein content	Not less than 3.5%
pH	Between 6.6-6.8