Microbiological Quality of Camel Milk Along The Market Chain and its Correlation With Foodborne Illness Among Children and Young Adults in Isiolo, Kenya

Dissertation submitted in partial fulfillment of the requirements for the degree of Master of Science in Applied Human Nutrition in the Department of Food Science, Nutrition and Technology, Faculty of Agriculture, University of Nairobi, Kenya

By:

Mulwa Dasel Wambua Kaindi

August 2009

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Declaration

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

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

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Dedication

This work is dedicated to my mother Victoria Mutheu Katuu, my brother John Ndundu, and my sisters; Belinda Mueni, Juliet Ngina and Ann Ngii and my grandfather John Ndundu Kaindi.

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Abbreviations and Acronyms

ASAL- Arid and Semi Arid Lands

CFU/ML- Colony forming units per milliliter

EBC- *enterobacteriaceae* count

ETHZ- Eidgenössische Technische Hochschule Zürich (Swiss Federal Institute of Technology-Zurich)

FAO- Food and Agriculture organization

GHP- Good Hygiene Practices

GoK- Government of Kenya

HH(s)- Household(s)

ILRI- Internal Livestock Research Institute- Kenya

KEBS – Kenya Bureau of Standards

PSC- presumptive *Staphylococcus aureus* count

PSEC- Presumptive *Streptococcal/ enterococcal* counts

RDA– Recommended Daily Allowance

SMHCDFs- small and medium holder camel dairy farmers

STI-Basel – Swiss Tropical Institute- Basel

TBC- Total bacterial count

UoN- University of Nairobi

WHO- World Health Organization

YMC- Yeast and mold Count

General Abstract

The study was done to determine the microbiological quality of raw camel milk along the informal market chain and to assess risk factors in symptoms of food-borne illnesses and the role of camel milk in the diet of camel pastoralists. Camel milk samples were collected from the milking point, camel milk first collection point (primary collectors) in the local market center and at the final market in Nairobi. Microbiological assessment involved enumeration of total bacterial count (TBC), presumptive *Streptococcal/ Enterococcal* count (PSEC), Yeast and Mold count (YMC), *Enterobacteriaceae* count *(EBC)*, and presumptive *Staphylococcal* count (PSC). Determination of the shelf life of pasteurized camel milk stored at 4-7°C, 25°C, and at 30°C was also investigated. Raw camel milk was pasteurized at 65°C for 30 minutes in a water bath. Further, a cross sectional study was carried out by interviewing 993 randomly selected households in peri-urban zone of Isiolo town to assess risk factors in symptoms of food-borne illnesses with special attention given to the consumption of camel milk, cow milk and goat milk.

Results indicate that microbial counts were increasing along the marketing chain. Camels` milk milked in aseptic manner from the udder had TBC $2.1x10^{1}$-$4.7x10^{4}$ $cfuml^{-1}$, PSEC $2.1x10^{1}$-$1.4x10^{3}$ $cfuml^{-1}$, YMC $1.1x10^{1}$-10^{2} $cfuml^{-1}$, EBC $1.1x10^{1}$-$8.1x10^{2}$ $cfuml^{-1}$ and PSC $1.8x10^{1}$-$2.4x10^{4}$ $cfuml^{-1}$. Bulked milk at the herd level had TBC $9.2x10^{2}$-$1.7x10^{4}$ $cfuml^{-1}$, PSEC $3.7x10^{1}$-$3.4x10^{2}$ $cfuml^{-1}$, YMC $2.1x10^{1}$-$2.7x10^{2}$ $cfuml^{-1}$, EBC $1.1x10^{1}$-$8.1x10^{2}$ $cfuml^{-1}$ and PSC $3.5x10^{2}$-$8.3x10^{3}$ $cfuml^{-1}$. Bulked camel milk at the primary collector at the local market center had TBC $1.1x10^{3}$-$5.6x10^{5}$ $cfuml^{-1}$, PSEC $3.1x10^{1}$-$2.7x10^{4}$ $cfuml^{-1}$, YMC $1.1x10^{1}$-$5.0x10^{4}$ $cfuml^{-1}$, EBC 10^{1}-$3.0x10^{5}$ $cfuml^{-1}$, PSC $6.0x10^{2}$-$8.2x10^{4}$ $cfuml^{-1}$ while bulked milk at the final market in Nairobi had TBC $4.7x10^{5}$-10^{7} $cfuml^{-1}$, PSEC $2.0x10^{2}$-$5.4x10^{4}$ $cfuml^{-1}$, YMC $9.8x10^{2}x3.2x10^{3}cfuml^{-1}$, EBC $1.4x10^{4}$-$3.5x10^{6}$ $cfuml^{-1}$ and PSC $9.1x10^{4}$-$2.8x10^{5}$ $cfuml^{-1}$.Milk at the milking level had TBCs not exceeding microbiological

limit of 10^5 cfuml^{-1} and thus a grade I quality milk. At primary collectors 25% had EBC exceeding 10^3 cfuml^{-1} indicating grade II quality of milk. 75% of bulked milk at the final market exceeded the TBC acceptable limits of 10^6 cfuml^{-1} and EBC of $5.0x10^4$ cfuml^{-1} which is in grade III and IV quality of raw milk which per the Kenya bureau of Standards 2006, indicates poor quality milk and a threat to human health.

The Kenya Bureau of Standards specifications for pasteurized cow milk were applied as criteria to establish the shelf life of camel milk. The shelf life was considered ended when the Total bacteria counts exceeded $3.0x10^4$ cfuml^{-1}, *Enterobacteriaceae* count was > 10 cfuml^{-1} or alcohol test positive. Raw milk used had Total Bacteria Count $5.7x10^5$ cfuml^{-1}, Enterobacteriaceae Count $1.4x10^4$ cfuml^{-1}, *Presumptive Streptococcal/ Enterococcal* Count $1.2x10^4$ cfuml^{-1}, Presumptive *Staphylococcal* Count $6.7x10^3$ cfuml^{-1}, Yeast and mold Count $9.5x10^1$ cfuml^{-1}, acidity 0.16%, pH 6.64, antibiotic residue free, hydrogen peroxide free and alcohol test negative . The residue TBC after pasteurization process was less than 10 cfuml^{-1} while EBC, PSEC, PSC and YMC were completely destroyed. TBC of pasteurized camel milk stored at 4-7°C exceeded the KEBS specifications in 49-54 days while TBCs of camel milk stored at 25°C and at 30°C exceeded the limit in less than 24 hours. Thus with appropriate refrigeration, pasteurized camel milk keeps for longer periods than when exposed to high ambient temperatures.

Results of the cross-sectional survey indicate raw camel milk as highly significant to food-borne illnesses. Raw camel milk had odds ratio (OR) 2.1; 95% confidence interval (CI) 1.38-3.22, and p-value of 0.001 for cases with diarrhoea and/or vomiting either with or without fever. Raw camel milk was also found to have OR 3.4; 95% CI= 1.52-7.80; p= 0.003 for cases with diarrhoea and/or vomiting without fever and was not significant for cases with

vomiting without fever (OR 2.9; 95% CI 0.91- 8.97; p=0.071). Backward selection multivariate logistic regression indicates raw camel milk as a risk factor to food-borne poisoning with OR 2.6; 95% CI=1.61-4.31, p=0.000; Log likelihood value (P (LRχ2)) = 0.0002; raw cow milk emerged as a protective factor with OR 0.5; 95% CI=0.33-0.89, p=0.015, P (LRχ2) = 0.0145. Washing of hands with soap, treating drinking water, boiling of milk, presence of proper drainage system and improved pit latrine emerged as significant protective factors to symptoms of food-borne poisoning. Since unhygienically handled raw camel milk was associated with food-borne illnesses, consumers of camel milk should be sensitized either to boil or consume processed camel milk. This study recommends for urgent development and adaptation of feasible and sustainable interventions to improve the camel milk hygiene and safety in Kenya and to mitigate food-borne related diseases in the agro-pastoralist regions.

Chapter 1.0: General Introduction

1.1 Overview

Camels constitute the most productive livestock among the pastoral communities of the arid and semi-arid lands (ASAL) of Northern Kenya. They are the best adapted to limited forage and scarce water resources, and play an important socio-cultural and economic role as the main source of income through sale of camel milk and meat as well as hides and skins (Farah 2004).

Majority of camels in ASAL are kept by migratory pastoralists in subsistence production systems. Slaughter of camels for home consumption is rare and off-take of live animals for sale or slaughter stock is limited. Currently, interest in interventions or development programs aimed at improving the camel as a long-distance transport animal has been declining. Thereby, camel milk being one of the most important food for the pastoralists, a lot of emphasis is placed on milk production (Schwartz 1992). The camel is able to provide milk almost all year around in quantities much greater than other animals living under similar conditions (El-Sayed and El-Agamy 2006). Owing to the scarcity of pasture due to the highly variable forage yields by season and year, the unique adaptation of the camels to the hot and arid environments makes the camels the most reliable milk producer in this system (Schwartz 1992). When milk yield is high, the camel can contribute up to 30% of the nutrient intake of the pastoralists (Farah 2004).

In recent years, the demand for camel milk among urban population has been increasing owing to the growing urbanization of camel milk consumers. Similarly, the demand for regular goods such as grains, oil, sugar, and clothes has increased among the pastoralists and milk sales have become the most important part of cash income for many camel owning pastoralists (Farah 2004).

However, there has been unprecedented number of constraints in production and marketing of the camel milk in Kenya. Milk handling is done with little consideration to hygiene (Younan and Abdurahman 2004), use of recycled plastic containers, which are difficult to clean, and scarce water resources at the milking level. Camel milk has to be transported to distant markets and thus long time lapses before the milk reaches the desired destination without cold chain and thereby proliferation of microorganisms (Farah and Fischer 2004). Knowledge of milk hygiene among camel milk handlers in many pastoralist communities is lacking and therefore a major bottleneck to improvement of camel milk quality and safety (Farah et al. 2007). Camel milk is commonly consumed in its raw state or as spontaneously fermented sour milk commonly called "*susac*".

This study will enhance the development of market-oriented camel milk and products of higher quality, safety and prolonged shelf life, creating income and improving in the long-term livelihoods based on camel production in the Northern region of Kenya.

1.2 Problem statement and justification

Harvesting and handling of camel milk is done with little consideration to hygiene (Farah 2004; Younan 2004). This problem is compounded by shortage/ unavailability of clean water in the ASAL regions (Farah 2004). Camel milk is collected, stored, transported, and sold in plastic jerry cans (Wangoh 2004) which are difficult to clean, and usually washed with limited amount of water. Transport of milk from the production sites to the collection points and finally to the markets can take 8-10 hours, with delays occurring due to long distance between scattered collection sites and poor road infrastructure (Farah 2004). This contributes to milk spoilage, which reduces the freshness of milk and/or its market value. There is also the risk of food-borne illnesses among the consumers.

Milk-borne pathogens are of public health concern since the early days of the dairy industry. Certain *Enterobacteriaceae* (e.g. *Escherichia coli. Salmonella spp*), *Staphylococcus aureus, Shigellae, Pyogenic Streptococci, Camplylobacter jejuni, Listeria monocytogenes, some brucella spp. Yersinia enterocolitica,* and pathogenic moulds among others have been associated with infections and intoxications in humans arising from poorly handled milk and milk products (De Buyser et al. 2001; Leclerc et al. 2002). Diarrhoea and vomiting are the main symptoms of food-borne illnesses and a major health burden in developing countries (Murray and Lopez 1997; WHO 2000; Kosek 2003). It is estimated that 1.8 million children worldwide died from diarrhoeal diseases in 1998. Up to 70% of cases of diarrhoea in infants may be food-borne (WHO 2000). Therefore, a study to improve the safety and hygienic handling of camel milk would protect the consumer from unwholesome camel milk and products.

Poor hygiene has often been considered as one of the major cause for spoilage of milk/ products for both farmers and smallholder dairies thereby causing lose of income (Brokken 1992) since sour camel milk cannot be processed into other products in the camel dairy plants and sour camel milk fetches lower prices than fresh camel milk (Younan and Abdurahman 2004).

Improving raw camel milk safety is necessary to increase nutrition and food security of camel milk consuming populations. To improve marketing strategies through capacity building, will lead to household livelihoods improvement, through the profitable sale of camel milk and camel milk products of high quality standards and better shelf life.

1.3 Objectives

1.3.1 General objective

To investigate the microbial contamination of raw camel milk during milking and along the informal marketing chain and to evaluate the contribution of camel milk consumption to the prevalence of food borne illnesses

1.3.2 Specific objectives

1. To determine the microbiological quality of raw camel milk along the camel milk market chain.
2. To determine the keeping quality of pasteurized camel milk under different storage temperatures.
3. To identify the risk factors in symptoms of food poisoning with special interest awarded to consumption of camel milk, cow milk and goat milk among persons 3-25 years of age.

Chapter 2.0: Literature review

2.1 The camels in Kenya

According to FAO statistics (FAO, 2004), there are about 19 million camels in the world, 15 million are found in Africa and 4 million in Asia. Of this estimated world population, 17 million are believed to be one-humped dromedary camels (*Camelus dromedarius*) and 2 million two-humped camels (*Camelus bacterianus*). Kenya has an estimated population of one million camels. This represents the fifth largest population in Africa.

There are two types of camel-oriented dairy systems in Kenya (Hashi 1988; Schwartz and Dioli 1992). One consists of the nomadic camel herds in the wide remote zones, which seasonally migrate through the 'water catchment areas' surrounding settlements, where pastoralists sell their milk surplus. The other system is a more intensive camel dairying and is based on private camel ranches established near urban centers in regions with adequate pasture and sufficient water availability. In a ranch, there are approximately 10 – 100 milking camels and the milk is marketed through traders who collect and sell the milk in urban centers.

Recent studies of market oriented small-holder (cattle) dairying in peri-urban areas in East and West Africa show that the benefits associated with dairying outweigh those from alternative traditional agricultural activities (Omore et al. 2004). The benefits include important income generation opportunities and nutritional benefits for resource-poor households in rural or urban setting through participation in processing and marketing of camel milk.

In Somalia and Kenya, camel milk production areas are often located far from the markets. Distances to local markets range from 20 to 90 kilometers (km) and may be up to 400 km for access to urban markets (Farah and Fischer 2004). During periods of milk surplus (rainy season),

transport is unreliable resulting in breakdowns and delays in milk delivery. Storage in unhygienic containers, mixing of evening and morning milk, pooling milk from different suppliers, prolonged transportation times, high environmental temperatures and road-side selling in open containers all increase contamination and spoilage of milk (Farah 2004). The unavailability of safe clean water also leads to difficulties in implementation of common hygiene recommendations and good hygiene practices thus making appropriate guidelines a challenge (Younan and Abdurahman 2004).

2.2 Physical properties of camel milk

Camel milk is generally opaque white and has sweet and sharp taste if the camel feed on green fodder but sometimes it can be salty due to feeding on certain shrubs and herbs in the arid regions (Farah 2004; El-Agamy 1994; Indra and Erdenebaatar 1994; El-Agamy 1983). According to Farah (2004), the pH of camel milk ranges from 6.2-6.5 and the specific gravity of 1.026-1.035 which are lower than that of cow milk. Titratable acidity (as percent lactic acid) ranges from 0.13-0.17 (El-Sayed & El-Agamy 2006). Table 6 shows the pH, acidity and specific gravity of camel milk (dromedary).

Table 1: pH, acidity and specific gravity of camel milk

Country	pH	Percent lactic acid	Specific gravity
Egypt	6.53	0.16	1.03
Saudi Arabia	6.50	0.13	-
Somalia	6.5	-	1.03
India	6.5	0.17	1.03
Tunisia	6.53	0.16	1.03
Pakistan	6.60	0.14	-

Source: El-Sayed & El-Agamy (2006)

2.3 Camel milk yield and lactation

According to Yagil (1985), the camel has a four-quartered udder, with teats which are well formed but usually not as long or as thick as those of a cow, but resembling more the teats of a heifer. Camels are mainly milked by hand but machine milking is also used in some countries on a small scale, as in Kazakhstan, Russia, India, Saudi Arabia, Mauritania and Egypt (Musaev 1982).

Machine milking has higher milk yields than milking by hand. According to El-Sayed and El-Agamy (2006) and Farah (2004), it is well known that camel milk yield is affected by several factors, such as quantity and quality of forage, watering frequency, climate, breeding age, parity, milking frequency, calf nursing, presence of the calf, milking method (hand or machine milking), health, reproductive status and individual merit. Thus data available on camel milk yields is very varied among regions as a result of one or more of the factors listed above. Table 1 shows camel milk yields and lactation periods per region from different references.

Table 2: Camel milk yields and lactation period per region

Country	Daily milk yield (kg)	Milk yield (kg) (305 days)	Lactation period (months)
Dromedary			
	2.1.1	**2.1.2**	**2.1.3**
Africa			
	2.1.4	2.1.5	2.1.6
Egypt	4	1,068-1,373	9
Ethiopia	5-13	1,525-3,965	12-18
Libya	8.3-10	2,532-3,050	9-16
Sudan	5-10	1,525-3,050	10-12
Tunisia	4	1,220	12
E. Africa	3.5-4.5	1,068-1,220	9-18
Algeria	4	1,220	9-18
Kenya	2.7-5.3	986-1,945	12-13
Somalia	3-9	915-2,745	9-18
Asia			
	2.1.7	2.1.8	2.1.9
India	4.5-18	1,655-5,551	10-18
Pakistan	8-20	2,440-1,0675	12-35
China	7.5	2,285	16-17
Bactrian			
	2.1.10	**2.1.11**	**2.1.12**
China	1.7-5	514-1,525	14-18
Mongolia	1-2	477	16

Source: El-Sayed and El-Agamy (2006)

2.4 The chemical composition of camel milk

According to Farah and Fischer (2004), the gross composition of camel milk compared to other animals as shown in table 2 is similar to that of cow milk and the ranges given in the literature are; dry matter 9.8 - 14.4%, protein 2.7 - 4.5%, fat 3.2 - 5.5%, lactose 4.0 - 5.6% and ash 0.6 - 0.9%. The average casein and whey protein content in camel milk varies between 1.9 - 2.3% and 0.7 - 1.0% respectively. The average values of the N-fractions in camel milk are similar to those in cow milk although, camel milk seems to contain somewhat higher amounts of NPN-fractions than cow milk.

Comparison of camel milk to individual bovine milk proteins reveal pronounced differences in quantitative distribution of casein and whey proteins. β-casein was found in higher concentration than in bovine milk, whereas κ-casein amounted to only 3.5% of the casein fraction (Farah and Fischer 2004). The whey proteins mainly consist of α-lactoalbumin, serum albumin and lactophorin (PP3 protein). β-lactoglobulin, the main whey protein of bovine milk, is not found in camel milk (Farah and Fischer 2004).

Table 3: Average composition of milk from camel, cow, goat, sheep, and humans

Species	Percentage composition				
	Moisture	Fat	Lactose	Protein	Ash
Camel	86-88	2.9-5.4	3.3-5.8	3.0-3.9	0.6-1.0
Cow	86-88	3.7-4.4	4.8-4.9	3.2-3.8	0.7-0.8
Goat	87-88	4.0-4.5	3.6-4.2	2.9-3.7	0.8-0.9
Sheep	79-82	6.9-8.6	4.3-4.7	5.6-6.7	0.9-1.0
Human	88.0-88.4	3.3-4.7	6.8-6.9	1.1-1.3	0.2-0.3

Source: Farah and Fischer (2004)

Camel milk casein differs from cow milk casein in terms of micellar size distribution. Electron microscopy studies showed a relatively broad size distribution of casein micelles in camel milk with a greater number of large micelles than cow milk. Compared to cow milk fat, camel milk fat

contains a lesser amount of short-chain fatty acids, but relatively high concentration of C14:0, C16:0 and C18:0 acids (Farah and Fischer 2004).

El-Sayed and El-Agamy (2006) indicate camel milk caloric value of 665 Kcal/liter compared to 701 Kcal/liter for cow milk. Camel milk is higher in vitamin C, niacin, copper, and iron while Ca, P, Mg, Na, K, Zn, and Mn are similar to cow milk. Camel milk has higher levels of carnitine (vitamin BT) (410 nmol/liter) than cow milk (235-290 nmol/liter). According to Farah (2004), camel milk is three times higher in vitamin C content compared to other milks thus making it important since there are very few vegetables in the northern districts of Kenya.

2.5 The nutritive value of camel milk

So far, many studies on the chemical composition of camel milk have been done. Camel milk is very white and unlikely to contain carotene the precursor of vitamin A while B complex vitamins are comparable in levels to those of milks from other domestic animals (El-Sayed & El-Agamy 2006).

All reported data reveal camel milk proteins have satisfactory quality balance of essential amino acids for human diets, or exceeding the FAO/WHO/UNU requirements (FAO/WHO/UNU 1985) for amino acids. Camel milk can meet at least as well or better significant portions of daily nutrient needs of humans, especially the essential amino acids. Because human nutritional requirements in the heat of arid lands are based less on calories and more on proteins and especially liquid, relatively small amounts of camel milk can supply this needs. A comparison of camel milk intake with recommended dietary allowances for adult men and women is given in table 3. Minimum daily requirements of calcium or phosphorus (800 mg) are easily met by 2.5 and 4 cups for Ca and P respectively (El-Sayed and El-Agamy 2006).

Consumption of camel milk has been observed to lower the rates of malnutrition among nomadic Rendille children of Northern Kenya as compared to children of sedentary agricultural communities, due to 2 -3 times higher milk consumption by nomadic children (Nathan et al. 1996).

Table 4: Contribution of taking 1 cup (245g) of camel milk to recommended dietary allowances (RDA) for humans.

1 cup (245g) camel milk Intake contains		RDA	
		Man	Woman
Energy (Kcal)	163	2300	2200
Protein (g)	7.9	63.0	50.0
Thiamine (mg)	0.114	1.2	1.0
Riboflavin (mg)	0.150	1.4	1.2
Niacin (mg)	1.127	15.0	13.0
Vitamin B_6(mg)	0.127	2.0	1.6
Vitamin B_{12}(µg)	0.490	2.0	2.0
Foliate (µg)	0.980	200.0	180.0
Vitamin C (mg)	9.0	60.0	60.0
Vitamin A (µg)	37.0	1000.0	800.0
Vitamin E (mg)	0.130	10.0	8.0
Calcium (mg)	317.0	800.0	800.0
Phosphorus (mg)	214.0	800.0	800.0
Magnesium (mg)	30.0	350.0	280.0
Potassium (mg)	354.0	-	-
Iron (mg)	0.466	10.0	10.0
Zinc (mg)	1.1	15.0	12.0

Source: (El-Sayed and El-Agamy 2006).

2.6 Camel milk hygienic quality and possible microbiological hazards

Camel milk is commonly consumed in its raw state hence presence of pathogenic bacteria in milk may be of public health importance (Saad & Thabet, 1993; Younan, 2004). Contamination of milk could result from various sources; milk from the udder as a result of teat canal bacterial infection leading to mastitis or no infections (Younan, 2001; Younan & Abdurahman 2004), hand or machine milking, container sanitation and water hygiene (Bonfoh et al. 2006; Gran et al. 2002; Farah & Fischer 2004), and feacal contamination that occurs primarily during milking (Oliver et al. 2005). However, under pastoral production conditions, environmental contamination is likely to play a bigger role in the hygiene of raw camel milk than initial bacterial contamination (Younan and Abdurahman, 2004). Several studies have indicated contamination during transportation and storage of milk. According to Soler et al. (1995) and Aumaitre, (1999), storage temperature and time elapsed between production and collection of milk is crucial since it determines the rate of microbial proliferation in milk. Marketed camel milk adulterations by adding water have been cited in South Somalia (Younan 2004) however, there is little evidence of camel milk adulteration in Kenya. To elaborate on the milk hygiene risk factors in camel milk production and marketing, Table 4 shows a list of risk factors at production and along the marketing chain based on practices in Somalia.

Table 5: List of milk hygiene risk factors at production and along the market chain based on the current practices of Somali milk producers/ traders

Camel milk production and marketing chain	Milk hygiene risk factors
lactating camel	unclean udder, subclinical mastitis, zoonotic infections transmitted through milk
↓ Milker (male)	Unclean hands, personal hygiene and health status, unclean (plastic) milking bucket, unclean milking site
↓ Milk handler (male/female)	No/unclean filtration, unclean storage container (plastic), pooling of fresh and old milk
↓ Primary milk collector (mostly female)	No/unclean filtration, unclean (plastic) transport container, pooling of milk from different producers, high environmental temperatures during intermediate storage, adding unclean water
↓ Transporter (male)	Delayed transport, prolonged exposure to high environmental temperatures
↓ Secondary milk collector (mostly female)	Additional pooling, exposure to high environmental temperatures, adding unclean water
↓ Milk vendor (female)	Selling from open containers in unclean environment, further exposure to high environmental temperatures, adding unclean water
↓ Consumer	Traditional preference for consumption of raw milk

Source: Younan and Abdurahman (2004)

2.6.1 Total Bacteria Count (TBC)

Different averages for TBCs in camel milk obtained at production and at points along the market chain in Kenya are shown in Table 5. These show that good quality raw camel milk is produced but it deteriorates rapidly as it enters the informal marketing chain. Pooling of different raw milk batches and unhygienic plastic containers accelerate spoilage. In non-refrigerated bulk milk TBC of up to 10^8 cfu/ml have been reported and raw milk turns sour in less than 24 hours at 25°C or in less than 12 hours under hot conditions (35°C) (Farah et al. 2007; Younan and Abdurahman, 2004).

Table 6: Total bacterial counts of camel milk samples across the market chain in Kenya

Milk sample	TBC (cfu/ml)
From udders milked directly into clean container	10^{2}-10^{4}
From traditional milking bucket	10^{3}-10^{4}
From transport container immediately after end of milking	10^{3}-10^{5}
From bulk milk stored 24h without cooling	10^{5}-10^{8}
From milk purchased	
– in the production area (less than 24h old milk)	10^{6}-10^{7}
– in Nairobi (24h to 36h old milk)	10^{6}-10^{8}

Source: Younan and Abdurahim (2004) and Farah et al. (2007)

2.6.2 Pathogens in camel milk

Enterobacteriaceae of public health significance and include Verotoxigenic *Escherichia coli* (VTEC) and *Salmonella* spps. VTEC produces shiga toxins or verotoxins responsible for heamorrhagic colitis, haemolytic uremic syndrome and thrombocytoplasmic purpura. According to World Health Organization (2005a), the camel was described as a reservoir for the VTEC serotype 0157:H7, however, according to Younan and Abdurahman (2004), no cases of infection in camels have been reported.

The *Salmonella* spp are of high importance in food safety, for they provoke severe intestinal infections in humans which can lead to death especially in elderly people (Kleer, 2004; WHO, 2005b). As in most animals, salmonella infections are common in camels in countries all over the world and some of the affected animals show clinical symptoms while others do not (Fazil and Hofman, 1981; Wernery, 2000; Semereab and Molla, 2001). According to Younan and Abdurahman (2004) cited that there were no documented cases of lactogenic transmission from camels to humans.

The presence of Streptococcus (S.) spp. is mentioned in most articles in connection with the hygiene of camel milk. When a differentiation was done, mainly Streptococcus *agalactiae*, S. *dysgalactiae* and S. *uberis* were found in camel milk (Almaw and Molla, 2000). Streptococcus

agalactiae is a known cause of human infections, particularly in newborn children and the main cause of clinical mastitis in camels (Younan and Abdurahman, 2004). There are no reasons to assume the effect of S. agalatiae on the decrease in milk production in camels differs substantially from the situation in dairy cattle (Radostits et al. 1997). *Streptococcus agalactiae* isolates from camels seem to be more closely related to the human than to the bovine biotype and may survive for up to 7 days in souring camel milk, showing no significant decline in viable numbers down to a pH of 4.5 (Younan and Abdurahman 2004), and thus health risk to consumers of fermented camel milk prepared from raw camel milk.

Staphylococcus aureus are frequently isolated from camel milk and are considered as a cause of subclinical mastitis in camels (Obied et al. 1996; Almaw and Molla, 2000; Sena et al. 2000; Younan and Abdurahman 2004; Abdel et al. 2005). Mastitis in camels is a direct threat to human health considering that *Staphylococcus aureus* produces heat stable enterotoxins that are not inactivated during pasteurization of milk and can therefore cause food intoxication (Younan and Abdurahman 2004). According to Noleto and Berdoll (1980), a short storage time of milk at ambient temperature can lead to enhanced proliferation of coagulase positive *S. aureus* and hence enterotoxin secretion which is a risk to human health.

According to Burgemeister et al. (1975) a sero-prevalence of 7.7 % of *Brucella abortus*-antibodies of was found in dromedaries in Tunisia, whereas Teshome and Molla (2002) reported a total sero-prevalence of *Brucella melitensis* in camels of 5.9 % in different regions of Ethiopia while Younan and Abdurahman (2004) indicated brucellosis prevalence in camels as ranging widely from 1 - 30% positive reactors in the Rose Bengal Plate Test. Regions where camels were kept under more stationary conditions and close together with other livestock had higher prevalence (Younan and Abdurahman 2004).

Coxiella (*C.*) *burnetii* is of public health importance because it can be transmitted to humans through consumption of raw milk (98%), but, it is inactivated by pasteurization (FAO, 2004c, Schelling et al. 2003). According to Burgemeister et al. (1975) *C. burnetii* seems to be widely spread in camels who observed 17.3 % of serological positive in Tunisia while camels in Chad had seroprevalence of 80% (Schelling et al. 2003).

Raw camel milk plays a role in transmission of tuberculosis to humans even if *M. bovis* is not capable of growing in milk (FAO, 2004d; Younan and Abdurahman 2004). According to Younan and Abdurahman (2004), tuberculosis is rare among camels under nomadic conditions, with almost all reports on tuberculosis in camels originating from non-pastoral situations where camels are kept in confinement and/or in close contact with other livestock.

Mycobacterium avium subsp. *paratuberculosis* is of worldwide concern in milk production due to the issue of its potential role in johne's disease in humans. Little is known about paratuberculosis in camels but, infections with *M. avium* subsp. *paratuberculosis* were reported in old world camels (Burgemeister et al. 1975; Fazil and Hofman 1981).

2.7 Pasteurized camel milk

The importance of various etiological agents in milk-borne disease has changed dramatically over time, with the routine pasteurization of milk having a significant impact. However, for instance, a study done by Hetzel et al. (2004) in Bamako, Mali demonstrated that some dairy products could increase the risk of a food-borne toxi-infection, even those with reputation of being safer, such as boiled milk. It was also noted that, the milk sold may not always be properly pasteurized partly due to the basic nature of the pasteurizers, lack of standardized procedures and the possibility of re-contamination during transportation or storage.

According to Oliver et al. (2005) and Hetzel et al. (2004), if there is no post-pasteurization contamination, spoilage of unopened milk packages results from recovery and growth of bacteria that survive pasteurization. The number of survivors is dependent on the types, life history and the number of bacteria initially present in the raw milk. Spore forming bacteria that can survive pasteurization are a major cause of spoilage of pasteurized milk (Credit 1972; Washam et al. 1977; Johnson and Bruce 1982).

2.8 Shelf life of camel milk

According to several studies, (Ohri and Joshi 1961; Lakosa and Shokin 1964; Attia et al. 2001; Farah 2004), camel milk keeps for longer periods than cow milk without refrigeration. Microbial growth curves demonstrate that camel milk has longer lag phase than cow milk demonstrating a buffering capacity by the dromedary milk (Attia et al. 2001). This inhibition phenomenon could be explained by the presence of high content of natural protective proteins present in the milk such as lysozyme, lactoferrin, lactoperoxidase, immunoglobulin G and A. The phenomenon also explains the formation of small colonies from camel milk unlike big ones from cow milk (Attia et al. 2001). Attia et al. (2001) also explains the longer shelf life of camel milk compared to cow milk as being as a result of late release of the micellar minerals which explains the higher stability of dromedary milk towards increased acidity.

Kamau (2007) demonstrated the use of lactoperoxidase system to extend the shelf life of pasteurized camel milk with best performance being detected when the camel milk was pasteurized 4 hrs after lactoperoxidase system was activated. In that study, pasteurized camel milk stored for 15 days at 10^{o} C, and 6 days at 20^{o} c.

According to Younan and Abdurahman (2004), non-refrigerated bulk milk reaches TBC of 10^{8} cfu/ml in less than 24 hours at 25°C or in less than 12 hours under hot conditions (35°C), but,

provision of clean containers and chilling of raw milk taken from milking buckets after normal (traditional) milking, resulted in TBCs remaining within acceptable limits ($<10^5$ cfu/ml) for four days. The combination of poor hygiene standards, high ambient temperatures and lack of refrigeration facilities render camel milk very much susceptible to spoilage due to common lactic acid bacteria (Cousin 1982; Younan and Abdurahman 2004; Kamau 2007).

Chapter 3: Microbiological quality of raw camel milk across the market chain

Abstract

The objective of this study was to determine the microbiological quality of camel milk at the critical points along the value chain. The critical points along the value chain were identified as milking, primary collection point in the local urban center and the final market in Nairobi. Camel milk samples were collected from these points and were assessed for total bacterial count (TBC), presumptive *Streptococcal/ Enterococcal* count (PSEC), Yeast and Mold count (YMC), *Enterobacteriaceae* count *(EBC)*, and presumptive *Staphylococcal* count (PSC). Results indicate that microbial counts increased along the marketing chain. Camel milk from individual camel udder had TBC $2.1x10^1$-$4.7x10^4$ $cfuml^{-1}$, PSEC $2.1x10^1$-$1.4x10^3$ $cfuml^{-1}$, YMC $1.1x10^1$-10^2 $cfuml^{-1}$, EBC $1.1x10^1$-$8.1x10^2$ $cfuml^{-1}$ and PSC $1.8x10^1$-$2.4x10^4$ $cfuml^{-1}$. Bulked milk at the herd level had TBC $9.2x10^2$-$1.7x10^4$ $cfuml^{-1}$, PSEC $3.7x10^1$-$3.4x10^2$ $cfuml^{-1}$, YMC $2.1x10^1$-$2.7x10^2$ $cfuml^{-1}$, EBC $1.1x10^1$-$8.1x10^2$ $cfuml^{-1}$ and PSC $3.5x10^2$-$8.3x10^3$ $cfuml^{-1}$. Bulked camel milk at the primary collector at the local market center had TBC $1.1x10^3$-$5.6x10^5$ $cfuml^{-1}$, PSEC $3.1x10^1$-$2.7x10^4$ $cfuml^{-1}$, YMC $1.1x10^1$-$5.0x10^4$ $cfuml^{-1}$, EBC 10^1-$3.0x10^5$ $cfuml^{-1}$, PSC $6.0x10^2$-$8.2x10^4$ $cfuml^{-1}$ while bulked milk at the final market in Nairobi had TBC $4.7x10^5$-10^7 $cfuml^{-1}$, PSEC $2.0x10^2$-$5.4x10^4$ $cfuml^{-1}$, YMC $9.8x10^2x3.2x10^3 cfuml^{-1}$, EBC $1.4x10^4$-$3.5x10^6$ $cfuml^{-1}$ and PSC $9.1x10^4$-$2.8x10^5$ $cfuml^{-1}$. The pH of camel milk from milking to final market changed from 6.49 to 6.39. The air and water at the milking level were grossly contaminated while the cleanliness of containers at the milking and primary collection centers was not significantly different. Milk at the milking level had TBCs not exceeding microbiological limit of 10^5 $cfuml^{-1}$ and thus grade I and grade II quality milk. At primary collectors 25% had EBC exceeding 10^3 $cfuml^{-1}$ indicating grade II quality of milk. 75% of bulked milk at the final market exceeded the

TBC acceptable limits of 10^6 cfuml^{-1} and EBC of $5.0x10^4$ cfuml^{-1} which is in grade III and IV quality of raw milk which per the Kenya bureau of Standards 2006, indicates poor quality milk and a threat to human health.

3.1 Introduction

Camel husbandry in Kenya is mainly conducted in the arid and semi arid (ASAL) regions (Farah 2004). Clean water for washing containers is scarce or unavailable in the ASAL regions and the use of recycled oil plastic jerry cans which are difficult to clean and the long durations during transportation in high ambient temperatures are among the constraints faced in camel milk production and marketing. Thereby microbial spoilage of camel milk inevitably reduces market value and freshness of marketed milk reducing the income to producers and vendors (Farah and Fischer 2004). Poor hygiene has been considered as a major cause of spoilage of camel milk products (Broken 1992, Farah 2004). As reported by Younan & Abdurahman, (2004), camel milk contaminants especially faecal organisms pose an important public health threat to consumers of marketed camel milk since there is traditional preference for raw camel milk consumption.

According to De-Buyser et al. (2001), Leclerc et al. (2002) and Harrington et al. (2002) public health concern associated with microbial food safety has arisen with certain *enterobacteriaceae* (e.g. *Escherichia coli*, *Salmonella* spp, *Shigellae*), *Staphylococcus aureus*, Pyogenic *Streptococci*, *Clampylobacter jejuni*, *Listeria monocytogenes*, some *brucella* spps, *Yersinia enterocolitica*, and pathogenic molds with milk repeatedly identified as a vehicle of these organisms (Harrington et al. 2002).

This study was conducted to investigate the microbiological contamination of camel milk along the informal market chain by assessing safety and quality indicator organisms to obtain the baseline situation of the camel milk microbiological quality and safety. The contamination of air at milking area, water for cleaning the containers, and milking level and primary collection containers were also evaluated.

3.2 Materials and methods

The study was carried out in Nanyuki and Isiolo Districts in Eastern and Northern Kenya. The two herd management practices i.e. semi-modern ranching system and pastoral (traditional) systems, which marketed their milk to major market outlets were captured. In each region, three camel herds were selected.

3.2.1 Sample collection

The sampling frame of Bonfoh et al. (2003) was used. The milking level, primary collection point in the local center and final market in Nairobi were identified as the critical points along the market chain. Samples from the milking level were collected between 6.00-7.00 am. Milk from three lactating camel was individually obtained into 50 ml sterile falcon tubes after milkers' hands and camel udder had been disinfected with 70% ethanol before milking by a hand sprayer and dried with disposal towel. Samples of bulked camel milk at milking level, primary collection and final market in Nairobi were also collected (Table 7). Prior to milking, the contaminations of the milking and storage containers were determined by rinsing them with 100ml sterile water. The primary collectors' containers were also rinsed in a similar manner. Two Petri dishes one containing Standard Plate Count Agar (Difco) and the other Yeast Mold agar (Difco) were exposed to the environment in the milking yard for 5 minutes to assess the environmental

bacteria, yeast and mold contamination. A sample of water (100ml) used for cleaning containers at the *boma* was collected into a sterile tube from their water container (Table 8).

The pH of all milk samples was measured upon sample collection using a digital pH meter (Model: Metrohm 604) which was recalibrated before any pH measurements with standard buffer solutions of pH 4.0 and 7.0 at the ambient temperature. The temperatures of the samples and the environment were measured upon sample collection. Samples were labeled appropriately, placed in cool box with dry ice and transported to a laboratory in Nairobi for analysis within 12 hours. During sample collection, other qualitative information was collected using a data collection sheet (Annex 3).

Table 7: Sample collection of camel milk at main points along the market chain for the two study areas

		Samples
Location (Isiolo/ Nanyuki)		
Individual camel milk		9
Bulked milk from the farmers containers		3
Bulked milk from the primary collectors' containers Isiolo		3
Bulked milk from the secondary collectors' milk Containers (Nairobi)		3
Total of milk samples	**18x2=**	**36**

Table 8: Sample collection of water for cleaning containers at milking level and air at the milking area, containers at the milking level and primary collection point for the two study areas

		Samples
Location (Isiolo/ Nanyuki)		
Water at the herd		3
Air (milking yard)		6
Farmers containers		3
Vendors containers		3
Total samples	**15x2=**	**30**

3.2.2 Microbiological analysis

Serial dilutions of samples were prepared using sterile 2.5% peptone water and 0.1 ml of appropriate 3 series dilutions surface plated in duplicate onto appropriate growth medium for enumeration of specific microorganisms. Total bacterial counts were enumerated by surface plating on Plate Count Agar (Difco) and plates incubated at 30°C for 24 hours. Enterobacteriaceae counts were enumerated by surface plating onto Violet Red Bile (VRBG) Agar (Merck) and plates incubated at 37°C for 24 hours. To check for positive bacterial growth reference strain *Escherichia coli xl-1 blue* was plated on the VRBG agar.

Presumptive *Staphylococcus aureus* counts were determined using Baird Parker Agar media (Biolife) supplemented with 20% egg yolk Tellurite emulsion (Oxoid code 423700) and plates incubated at 37°C for 24 hours. To check for positive bacterial growth, reference strain *Staphylococcus aureus RN4220/PVC5* was also plated on Baird Parker Agar. Presumptive *Enterococci and Streptococci* counts were determined by using KF *Streptococcus* Agar (Difco) supplemented with 1% 2, 3, 5-Triphenyl Tetrazolium Chloride (Fluka) and plates incubated at 43°C for 24 – 48 hours. To check positive bacterial growth, reference strain *Enterococci faecalis* SH-2-2 was also plated on KF-*Staphylococcal* agar.

Yeast and mold counts were determined using Yeast Mold Agar and Yeast Mold Broth supplemented with 20µg of chloramphenical as a selective agent. Yeast and molds colonies were enumerated after incubation at 30°C for 2-4 days. To check for positive growth, reference strain *Rhodotorula mucilaginoasa FSQE63* was also plated on Yeast and Mold Agar. Water used for sanitation at the herd level was tested for hygienic quality using MacConkey broth.

3.2.3 Statistical data analysis

All data obtained in the field questionnaire and from bacteriological analysis was entered in Microsoft Access database. Statistical data analysis was carried out using Intercooled Stata Version 9.0 (Stata Corporation, College Station, TX, USA, 1984–2000). Data on the microbial counts was first transformed to logarithm of colony forming units per milliliter of sample (Log $cfuml^{-1}$) and the results were presented as the geometric means and other descriptive statistics. GENSTAT statistical package (Lawes Agricultural Trust, Rothamsted Experimental Station, 9^{th} Edition) was used for linear contrasts of microbial counts at different sampling points along the market chain and one-way analysis of variance to compare data from the two locations.

3.3 Results

3.3.1 pH, temperature of camel milk, environmental temperature and time elapsed between identified critical points along the market chain

There was a slight decrease in the pH of camel milk at critical points along the market chain (Table 9). The pH of bulked milk at the herd level was 6.49 and decreased to 6.39 at the final market in Nairobi. The milk temperature at milking during the cold and warm weather was between 27-29°C with environmental temperature of 17-21°C. The temperature of the milk on arrival at the primary collectors was about 29-30°C with environmental temperature of 24-30°C. At the final market the temperature of milk was between 10-11°C as a result of refrigeration at the primary collection point before milk transportation to final market in Nairobi. The time elapsed between milking and primary collection point was 2.75-6.5 hours while the milk took 18.75-24.75 hours between the primary collection point and final market in Nairobi.

Table 9: pH of camel milk at different points along the market chain

Sample description	n	Mean	Min	Max
pH				
Individual animal milk	11	6.49	6.34	6.63
Bulked morning milk at herd level	5	6.49	6.4	6.56
Bulked milk at 1st collection point	5	6.46	6.34	6.57
Bulked milk at final market (Nairobi)	5	6.39	6.30	6.46

3.3.2 Contamination of air at the milking area, washing water, containers at the milking level and at primary collection point

Microbial quality of milk containers at the herd level and primary collection point was not significantly different ($p>0.05$). The containers at the milking level had TBC 10^1-10^5 cfuml^{-1}, PSEC 10^3 cfuml^{-1}, EBC 10^4 cfuml^{-1}, YMC 10^2-10^3 cfuml^{-1} and PSC 10^2-10^3 cfuml^{-1} while the containers at the primary collection point had TBC 10^2-10^5 cfuml^{-1}, PSEC 10^2-10^4 cfuml^{-1}, EBC 10^1-10^5 cfuml^{-1}, YM 10^2-10^5 cfuml^{-1} and PSC 10^1-10^4 cfuml^{-1}.

Water at the herd level was heavily contaminated with more than180 coliforms per ml of water and TBC ranging from 10^3-10^5 cfuml^{-1}. The air at the milking yard had TBC 10^2-10^3 and YMC 10^2 per plate.

3.3.3 The camel milk microbiological quality

A summary of level of significance of microbiological counts between the main points along the market chain are given in Table 10. The geometric means of the microbial counts and the range of counts are detailed in Table 11.

Table 10: Level of significance between geometric means of the log cfuml^{-1} at different points along the market

microorganism	Individual animal	Milking level	Primary collection centers level	Final market level
TBC		ns	*	*
PSEC		ns	ns	*
YMC		ns	ns	ns
EBC		ns	ns	*
PSC		*	*	**

Note: ns Not significant, * $p<0.05$, ** $p<0.001$

Table 10 and 11 shows that milk obtained from the udder and bulked milk at the milking level had mean TBC of $3.6x10^2$ and $3.2x10^3$ cfuml^{-1} respectively which was not significantly different ($P>0.05$). Milk at the primary collector had TBC $5.9x10^4$ cfuml^{-1} which was significantly different from final market milk TBCs of $3.2x10^6$ cfuml^{-1} on average. Correlation between the TBCs along the market chain and the time elapsed between the points had a highly significant correlation coefficient ($r=0.890$; $p<0.001$). The TBCs of camel milk along the chain for the two locations/ herd management systems were not significantly different ($p>0.05$).

PSEC of milk from the udder of $1.7x10^2$ cfuml^{-1}, bulked milk at the milking level of $1.3x10^1$ cfuml^{-1} and bulked primary collection point of $3.9x10^2$ cfuml^{-1} were not significantly different ($p>0.05$). PSEC of bulked primary collection point was significant ($p<0.05$) when compared to those of bulked final market milk of $4.4x10^3$ cfuml^{-1}. Correlation between the PSECs in camel milk and the time elapsed before collection show a highly significant correlation coefficient ($r= 0.874$; $P<0.001$). Comparisons of PSEC between the two locations/ herd management systems were not significantly different ($p>0.05$).

Table 11: Total bacterial counts, presumptive streptococci/ enterococcal count, yeast and mold counts, enterobacteriaceae count and presumptive staphylococcus counts in raw camel milk along the market chain in Kenya

	Individual animal		Pooled milk at milking		Primary collectors		Final market (Nairobi)	
Microorganism	Geometric mean ($cfuml^{-1}$)	Range of counts ($cfuml^{-1}$)	Geometric mean ($cfuml^{-1}$)	Range of counts ($cfuml^{-1}$)	Geometric mean ($cfuml^{-1}$)	Range of counts ($cfuml^{-1}$)	Geometric mean ($cfuml^{-1}$)	Range of counts ($cfuml^{-1}$)
TBC	$3.6x10^{2}$	$2.1x10^{1}$-$4.7x10^{4}$	$3.2x10^{3}$	$9.2x10^{2}$-$1.7x10^{4}$	$5.9x10^{4}$	$1.1x10^{3}$-$5.6x10^{5}$	$3.2x10^{6}$	$4.7x10^{5}$-$1.0x10^{7}$
PSEC	$1.7x10^{2}$	$2.1x10^{1}$-$1.4x10^{3}$	$7.1x10^{1}$	$3.7x10^{1}$-$3.4x10^{2}$	$3.9x10^{2}$	$3.1x10^{1}$-$2.7x10^{4}$	$4.4x10^{3}$	$2.0x10^{2}$-$5.4x10^{4}$
YMC	$2.8x10^{1}$	$1.1x10^{1}$-$1.0x10^{2}$	$6.2x10^{1}$	$2.1x10^{1}$-$2.7x10^{2}$	$1.2x10^{2}$	$1.1x10^{1}$-$5.0x10^{4}$	$1.4x10^{3}$	$9.8x10^{2}$-$3.2x10^{3}$
EBC	$1.8x10^{1}$	$1.1x10^{1}$-$8.1x10^{2}$	$5.2x10^{1}$	$1.1x10^{1}$-$8.1x10^{2}$	$9.5x10^{1}$	$1.0x10^{1}$-$3.0x10^{5}$	$1.6x10^{5}$	$1.4x10^{4}$-$3.5x10^{6}$
PSC	$2.4x10^{2}$	$1.8x10^{1}$-$2.4x10^{4}$	$1.3x10^{3}$	$3.5x10^{2}$-$8.3x10^{3}$	$6.3x10^{3}$	$6.0x10^{2}$-$8.2x10^{4}$	$2.0x10^{5}$	$9.1x10^{4}$-$2.8x10^{5}$

The EBC for camel milk obtained from the udder was $1.8x10^{1}$ $cfuml^{-1}$, bulked milk at milking level had $5.2x10^{-1}$ $cfuml^{-1}$ and at primary collectors was $9.5x10^{1}$ $cfuml^{-1}$. The counts were not significantly different ($p>0.05$). However, EBC in camel milk increased significantly from $9.5x10^{1}$ to $1.6x10^{5}$ $cfuml^{-1}$ between the primary collection point and final market ($p<0.05$). Correlation between the EBC at sampling points and the time taken along the market chain had significant correlation coefficient ($r= 0.869$; $p<0.05$). The results on EBC between the two locations/ herd management systems were not significantly different ($p>0.05$).

Camel milk obtained from the udder had PSC of $2.4x10^{2}$ $cfuml^{-1}$ which was significantly different ($p<0.05$) from $1.3x10^{3}$ $cfuml^{-1}$ of bulked milk at the herd level. Comparisons of PSC of bulked milk at the milking level of $1.3x10^{3}$ $cfuml^{-1}$ and bulked milk at the primary collection point of $6.3x10^{3}$ $cfuml^{-1}$ were significantly different ($p<0.05$). The differences of PSC of bulked milk at the primary collection point above and at the final market of $2.0x10^{5}$ $cfuml^{-1}$ were highly significant ($p<0.001$). Correlation between the PSC along the chain and time taken showed a highly significant correlation coefficient ($r= 0.874$; $p<0.001$). PSC differences at points along the chain for the two locations/ herd management systems were not significantly.

3.3 Discussion

3.4.1 pH of camel milk, temperature of milk, temperature of the environment, time elapsed between points along the market chain

The pH of camel milk in this study was within 6.3-6.5 similar to findings of Farah 2004. According to Soler et al. (1995) and Aumaitre (1999), microbial counts in raw milk before it leaves the farm depend not only on the contamination during milking and storage but also on the temperature at which milk is stored and on the time elapsed between production and collection.

Time factor is critical in keeping microbial build up in milk low. Long delays in camel milk delivery are mainly as a result of delays in transportation of milk to the desired destination mainly due to poor infrastructure, long distance from the production areas to the markets, and it is uneconomical to transport small quantities of milk by expensive and more effective means such as vehicles. Camel milk was observed to take up to more than 6 hours without cooling before it reaches the primary collectors while it takes 21 - 24 hours from primary collection to final market in Nairobi. Thereby, milk reaches the primary collectors at elevated temperatures of up to 30°C owing to the high ambient temperatures of up to 30°C observed in this study and lack of cooling system. Coolers at the primary collection point may not accommodate all the camel milk and thus cooling may be inadequate; however milk reached the final market in Nairobi at 10-11°C but may be higher due to delays during transportation by bus.

The stability of camel milk pH due to its buffering phenomenon as observed in Attia et al (2001) was also observed in this study since the pH at final market was still acceptable at 6.39. Contrary, total titratable acidity of milk in the final market indicated that the milk was already souring (Personal observation) but without a firm coagulum (Yagil et al. 1983; Wangoh 1997; Attia et al. 2001; Farah and Fischer 2004).

3.4.2 Camel Milk Contamination Factors

The contamination factors along the production and informal market chain disrupt the shelf life, quality and safety of camel milk. The air at the milking area in this study had high TBC and YMC showing possibility of contamination of milk during milking and during storage if the milk containers were left open. The area is usually dusty and therefore microorganisms from the soil could find their way into the milk as well from the milkers' hands or camel coat since there is no washing of camels' udder (Younan 2004) or directly into the unclosed milking and storage containers.

Sanitation and water hygiene are extremely important if contamination of food is to be avoided (Gran et al. 2002). In this study, water at the milking level was sourced from the river or lagoons with coliform counts being more than 180 cfu/ml and high TBC making it an important source of contamination to milk if the water is not adequately boiled before washing the containers. Farah (2004) notes that water in the ASALs is grossly contaminated and its availability in the camel milk production areas is scarce or unavailable, thus making it difficult to improve milk hygiene at the milking level. However, majority of water at the primary collection point was potable water and that majority of containers are cleaned at the primary collection point using municipal water. Water for cleaning the containers should be clean potable water (Lore et al. 2006).

The containers for milking, transporting, and storage of milk should be clean to avoid microbial contamination as a result of adequate cleaning and disinfection procedures (Lore et al. 2006). Plastic jerry cans are commonly used during handling, storage and transportation of camel milk. The use of many containers of small capacity with small opening creates difficulty in cleaning (Bonfoh, et al. 2003; Wangoh 2004; Bonfoh, et al. 2006). The primary collectors in informal camel milk market sanitize containers that bring milk to the centers. However, after using treated municipal water and container smoking, their containers were not significantly different from containers at the herd level. This shows that appropriate container sanitizing procedures are not adhered to.

In this current study, during cleaning of the containers, disinfection with either chemicals or hot water was not a common practice. However, the use of detergents, and good quality water for cleaning the equipment could be expected to remove milk remains, including microorganisms, and thereby improve the microbiological quality of the milk (Bonfoh et al. 2006). Notably, many interactive factors contributed to the poor hygienic quality of the camel milk sold at the markets. Similarly observed in this current study, as reported by Younan & Abdurahman (2004) on the

risk factors at various points along the camel milk market chain, camel milking is done with little consideration to hygiene, pooling of morning and evening milk at the farm and bulking milk from different herds and the intense manipulation of small quantities of milk using several containers of small capacity at the primary collectors, transportation and handling is done without any cooling which compromises the milk quality. Presence of food-borne pathogens in bulked milk seems to be directly linked to feacal contamination that occurs primarily during milking, while, some pathogens are directly excreted into the milk from mastitic udders (Younan et al. 2001; Younan and Abdurahman 2004; Oliver et al. 2005).

3.4.3 Milk Microbiological Quality

The legislation on camel milk microbiological limits in Kenya has not yet been approved, but the specifications used in this study were KEBS 2006 preliminary draft on the raw whole camel milk (Annex 4).

The results of the TBC in camel milk drawn directly into a clean container of 10^2-10^4 cfuml^{-1} is in agreement with those of Younan 2004 and Farah et al. 2007 while their findings in bulked milk after milking of 10^3-10^5 cfuml^{-1}, primary collection point of 10^6-10^7 cfuml^{-1} and final market at 10^6-10^8 cfuml^{-1}, were higher than the findings in this study. The current findings are also in agreement with those of camel milk in Qassim region and Moroccan camels which had mean counts 5 log cfuml^{-1} and maximum of 7.15 log cfuml^{-1} (El-Ziney and Al-Turki, 2007), and mean of 5.4 log cfuml^{-1} in Saudi Arabia (Al Mohizea, 1994) and 5.6 log cfuml^{-1} in Ethiopia (Semereab and Molla, 2001). Seventy five percent of the bulked milk at the primary collection point was within the microbiological acceptable limit of 10^6 indicating milk of grade I and II quality while 75% bulked milk at the final market exceeded the microbiological acceptable limits of 10^6 cfuml^{-1} (grade III and IV) of raw milk (KEBS 2006) which indicates poor quality milk and

a threat to human health. This indicates significant increase or buildup of TBC in milk between the primary collection point and the final market.

The presumptive *Streptococcal/Enterococcal* counts in camel milk shows no significant difference between individual animal, bulked milk at the farm and primary collection centers. Significant differences were noted between the primary collection and final market in Nairobi which had mean 10^3 cfuml^{-1} and a maximum count of 10^4 cfuml^{-1}, probably as a result of microbial build up due to long storage period of market milk and further contamination at the primary collection point. According to Frazer and Westhoff (1988) these organisms unlike *Esherichea coli* are useful indicators of possible presence of enteric pathogens because when compared they are more resistant to freezing, low pH and moderate heat treatment, thus they are likely to be found in foods which have received cursory heat treatment, even when *Esherichea coli* has been destroyed by inimical conditions.

Yeasts and moulds in this study had maximum counts of 10^4 cfuml^{-1} in bulked camel milk at the primary collection point which was slightly lower than findings of El-Ziney and Al-Turki (2007) with mean and maximum values of 1.9 and 5.65 log cfuml^{-1} respectively, while their content in Moroccan camel's milk was found to have on average 4.6 log cfuml^{-1} (Benkerroum 2003). According to Frazier and Westhoff (1988) and Pitt and Hocking (1997), the high counts of yeast and moulds in milk are rather uncommon considering the natural pH of milk, causing bacteria to predominate, however, yeast and molds are able to grow in a wide pH of 2-9 and in many cases can alter the pH to one that is more favourable for their growth, usually 4-6.5 which is in the range of fresh and fermented milk (FAO 1992).

In this study EBC had a high increase from $9.5x10^{1}$ to $1.6x10^{5}$cfuml^{-1} on average between the primary collection centers and final market indicating significant contamination and microbial build up at this point. 25% of bulked camel milk at primary collection point had EBC exceeding 10^{3} cfu/ml indicating grade II quality of milk while 75% of bulked final market milk had EBC exceeding microbiological acceptable limit of $5x10^{4}$ cfuml^{-1} indicating milk of grade III quality (KEBS 2006). The results are in agreement with the findings of camel milk in Qassim region with a mean of 2.7 log cfuml^{-1} and a maximum of 6.82 log cfuml^{-1} (El-Ziney and Al-Turki, 2007). Similarly, high coliform counts were observed in camel milk in Ethiopia by Semereab and Molla (2001) and Benkerroum et al (2003) in Moroccan camel milk which was up to 6.8 log cfuml^{-1} on average. Younan and Adburahman (2004) found coliform counts in milk samples from traditional milking buckets to be less than 10^{2} cfuml^{-1}. The existence of coliform bacteria may not necessarily indicate a direct feacal contamination of milk, but is an indicator for poor sanitary practices during milking and further handling processes (Frazer and Westhoff 1988).

The PSC counts of bulked camel milk at the farm and primary collection point had mean counts of 10^{3} cfuml^{-1} while at final market it was 10^{5} cfuml^{-1}. The mean counts of PSC in bulked milk are in agreement with finding of 5.1 log cfuml^{-1} in Moroccan camel milk and a slightly lower compared to camels in Qassim region in Saudi Arabia where mean count was up to 6.72 log cfuml^{-1} (El-Ziney and Al-Turki, 2007).

During milk trading the anomalies in microbial load go unnoticed since there are no quality control checks in place except for organoleptic testing practiced by the buyers and sellers. Thus the informal market of camel milk provides a safe haven for retailing milk since milk rejects have discouraged many camel farmers from supplying the Nanyuki camel dairy which has quality control measures in place. The results of this study are worrying since, pastoralists believe that the unique beneficial properties of camel milk are lost by boiling and thus predominantly consume raw or unpasteurized milk for medicinal or therapeutic purposes. This is

true with the heat labile proteins which can be denatured on heat treatment (Farah 1986; El-Agamy 2000a) and heat labile vitamins such as vitamin C. However, consumption of unprocessed milk poses potential public health risk (Kaufmann and Binder 2002; Farah and Fischer 2004; Younan and Abdurahman 2004; Farah et al. 2007).

3.5 Conclusion and recommendations

Milk at the milking level had TBCs not exceeding microbiological limit of 10^5 cfuml^{-1} and thus a grade I quality milk. At primary collectors 25% had EBC exceeding 10^3 cfuml^{-1} indicating grade II quality of milk while 75% was grade I quality. However, 75% of bulked milk at the final market exceeded the TBC acceptable limits of 10^6 cfuml^{-1} and EBC of $5.0x10^4$ cfuml^{-1} which is in grade III and IV quality of raw milk (KEBS 2006) which indicates poor quality milk and a threat to human health.

Scarcity of clean water at milking level, herds health, milking in a dusty area, inadequately sanitizable plastic containers, non-washing of the udder and hands during milking, stimulation of milk let down by calves, long time span before selling the milk, high ambient temperatures, lack efficient transportation and storage systems contribute to contamination of camel milk. In order to safeguard consumer health and to strengthen the source of income through the sale of milk by producers and vendors, there should be initiatives to lower microbiological contamination of camel milk at the primary collectors at the local centers and final market in Nairobi since 75% of camel milk sold the final market was of poor microbiological quality.

To improve camel milk hygiene quality and safety appropriate interventions should be designed for the milking level, primary collection level and during transportation to the final market. At the milking level specific interventions are to improve clean water supply, provision of veterinary health services and set up training on hygiene handling of milk and personal hygiene.

After milking camel milk should be transported in the shortest time possible to the primary collection point. At the primary collection point adequate cooling of milk during storage should be emphasized since this lowers the rate of microbial build up. Training on hygiene handling of milk for herders, the primary collectors and vendors needs to be carried out. These interventions would require multi-sectoral interventions including the government ministries, NGOs and all other major stakeholders including active community participation.

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Chapter 4: The shelf life of pasteurized camel milk stored at different temperatures

Abstract

This study was conducted to predict the shelf life of pasteurized camel milk stored at 4-7°C, 25°C and 30°C by assessing bacterial load, acidity, pH and alcohol test. Pasteurization was done at 65°C for 30 minutes in a water bath. The Kenya Bureau of Standards specifications for pasteurized cow milk were applied as criteria to establish the shelf life of camel milk. The shelf life was considered ended when the Total bacteria counts exceeded $3.0x10^4$ $cfuml^{-1}$, *Enterobacteriaceae* count was > 10 $cfuml^{-1}$ or alcohol test positive. Raw milk used had Total Bacteria Count $5.7x10^5$ $cfuml^{-1}$, Enterobacteriaceae Count $1.4x10^4$ $cfuml^{-1}$, *Presumptive Streptococcal/ Enterococcal* Count $1.2x10^4$ $cfuml^{-1}$, Presumptive *Staphylococcal* Count $6.7x10^3$ $cfuml^{-1}$, Yeast and Mold Count $9.5x10^1$ $cfuml^{-1}$, acidity 0.16%, pH 6.64, antibiotic residue free, hydrogen peroxide free and alcohol test negative. The residue TBC after pasteurization process was less than 10 $cfuml^{-1}$ while EBC, PSEC, PSC and YMC were completely destroyed. TBC of pasteurized camel milk stored at 4-7°C exceeded the KEBS specifications in 49-54 days while TBCs of camel milk stored at 25°C and at 30°C exceeded the limit in less than 24 hours.

4.1 Introduction

Development of value added camel milk products of good microbiological quality, safety and prolonged shelf life depends mainly on control of raw camel milk microbiological contamination at the production, processing and marketing levels before the milk products reach the consumer's (Younan and Abdurahman 2004). Currently, there are few publications on shelf life of pasteurized camel milk. In the dry and hot areas, storing milk for future use is even more important than in the temperate climates since milk is often all there is to consume. Traditionally the nomads 'store' milk by making fermented products which can be consumed at a later date

(Yagil 1982) but, most of the camel milk is consumed either in the raw or fermented form. The milk is allowed to ferment naturally at ambient temperature and without prior heat treatment until it turns sour (Farah et al. 1989) and this pose a potential public health risk. Pasteurization process destroys all pathogenic organisms and thus makes milk products safe for human consumption (Oliver et al. 2005). If there is no post pasteurization contamination pasteurized milk spoils from the survivors which are mainly spore forming bacteria and also due to initial microbial load before pasteurization which determines the residual count after pasteurization.

The Vital Camel Dairy Ltd is the only camel dairy in Kenya and has to meet the ever increasing demand for pasteurized camel milk and other camel milk products in the country. The dairy plant processes and packages pasteurized camel milk, cultured sour camel milk and camel milk yoghurt for both local and international markets. However, a lot of milk is traded informally as raw milk or *susac* made from unboiled raw camel milk. The aim of this study was to determine the shelf life of pasteurized camel milk stored at different storage temperatures.

4.2 Materials and methods

Camel milk was collected from two previously selected herds in Isiolo district. The history of the raw camel milk including acidity, pH, time of milking were studied. Two milk samples of 2 liters each were obtained at the primary collection center from 10 liter plastic milk containers after homogenous agitation into sterile bottles. The milk samples were transported in cooler box with dry ice to Nairobi for analysis within 12 hours. The Total Bacterial Count (TBC), Presumptive *Staphylococcal* count (PSC), *Enterobacteriaceae* Count (EBC), Presumptive *Streptococcal/ Enterococcal* Count (PSEC), and yeast and mold count (YMC) were carried out before and after pasteurization to evaluate the effectiveness of pasteurization in mitigating microbial hazards (Chapter 3.2.2). Acidity, pH, presence of antibiotics and hydrogen peroxide residue, alcohol test were done according to Analabs Ltd. laboratory procedure reference manual.

One liter of each camel milk sample was dispensed aseptically into 25 ml colourless screw-capped bottles which were then tightly closed and then pasteurized at 65^{0}C for 30 minutes in a water bath. The samples were then cooled rapidly by running tap water to approximately 10°C. The screw-capped bottles containing pasteurized camel milk were then distributed for 3 incubation temperatures 4-7°C, 25°C and 30°C. When drawing milk sample for assessment a new screw capped bottles were opened aseptically by flaming each time. Milk samples stored at 4-7°C were sampled after 1, 2, 3, 8, 15, 20, 23, 30, 38, 43, 49, 54, and 56th day. Sampling of milk stored at 25°C and 30°C was sampled at 0, 4, 10, 24, 48, 72, 96, and 120 hour respectively.

Acidity expressed as percent lactic acid, pH, total bacteria count, *coliform* count, and alcohol test were used to predict the shelf life. Since there are no standards for pasteurized camel milk, specifications for pasteurized cow milk (KEBS 2002) were used as criteria to predict the shelf life of pasteurized camel milk. The shelf life was considered as over when the TBC exceeded $3.0x10^4$ cfuml^{-1} and coliform count exceeded 10 cfuml^{-1} of pasteurized camel milk (KEBS, 2002).

4.2.1 Statistical data analysis

Data analysis was carried out using Intercooled Stata Version 9.0 (Stata Corporation, College Station, TX, USA, 1984–2000). Before statistical analysis, bacterial counts were transformed to log base10 for descriptive statistics. The geometric mean of the bacteriological counts was used to present the results of camel milk before and after pasteurization and during storage. Analysis of variance (one way ANOVA) was used to compare the trends in bacterial counts of pasteurized camel milk stored at different temperatures.

4.3 Results

4.3.1 Quality of camel milk before and after pasteurization

Sampled milk had TBC $5.7x10^5$ $cfuml^{-1}$, EBC $1.4x10^4$ $cfuml^{-1}$, PSEC $1.2x10^4$ $cfuml^{-1}$, PSC $6.7x10^3$ $cfuml^{-1}$ and YMC $9.5x10^1$ $cfuml^{-1}$ before pasteurization (Table 12). The residue TBC after pasteurization process was less than 10 $cfuml^{-1}$ while EBC, PSEC, PSC and YMC were not detectable. The raw camel milk was antibiotic and hydrogen peroxide residue free, acidity 0.16%, pH 6.64, and alcohol test was negative (Table 13).

Table 12: Total bacteria count, enterobacteriaceae, presumptive streptococcal/ enterococcal count, presumptive staphylococcal count, yeast and mold count of camel milk before and after pasteurization of camel milk

	Pasteurization	
Parameter	Before	After
Total bacteria count	$5.7x10^5$ cfu/ml	< 10 cfu/ml
Enterobacteriaceae count	$1.4x10^4$ cfu/ml	Nil
Presumptive streptococcal/enterococcal Count	$1.2x10^4$ cfu/ml	Nil
Presumptive staphylococcal count	$6.7x10^3$ cfu/ml	Nil
Yeast and mold count	$9.5x10^1$ cfu/ml	Nil

Table 13: Acidity, pH, antibiotic residue test, hydrogen peroxide and alcohol test of camel milk before and after pasteurization of camel milk

Acidity	0.16%
pH	6.64
Antibiotic residue test	Negative
Hydrogen peroxide test	Negative
Alcohol test	Negative

4.3.2 Shelf life of pasteurized camel milk

4.3.2.1 Pasteurized camel milk at 4-7°C

Figure 1 shows the TBC log $cfuml^{-1}$ against the storage period in days. TBC of pasteurized camel milk stored at 4-7°C exceeded $3.0x10^4$ $cfuml^{-1}$ (KEBS 2002) between the 49th and 54th day of storage. The shelf life of pasteurized camel milk was between 49 and 54 days. The

titratable acidity was 0.195% lactic acid on 54th day when TBC exceeded 3.0x10^{4} cfuml^{-1} and the alcohol test was negative (Table 14). The alcohol test was negative until the 56th day with acidity and pH of 0.21% and 6.48 respectively (Figure 2 and 3). TBC of milk stored at 4-7°C were highly significant ($p<0.001$) when compared with milk stored at 25°C and 30°C.

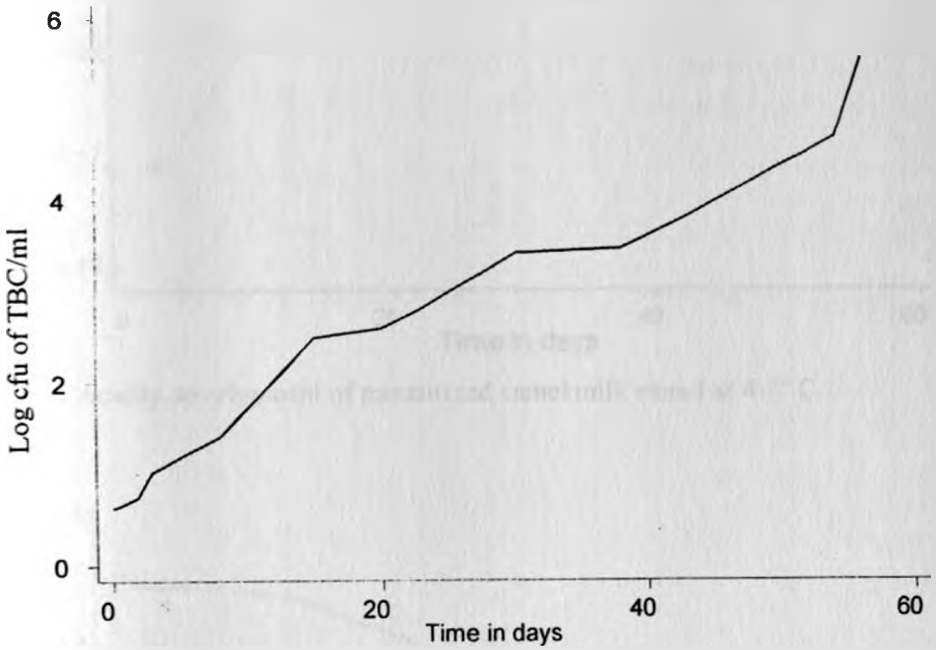

Figure 1: Log CFU of total bacteria count per ml of pasteurized camel milk stored at 4-7°C.

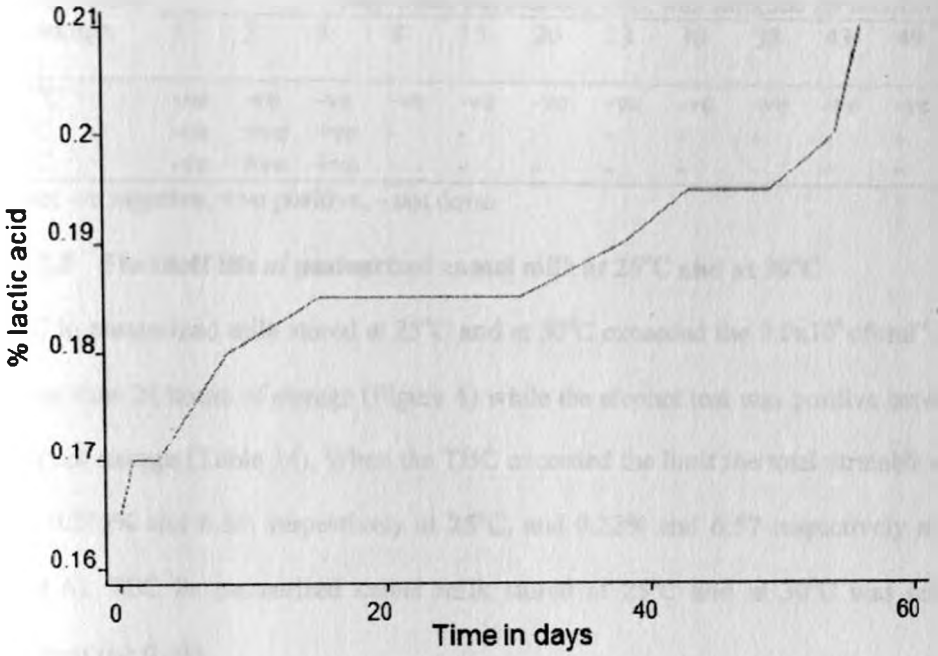

Figure 2: Acidity development of pasteurized camel milk stored at 4-7° C.

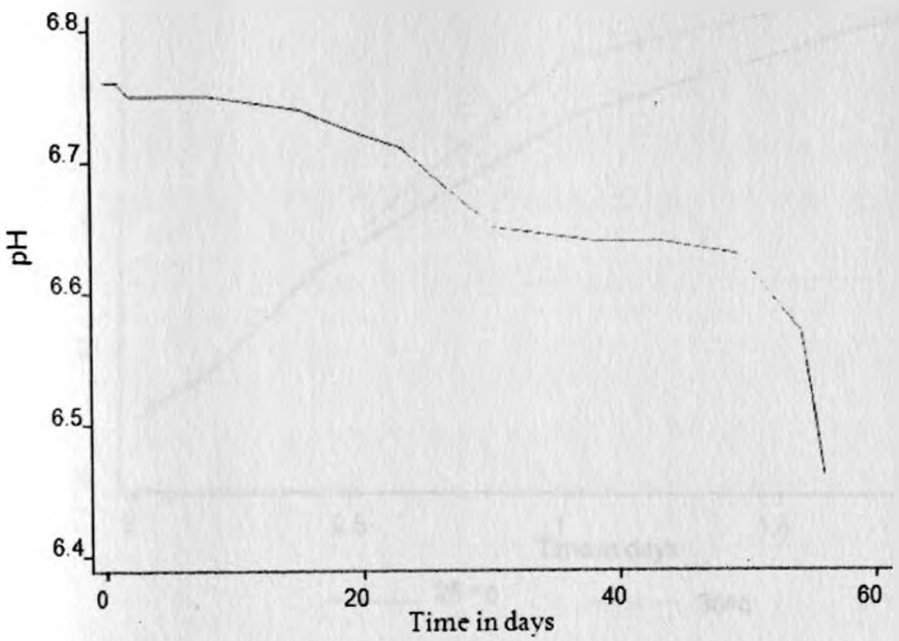

Figure 3: The change in pH of pasteurized camel milk stored at 4-7 ° C.

Table 14: Alcohol test of pasteurized milk stored at 4-7°C, 25°C and 30°C at different storage periods

Temperature of storage (°C)	Day when pasteurized milk was sampled for alcohol test													
	1	2	3	8	15	20	23	30	38	43	49	54	56	60
4-7°C	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	+ve	+ve
25°C	-ve	+ve	+ve	-	-	-	-	-	-	-	-	-	-	-
30°C	-ve	+ve	+ve	-	-	-	-	-	-	-	-	-	-	-

Note: -ve negative, +ve positive, - not done

4.3.2.2 The shelf life of pasteurized camel milk at 25°C and at 30°C

TBC in pasteurized milk stored at 25°C and at 30°C exceeded the $3.0x10^4$ $cfuml^{-1}$ (KEBS, 2002) in less than 24 hours of storage (Figure 4) while the alcohol test was positive between 24 and 48 hours of storage (Table 14). When the TBC exceeded the limit the total titratable acidity and pH was 0.215% and 6.59, respectively at 25°C, and 0.22% and 6.57 respectively at 30°C (Figure 5and 6). TBC in pasteurized camel milk stored at 25°C and at 30°C was not significantly different ($p > 0.05$).

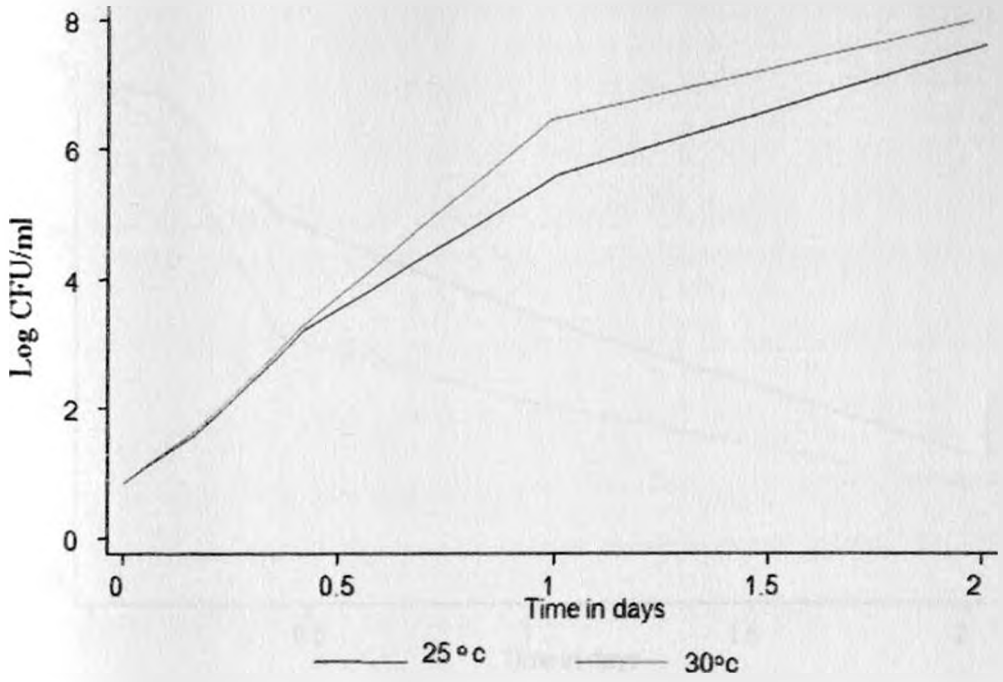

Figure 4: Log CFU of total bacteria count per ml of pasteurized camel milk stored at 25°C and at 30°C.

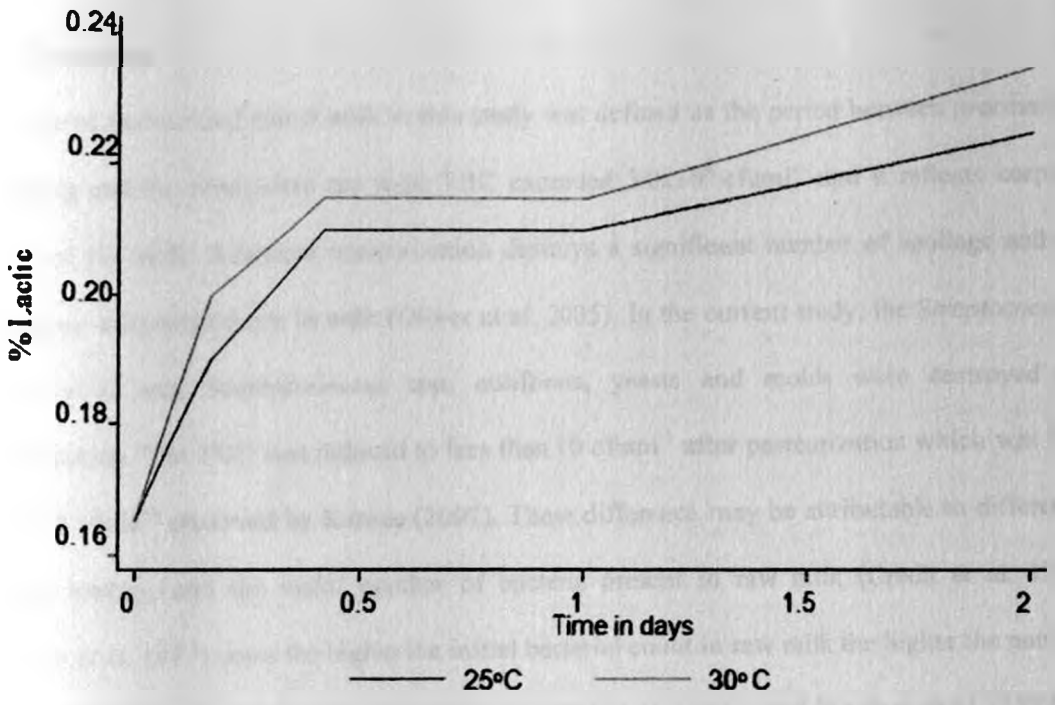

Figure 5: Acidity development in pasteurized camel milk stored at 25°C and at 30° C

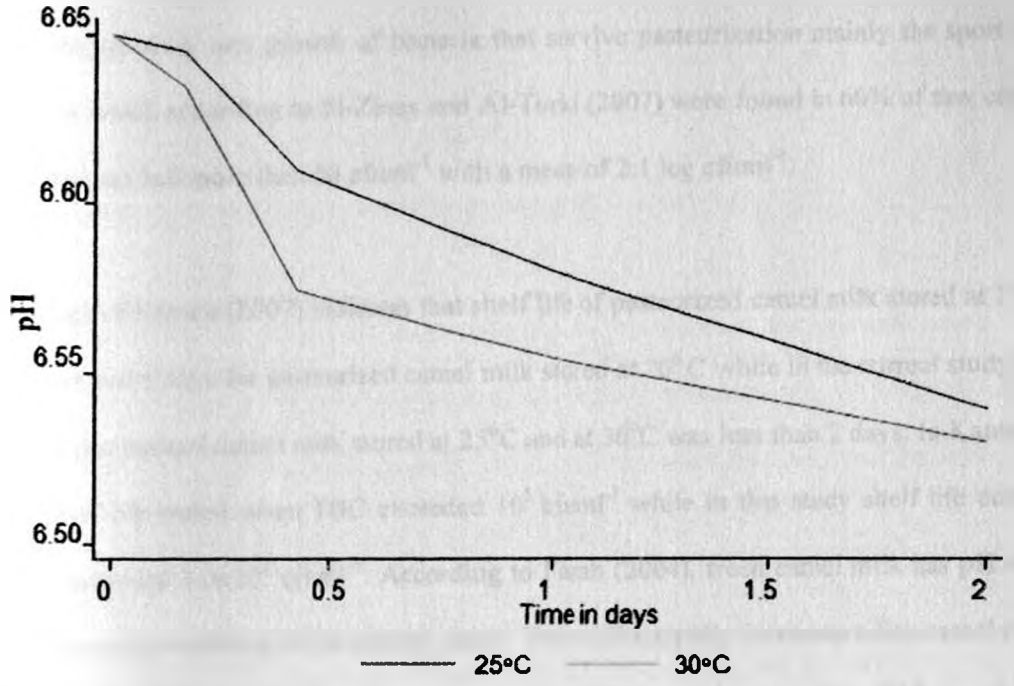

Figure 6: pH development in pasteurized camel milk stored at 25°C and at 30°C

4.4 Discussion

Shelf life of pasteurized camel milk in this study was defined as the period between processing/ packaging and the time when the milk TBC exceeded $3.0x10^4$ cfuml^{-1} and it reflects keeping quality of the milk. Adequate pasteurization destroys a significant number of spoilage and all pathogenic microorganisms in milk (Oliver et al. 2005). In the current study, the *Streptococcus/ Enterococcal* spp, *Staphylococcus* spp, coliforms, yeasts and molds were destroyed on pasteurization. The TBC was reduced to less than 10 cfuml^{-1} after pasteurization which was less than 150 cfuml^{-1} observed by Kamau (2007). These difference may be attributable to difference in milk history, and the initial number of bacteria present in raw milk (Credit et al. 1972; Washam et al. 1977) since the higher the initial bacterial count in raw milk the higher the number of survivors in pasteurized milk. According to Credit et al. (1972) and Washam et al. (1977) if post-pasteurization contamination does not occur, spoilage of unopened milk packages results from the recovery and growth of bacteria that survive pasteurization mainly the spore forming bacteria which according to El-Ziney and Al-Turki (2007) were found in 60% of raw camel milk samples and had more than 50 cfuml^{-1} with a mean of 2.1 log cfuml^{-1}.

Findings of Kamau (2007) indicates that shelf life of pasteurized camel milk stored at 10°C to be 15 days and 6 days for pasteurized camel milk stored at 20° C while in the current study the shelf life of pasteurized camel milk stored at 25°C and at 30°C was less than 2 days. In Kamau (2007) the shelf life ended when TBC exceeded 10^5 cfuml^{-1} while in this study shelf life ended when TBC exceeded $3.0x10^4$ cfuml^{-1}. According to Farah (2004), fresh camel milk has pH of 6.5-6.7 and this was confirmed in the current study. The acidity rapidly increases when camel milk stays for a longer period (Ohri and Joshi 1961) and the milk becomes sour within 12 hours at 25°C and within 8 hours at 30°C (Younan and Abdurahman 2004), which is comparable to pasteurized milk stored at the same or a higher temperature of 35°C implying rapid proliferation of

microorganisms that survive pasteurization. Pasteurized camel milk should be stored under refrigeration to benefit from the prolonged shelf life of up to 49 to 54 days as was observed in the current study. Pasteurization of raw milk results in safer dairy products since pathogenic microorganisms are destroyed (Oliver et al 2005) and thereby reduce the risk of milk-borne diseases.

Comparisons between the shelf life of pasteurized camel milk and of cow milk was not investigated in the current study. However, existing literature suggest camel milk has superior keeping quality than cow milk with this phenomenon explained by the presence of high content of natural protective proteins such as lysozyme, lactoferrin, lactoperoxidase, immunoglobulin G and A present in camel milk than in cow milk (Farah 2004; Younan and Abdurahman 2004; Ohri and Joshi 1961; Lakosa and Shokin 1964; Attia, et al. 2001).

4.5 Conclusion and recommendations

Pasteurization of camel milk and storage under refrigeration prolonged its shelf life to 49-54 days while at ambient temperatures pasteurized camel milk spoils within 24 hours. It is important to adequately boil or pasteurize camel milk before consumption since pasteurization eliminates the pathogenic and spoilage microorganisms. Consumers of camel milk need to be encouraged to consume processed camel milk products. Since this alleviates the health hazards associated with consumption of unprocessed camel milk and products.

4.6 References

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Chapter 5: Risk factors in symptoms of food poisoning among children and young adults of Isiolo (Kenya)

Abstract

This study was conducted to assess the risk factors in symptoms of food poisoning by 14 days recall period among children and young adults with special interest awarded to consumption of camel, cow, and goat milk. The role of camel milk in diet of pastoralists and the methods of preparation of the different products from camel milk were also assessed. In total, 993 respondents were interviewed from randomly selected households in peri-urban zones inhabited by sedentary populations and partly mobile pastoralists of different ethnic groups in Isiolo, Kenya. Potential risk factors for food poisoning were analyzed using both univariate and multivariate logistic regression models with random effect on ethnic group.

Raw camel milk consumption was significantly associated to the occurrence of diarrhoea and/or vomiting either with or without fever (OR 2.1; 95% CI 1.38-3.22; p= 0.001). Consumption of raw camel milk was also associated significantly with diarrhoea cases without fever (OR 3.4; 95% CI 1.52-7.80; p= 0.003) and was not significant for vomiting cases without fever (OR 2.9; 95% CI 0.91- 8.97; p= 0.071). When multivariate logistic regression model was applied raw camel milk remained a risk factor to diarrhoea and/or vomiting (OR 2.6; 95% CI 1.61-4.31; P(LRχ2)= 0.0002). In the multivariate model, raw cow milk emerged as a preventive factor to diarrhoea/vomiting (OR 0.5; 95% CI 0.33-0.89; P(LRχ2)= 0.0145), which was also the case for 'washing of hands with soap', 'treating drinking water', 'boiling of milk' and 'presence of proper drainage system' .

This study confirms the hypothesized need for feasible and sustainable interventions to mitigate food-borne related diseases in the agro-pastoralist regions of Northern Kenya. Possible interventions may include consumer health education, provision of adequate clean water and improved sanitation and hygiene.

5.1 Introduction

In recent years, there has been a heightened concern about food safety. The global incidence of food-borne diseases is difficult to estimate, but it was reported that in the year 2005 alone, 1.8 million people died from diarrhoeal related diseases. A great proportion of these cases can be attributed to consumption of contaminated food and drinking water. Additionally, diarrhoea is a major cause of malnutrition and high mortality in infants and young children (WHO 2000).

In Kenya, especially the arid and semi-arid lands (ASALs), harvesting and handling of raw camel milk and "*susac*" a product of spontaneous fermentation of camel milk is done with little consideration to hygiene (Younan and Abdurahman 2004). This handling is compounded by shortage and/or unavailability of clean water in the ASAL regions. The camel milk is collected, stored, transported, and sold in 5-20 liters plastic jerry cans (Wangoh 2004; Bonfoh et al. 2006) which are difficult to clean and are usually washed with limited amount of water. Transport of milk from the production sites to the milk collection points and to the markets can take 8-10 hours, with delays occurring due to long distance between scattered collection sites and poor roads infrastructure (Farah 2004). These contribute to milk spoilage reducing the freshness of marketed camel milk or its market value and increase the risk of milk-borne food poisoning among the consumers. Camel milk is predominantly consumed raw and this

might be a major risk factor contributing to incidences of diarrhoea and vomiting among the sedentary pastoralists of Northern Kenya. Camel breeders say that camel milk if not boiled "inaarisha mgeni" i.e. cause a short bout of diarrhoea to visitors consuming camel milk for the first time. There is a believe that consumption of raw and fermented camel milk cures several diseases (Khalif Abbey, personal communication).

The objectives of this study were to evaluate the prevalence of diarrhoea and/or vomiting and to associate their occurrence to the consumption of camel, cow, and goat milk. The role of camel milk consumption in the sedentary nomadic households' diet was also assessed. The events of diarrhoea, vomiting and fever during the past 14 days were based on reports by the interviewed persons after probing.

5.2 Subjects and methods

5.2.1 The study site

This research was undertaken in Isiolo district of Northern Kenya, which is part of the arid and semi-arid lands (ASALs) of Kenya. ASALs comprise approximately 80% of Kenya's land area and an estimated 75% of livestock is kept in these areas. According to FARM-Africa, Kenya (2002), the soils here are of low fertility, climatic conditions vary between lowlands and highlands and rainfall is generally below 200 to 300 mm per year, erratic in season, duration and distribution. Agricultural productivity is dependent on rainfall and varies greatly between areas and seasons. The inherent production systems adopt strategies aimed at mutual coexistence between humans and the livestock they depend on which is often their sole means of livelihood. Major ethnic groups living in this district are; Borana, Somali, Turkana, Samburu and

Sakuye communities in Isiolo. The Gabra, Rendille, Turkana, Sakuye and Somali are primarily camel keepers whilst the Borana and Samburu are traditional cattle owners who have increasingly adopted the camel in recent years. The major town of Isiolo is metropolitan with different ethnic groups many of whom are not pastoralists. The camel is drought tolerant, environmentally friendly and well suited for conditions in Northern Kenya.

5.2.2 Sampling

Three divisions of Isiolo district (namely, East, West and Central divisions) were purposively selected for this study. This sample represented camel milk consumers, non consumers and involved a combination of different ethnic groupings. The villages/estates in the divisions were selected based on gridlines covering one km^2 on a satellite map of Isiolo (Annex 5). The grid boxes were labeled 1-12 and then six grid boxes were randomly selected by drawing random numbers. The first household and direction taken was determined by spinning a pen. Every 4^{th} household was selected depending on the average population density per square kilometer (GOK 1996). Participants in the household were selected by interviewing either children or young adults that were about to celebrate their birthday. The use of satellite map in targeting households in the study region was crucial because of the ease in marking and traceability of targeted households on certain specific locations and also because it assures representative targeting as area population density can be estimated by looking at the satellite photograph of the area. Figure 8 below summarized the sampling methodology used.

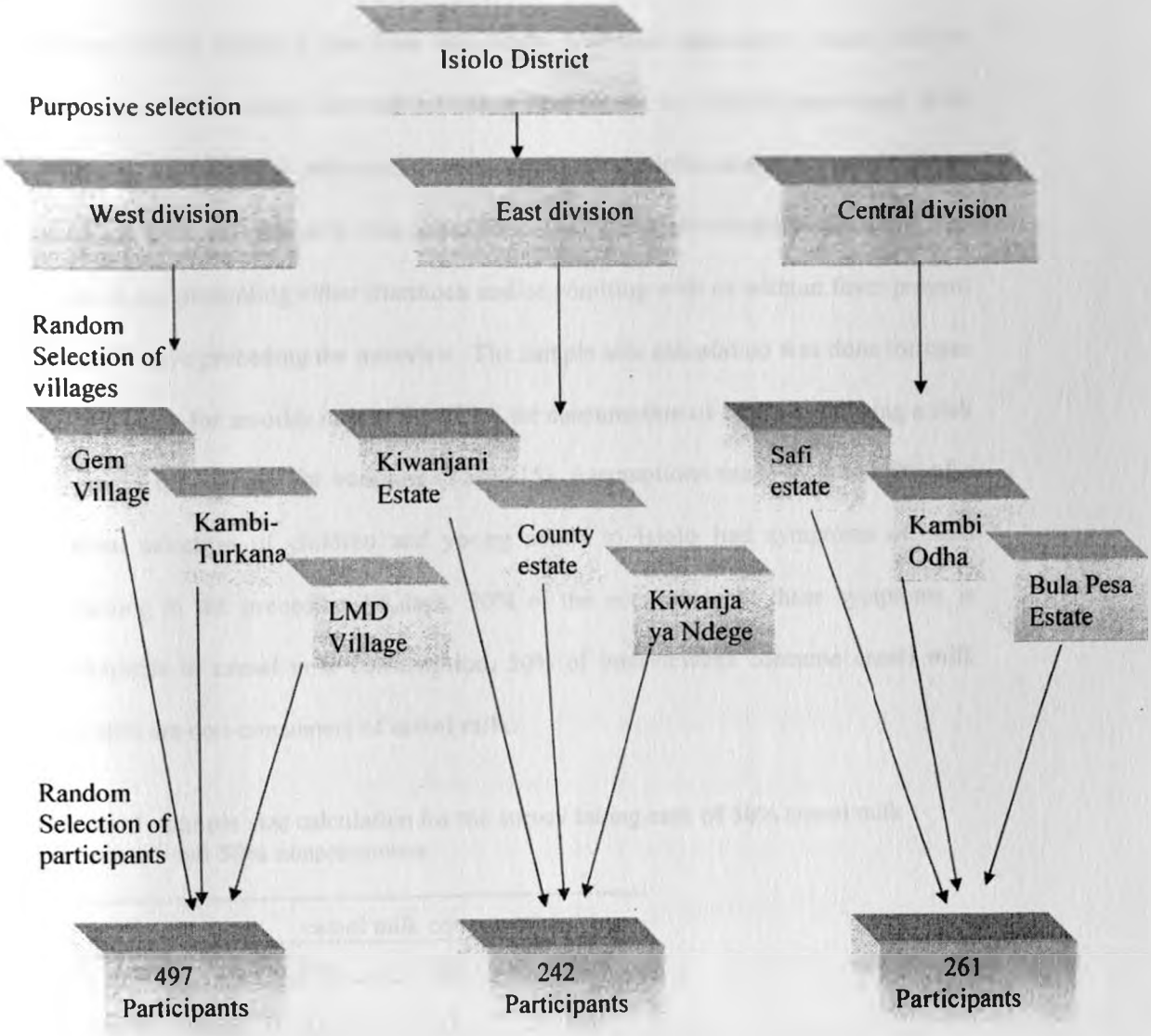

Figure 7: Sampling scheme and the number of participants selected in each village in peri-urban zones of Isiolo

5.2.3 Study design

A cross-sectional survey was carried out by interviewing a random sample of 993 households in locations on grids selected randomly from the map of Isiolo district. The target groups consisted of households that predominantly consume camel milk and those not consuming. Interviewees were limited to children (whereby mothers or other care givers of young children were questioned) and young adults (3-25 years)

because it was assumed that from this study, a nested case-control study will be constructed. This study allowed for identification of risk factors associated with diarrhoea and vomiting with special consideration to the influence of the consumption of camel, cow and goat milk. The positives (+ves) were defined as persons aged 3-25 years of age presenting either diarrhoea and/or vomiting with or without fever present in the 14 days preceding the interview. The sample size calculation was done for case control study for an odds ratio (OR) of 2.4 for consumption of camel milk being a risk factor for diarrhea and/or vomiting (Table 15). Assumptions made included 5% of a random selection of children and young adults in Isiolo had symptoms of food poisoning in the preceding 14 days, 70% of the occurrence of these symptoms is attributable to camel milk consumption, 50% of interviewees consume camel milk and 50% are non-consumers of camel milk.

Table 15: Sample size calculation for the survey taking care of 50% camel milk consumers and 50% nonconsumers

		camel milk consumption		
		Yes	No	**Total**
Food poisoning	+ves	35	15	**50**
	-ves	465	485	**950**
Total		**500**	**500**	**1,000**

5.2.4 Data collection

Before the interview, informed consent was obtained from local people and the provincial administration. The interviews were conducted using a semi-structured questionnaire (Annex 1). Before administering the questionnaire, it was pre-tested (including translation into local language and re-translation in English). Pretesting of the questionnaire involved households that were not included in the survey. Questions

covering from demographics, food consumption frequencies, methods of preparation of camel milk before consumption, hygiene and sanitation, symptoms of food poisoning and the participants risk perception concerning the latter were included. Enumerators were local persons who understood and were familiar with the local language. They underwent appropriate training and supervision prior to undertaking the study. Interviews were conducted in Swahili language and translated where necessary to local language. Recruitment and training of the field assistants was done as per the already established plan (Annex 2).

5.2.5 Statistical data analysis

Data analysis was carried out using Intercooled Stata Version 9.0 (Stata Corporation, College Station, TX, USA, 1984–2000). Univariate analyses were carried out for all plausible variables from the questionnaire, including the different forms of consumption of camel, cow and goat milk. Case definitions for the study included: diarrhoea and/or vomiting, diarrhoea and/vomiting without fever and vomiting without fever. The logistic regression models included random error on five major ethnic groups. Backward stepwise multivariate logistic regression analysis was carried on the diarrhea/vomiting case definition. Only variables with a significance level of $P < 0.2$ (based on the likelihood ratio test) and those which were biologically plausible were fitted into the multivariate model. The significance level was set at $P < 0.05$ (likelihood ratio test or Wald test statistics). Association of perceived risks with age and ethnic group was assessed by cross-tabulation and chi square test for significance testing. The background information and food consumption frequency were summarized by contingency tables. The prevalence of symptoms of food poisoning

were calculated by assessing the frequencies of recalled presence of illness by the respondents.

5.3 Results

5.3.1 General information

The total sample size was 993 individuals of ages 3-25 years of age. Table 16 shows the demographic characteristics of the respondents. In this study, more females (60%) than males (40%) were interviewed. A higher percentage (80%) of the respondents was not married. Sons (36.8%) and daughters (41.6%) of the household heads formed the majority of the interviewees followed by spouses (14.8%). All year residents were 82.7% while 16.6% were regularly absent from their households. The education status of the majority of respondents was below college level of education (Table 16). The ethnic groups included the Somali, Turkana, Boran, Meru, Ajuran, Kikuyu, Samburu, Ogaden, Sakuye, Rendille, Indian, Embu, Dogodia, Gabra, and Garrey. These were summarized in five major groups; Boran 21.1%, Somali 55%, Turkana 19.7%, Meru 15.2% and other tribes 11.1%. Camel milk consumers were found among all ethnic groups, this was sometimes at a low proportion (Table 16).

Forty six percent (46.3%) of the respondents were camel milk consumers while 53.7% did not consume camel milk. The Somali, Ajuran, Garrey (73%, 82.8% and 81%, respectively) showed the highest frequencies of consumption of camel milk.

Table 16: Percent distribution of participants by background characteristics, in Central, West and East divisions of Isiolo district

Category	Males (%)	Females (%)	Total	Percent
Age				
3-5 yrs	53 (13.2)	6 5(11.0)	118	11.9
6-15 yrs	210 (52.2)	226 (38.4)	436	44
15-25 yrs	139 (34.6)	298 (50.6)	437	44.1
Marital status				
Single	158 (40)	157 (27.0)	315	32.3
Married monogamously	19 (4.8)	156 (26.9)	175	17.9
Married polygamous	2 (0.5)	3 (0.5)	5	0.5
Divorced	2 (0.5)	4 (0.7)	6	0.6
Widowed	2 (0.5)	6 (1.0)	8	0.8
Youth	212 (53.7)	255 (43.9)	467	47.9
Residence time				
Full-time	311 (77.6)	505 (86.2)	816	82.7
Regularly absent	86 (21.5)	78 (13.3)	164	16.6
Non-resident	3 (0.8)	1 (0.2)	4	0.4
Other (specified)	1 (0.3)	2 (0.3)	3	0.3
Occupation				
Regularly employed	6 (1.5)	8 (1.4)	14	1.4
Temporarily employed	4 (1.09	7 (1.2)	11	1.1
Self-employed	17 (4.3)	39 (6.8)	56	5.7
Casual labourer	2 (0.5)	5 (0.9)	7	0.7
Unemployed	77 (19.4)	81 (14.0)	158	16.2
Student	290 (73.1)	332 (57.4)	622	63.8
H/wife	0	106 (18.3)	106	10.9
Other	1 (0.3)	0	1	0.1
Relation to household head				
HH head	23 (5.8)	17 (2.9)	40	4.1
Spouse	6 (1.59	140 (23.9)	146	14.8
Son	338 (84.5)	25 (4.3)	363	36.8
Daughter	18 (4.5)	393 (67.0)	411	41.6
Other relative	8 (2.0)	6 (1.0)	14	1.4
Friend	6 (1.5)	2 (0.3)	8	0.8
Education level				
1-4 years	74 (18.6)	86 (15.0)	160	16.5
5-8 years	75 (18.9)	104 (18.1)	179	18.4
Secondary school	140 (35.3)	216 (37.6)	356	36.7
College	93 (23.4)	155 (27)	248	25.5
University	8 (2.0)	3 (0.5)	11	1.1
N/A	7 (1.8)	10 (1.7)	17	1.8
Ethnic groups				
Boran	75 (18.7)	134 (22.7)	209	21.07
Somali	133 (33.1)	214 (36.3)	347	34.98
Turkana	95 (23.6)	100 (17.0)	195	19.7
Meru	50 (12.4)	81 (13.7)	131	13.2
Other tribes	49 (12.2)	61 (10.3)	110	11.1

5.3.2 Food consumption

To determine the role of camel milk in the dietary habits of the pastoralists, a comprehensive diet profile was assessed by looking at the consumption frequency of various foods (Table 17). The quantities of foods consumed nor their recipes were not assessed in this study. However, recipes for the different forms of consumption of camel milk were assessed. We observed that raw milk is consumed mainly by the pastoralist communities in comparison to urban communities with no pastoralist background. However, fermented and boiled milk were consumed more than raw milk. Boiled cow milk (51.1%) is grossly the most frequently consumed milk followed by camel milk (25.8%) then goat milk (18.3%) on daily basis. Cow milk sold in the study area originates from the neighbouring Meru District or other areas where cattle dairy farming is conducive while camel and goat milk are mainly produced and supplied by the pastoralist groups.

Rice and maize form the staple food among the inhabitants of Isiolo. Rice (41.2%) is consumed by a majority of the population to a large extend on daily basis than wheat (32.7%), maize (25.5%) and spaghetti (25.5%). Among roots and tubers, irish potatoes (70.2%) are the most consumed whilst cassava and arrow roots are rarely consumed.

Table 17: Summery of food consumption frequencies for children and young adults in peri-urban zones of Isiolo

Type of food (n=826)	Daily	4-6 times a week	2-3 times a week	Once a week	Twice a month	Once a month	Never
Raw camel milk	11.5	0.9	8.2	1.1	0.7	0.5	76.4
Boiled camel milk	25.8	1.6	10.9	1.8	0.5	0.7	58.4
Fermented camel milk	9.7	2.7	4.8	8.5	4.0	3.2	65.7
Raw cow milk	14.5	3.5	13.6	3.5	2.3	1.0	60.5
Boiled cow milk	51.1	7.5	21.4	3.2	1.9	1.1	13.8
Fermented cow milk	9.0	5.8	12.5	13.0	6.2	7.0	41.4
Raw goat milk	6.3	4.0	9.6	5.9	3.4	2.1	67.1
Boiled goat milk	18.3	7.3	18.4	5.7	4.5	2.8	40.4
Fermented goat milk	4.4	1.9	4.8	6.8	4.1	5.9	68.3
Maize	25.8	12.7	26.2	12.2	7.0	10.9	4.8
Spaghetti	25.5	8.5	30.9	9.3	8.1	7.8	8.0
Rice	41.2	10.2	33.3	4.5	2.9	4.2	3.0
Sorghum	5.7	2.8	4.8	1.9	2.8	3.6	75.7
Wheat	32.7	4.5	11.6	7.8	7.5	4.7	23.9
Arrow roots	2.2	2.7	4.1	2.2	5.1	5.0	71.1
Cassava	2.4	1.1	3.0	1.8	5.3	5.0	74.8
Irish potatoes	70.2	5.7	8.7	1.3	1.1	2.7	7.9
Beans	18.0	16.1	39.0	5.8	5.6	8.0	6.8
Chicken pea	0.7	0.5	4.5	1.6	4.0	4.2	82.1
Cow pea	0.9	2.1	5.3	4.8	5.7	4.6	72.5
Green grams	4.4	7.0	20.3	11.0	13.4	9.0	32.1
Pigeon peas	0.7	0.9	3.8	3.2	4.1	3.6	80.5
Soy beans	3.2	1.9	5.3	2.2	3.6	5.9	67.8
Indigenous vegetables	3.5	2.2	7.4	2.1	3.6	3.4	58.0
Cabbages	32.8	13.0	43.7	3.5	2.2	1.5	2.2
Kales	39.7	13.1	39.6	2.5	1.3	0.2	3.3
Cassava leaves	1.8	1.5	4.4	1.1	2.9	3.9	82.9
Cowpea leaves	0.6	1.7	6.1	6.7	5.3	4.4	71.9
Pumpkin leaves	1.1	0.9	3.8	1.2	4.1	2.1	81.5
Spinach	13.4	6.8	33.1	7.3	8.7	8.0	18.6
Carrots	32.5	7.3	30.3	6.4	5.5	5.8	10.8
Onions	86.8	2.2	2.9	1.1	1.8	1.1	3.8
Pumpkin	6.9	1.5	3.4	3.6	6.8	4.2	65.0
Tomatoes	90.4	1.9	2.7	0.9	0.9	1.3	1.7
Avocado	22.3	9.7	26.5	11.9	13.2	6.2	8.2
Lemon	7.5	4.8	11.4	16.5	20.7	6.1	26.5
Mango	20.1	7.6	18.6	14.5	11.0	7.0	7.8
Oranges	14.3	6.1	17.9	20.2	16.2	8.8	9.8
Pawpaw	10.1	7.1	19.5	15.0	20.2	12.5	11.9
Pineapple	4.2	5.1	10.9	9.8	17.7	12.5	23.7
Guavas	1.6	1.6	2.2	2.8	9.1	4.6	66.0
Eggs	27.2	18.2	21.7	10.5	6.3	4.4	11.3
Beef	29.8	10.9	30.5	7.1	4.5	5.1	10.5
Camel meat	23.7	7.4	21.7	6.1	3.0	4.4	32.2
Goat meat	9.0	8.7	29.4	12.2	7.4	9.4	17.1
Mutton	5.1	2.7	13.6	7.8	10.2	7.4	41.8
Fish	1.8	1.0	2.2	4.5	3.3	3.4	73.2
Sugar	93.8	1.3	1.7	0.2	0.1	0.2	2.3
Bread	48.9	6.1	24.7	3.5	7.0	1.5	8.2
Fats/oils	94.9	1.6	2.4	0.1	0.2	-	0.7
Tea	93.8	1.2	2.8	0.2	0.9	0.1	1.0
Coffee	5.7	3.4	15.5	13.0	13.4	7.4	35.2
Cocoa	3.2	2.4	6.5	9.1	8.2	8.0	54.8

Beans (93.2%) and green grams (67.9%) were the most commonly consumed legumes. All legumes apart from the green grams were referred to as *"digiri"* in Somali language (Table 17).

In this study, tomatoes (90.4%), onions (86.8%), cabbages (32.8%), kales (39.7%), carrots (32.5%) and spinach (13.4%) are the commonly consumed vegetables on a daily basis since they are available at the local market. Consumption of indigenous vegetables (3.5%), cassava leaves (1.8%), pumpkin leaves (1.1%), and cow pea leaves (0.6%) is quite low on a daily basis but are commonly consumed by the non pastoralist communities. The majority of the fruits are consumed frequently when they are in season. Avocado (22.1%), mangoes (20.1%), oranges (14.3%), and pawpaw (10.1%) are the commonly consumed fruits on daily basis (Table 17).
For animal protein source, cattle beef is the most commonly consumed (29.8%) while camel meat is more (23.7%) frequently consumed than goat meat (9.0%) and mutton (5.1%) on daily basis. Fish was rarely consumed (1.8%) reason could be due to lack of adequate or no supply in the town. Sugar (93.8%), tea (93.8%) and bread (48.9%), were consumed daily unlike coffee (5.7%) and cocoa (3.2%) that were consumed by a small proportion of the population. Fats/oils are consumed by 94.9% of the population on daily basis (Table 17).

5.3.3 Description of camel milk preparation methods at household level

Camel milk is consumed either raw, in tea, boiled or in the form of *susac*. The majority of people consumed raw and fermented camel milk for its medicinal benefits. Raw and fermented camel milk consumed in the household were either obtained from the market or from own camels. The preschool children are mainly fed on boiled camel milk while majority of aged 6-25 years preferred raw or fermented

milk taken as an accompaniment with other foods or sometimes plain. Traditional fermentation of milk was practiced in a few households with the large majority buying *susac* from the market. *Susac* prepared in the household was as a result of spontaneous fermentation by storing the milk in a guard or plastic container at room temperature for 2-3 days while others fermented the milk up to 4-6 days. Tea made using camel milk was commonly consumed in all households with some households preferring to use milk in tea than milk alone. Tea is prepared by boiling together milk, water, tea leaves, and sugar. The proportions of the ingredients vary among households. The temperature achieved during boiling of milk was not measured during this study. But many households suggested milk was either boiled to attain a single bouyance followed by cooling or milk was slightly heated to get enough warmth to avoid milk coagulation. Others suggested that camel milk is disease free especially milk obtained that was obtained from their own camels unlike milk obtained from the market.

5.3.4 Food poisoning

Households in the West division had the highest frequency of symptoms of food poisoning while Central and East divisions had similar frequencies (chi square test $p>0.05$). Univariate analysis on case group with diarrhea and/or vomiting with or without fever (Table 18) and using a random effect logistic model (on the level of ethnic group) indicate consumption of raw camel milk was highly significant with odds ratio (OR) 2.1; 95% CI= 1.38-3.22; P-value= 0.001 while 'treating of drinking water', 'washing hands with soap' and 'presence of proper drainage' emerged as protective factors.

Table 18: Associatinon of risk factors to diarrhea and or vomiting with or without fever as assessed by univariate analysis

Diarrhoea/vomiting	+ve(%) n=104	-ve(%) n=797	OR	p-value	CI
Age (yrs)					
3-5yrs	9(8.7)	98(12.3)	1.00		
6-15	41(39.4)	345(43.3)	1.26	0.547	0.59 - 2.68
16-25	54(51.9)	345(43.3)	1.70	0.158	0.81 - 3.57
Sex					
Male	41(39.4)	318(39.9)	1.00		
female	63(60.6)	479(60.1)	1.02	0.926	0.67 - 1.55
Raw camel milk	42(40.4)	194(24.3)	2.11	0.001***	1.38 - 3.22
Boiled camel milk	53(51.0)	337(42.3)	1.42	0.094	0.94 - 2.14
Fermented camel milk	44(42.3)	272(34.1)	1.42	0.101	0.93 - 2.14
Raw cow milk	37(35.6)	322(40.4)	0.81	0.345	0.53 - 1.25
Boiled cow milk	83(79.8)	686(86.1)	0.64	0.091	0.38 - 1.07
Fermented cow milk	54(51.9)	469(58.9)	0.76	0.179	0.50 - 1.14
Raw goat milk	27(26.0)	254(31.9)	0.75	0.222	0.47 - 1.19
Boiled goat milk	52(50.0)	465(58.3)	0.71	0.107	0.47 - 1.08
Fermented goat milk	31(29.8)	246(30.5)	0.95	0.826	0.61 - 1.49
Source of water					
Tap	49(47.1)	386(48.4)	1.00		
Delivery	23(22.1)	140(17.6)	1.29	0.342	0.76 - 2.20
River and dam	31(29.8)	267(33.5)	0.91	0.713	0.57 - 1.47
Other	1(1.0)	4(0.5)	1.97	0.548	0.22 - 17.98
Do you treat drinking water?	45(43.3)	427(53.6)	0.66	0.049*	0.44 - 1.00
Boiling water	22(46.8)	252(58.2)	1.00		
Use of chemicals	24(51.1)	173(40.0)	1.59	0.137	0.86 - 2.92
Boiling and chemicals	0	1(0.2)	0.00	0.999	0.00
Boiling water	1(2.1)	7(1.6)	1.64	0.652	0.19 - 13.91
Do you treat milk?	96(93.2)	740(93.3)	0.98	0.966	0.43 - 2.22
Do you always use soap to wash hands?	52(50.0)	483(60.6)	0.65	0.039*	0.43 - 0.98
Traditional pit latrine	81(77.9)	594(74.5)	1.00	-	-
No toilet	22(21.2)	152(19.1)	1.06	0.817	0.64 - 1.76
Improved pit latrine	1(1.0)	38(4.8)	0.19	0.107	0.03 - 1.42
Water in-closet toilet	0	13(1.6)	0.00	0.997	- -
Was proper drainage present?	22(21.2)	261(32.8)	0.55	0.018*	0.34 - 0.90
Was sewerage system present?	2(2.9)	23(2.9)	0.66	0.575	0.15 - 2.84
Was compound littered?	38(36.5)	267(33.5)	1.14	0.538	0.75 - 1.75

Level of significance; *** p <= 0.001, * p<0.05

Raw camel milk was also significant for diarrhea and/ or vomiting without fever (OR 3.4; 95% CI= 1.52-7.80; p= 0.003) (Table 19). Treating water, boiling milk, washing hands with soap and presence of proper drainage were protective factors. Vomiting without fever, raw camel milk was not significant (p-value of 0.071 and OR 2.9; 95% CI 0.91- 8.97).

Table 19: Association of risk factors to diarrhoea and/or vomiting without fever as assessed by univariate analysis

Diarrhoea/ vomiting no fever	+ve(%) n=24	-ve(%) n=873	OR	p-value	95%CI
Age(yrs)					
3-5	-	107(12.3)	-	-	- 2.2
6-15	12(50)	382(43.8)	-	-	-
16-25	12(50)	384(44.0)	-	-	-
Sex					
Male	8(33.3)	350(40.1)	1.00	-	- 2.3
female	16(66.7)	523(60.1)	1.34	0.51	0.56 -3.16
Division					
Central	6(25)	240(27.5)	1.00	-	- 2.4
East	3(12.5)	209(24.0)	0.57	0.437	0.14 - 2.32
West	15(62.5)	424(48.6)	1.42	0.478	0.54 - 3.70
Raw camel milk	13(54.2)	223(25.5)	3.44	0.003*	1.52 - 7.80
Boiled camel milk	13(54.2)	377(43.2)	1.55	0.288	0.69 - 3.51
Fermented camel milk	10(41.7)	306(35.1)	1.32	0.541	0.54 - 3.24
Raw cow milk	12(50)	347(39.8)	1.54	0.304	0.68 - 3.48
Boiled cow milk	19(79.2)	747(85.6)	0.65	0.414	0.23 - 1.83
Fermented cow milk	11(45.8)	510(58.4)	0.61	0.231	0.27 - 1.38
Raw goat milk	9(37.5)	272(31.2)	1.33	0.503	0.57 - 3.09
Boiled goat milk	13(54.2)	502(57.5)	0.88	0.755	0.39 - 1.99
Fermented goat milk	7(29.2)	269(30.8)	0.91	0.844	0.37 - 2.24
Tap	8(33.3)	426(48.8)	1.00	-	- -
Delivery	5(20.8)	158(18.1)	1.66	0.384	0.53 - 5.20
River and dam	10(41.7)	285(32.7)	1.85	0.209	0.71 - 4.82
Other	1(4.2)	4(0.5)	13.70	0.027*	1.34 - 140.4
Do you treat drinking water?	9(37.5)	459(52.6)	0.54	0.148	0.23 - 1.25
Boiling water	6(66.7)	264(56.5)	1.00	-	- -
Use of chemicals	2(22.2)	195(41.8)	0.45	0.333	0.09 - 2.26
Boiling and chemicals	0	1(0.2)	0.00	0.999	0.00 -
Boiling water	1(11.1)	7(1.5)	6.29	0.109	0.67 - 59.41
Do you treat milk?	22(91.7)	810(93.3)	0.78	0.747	0.18 - 3.43
Do you always use soap to wash hands?	14(58.3)	517(59.2)	0.96	0.922	0.42 - 2.19
No toilet	20(83.3)	652(74.7)	1.0	-	- -
Traditional pit latrine	4(16.7)	169(19.4)	0.78	0.658	0.26 - 2.35
Improved pit latrine	-	-	0.00	0.999	- -
Water in-closet toilet	-	-	0.00	0.999	- -
Was proper drainage present?	2(8.3)	280(32.1)	0.19	0.027*	0.05 - 0.83
Was sewerage system present?	-	-	0.00	0.998	0.00 -
Was compound littered?	9(37.5)	296(33.9)	1.17	0.712	0.51 - 2.71

Level of significance; * $p<0.05$

Raw camel milk still remains as a strong risk factor to gastrointestinal illnesses in the backward selection multivariate logistic regression (Table 20) with OR 2.6; 95% CI=1.61-4.31; p=0.000; P(LRχ2)= 0.0002, raw cow milk emerge as a protective factor with OR 0.54; 95% CI=0.33-0.89; p =0.015; P(LRχ2)= 0.0145 . Washing of hands with soap, treating drinking water, boiling of milk and presence of proper drainage system and improved pit latrine have emerged as a significant risk mitigation factors.

Table 20: Association of risk factors to diarrhoea and vomiting as assessed by step-wise backward multivariate logistic regression.

Diarrhoea/ vomiting	+ves (%)	-ves (%)	OR	P-value	95%CI	[1]P (LR χ2)
Raw camel milk	42(40.38)	194(24.34)	2.63	0.000***	1.61 - 4.31	0.0002
Raw cow milk	37(35.58)	322(40.4)	0.54	0.015*	0.33 - 0.89	0.0145
Proper drainage	22(21.15)	261(32.75)	0.68	0.141	0.41 - 1.13	0.0963
Pit toilet	22(21.15)	152(19.07)	1.09	0.757	0.65 - 1.82	0.0597
Improved latrine	1(0.96)	38(4.77)	0.15	0.059	0.02 - 1.08	-

[1]Note: P (LR χ2) is the log likelihood test;
Level of significance; *** P<0.0001, * p<0.05

5.3.5 Perceived risks of food poisoning

A series of closed questions were asked to assess the risk perception of the respondents. The solutions offered were varied depending on the ethnic community and age of the individuals. Causes of diarrhoea were perceived differently by the five groups involved, whereas the Somali group thought raw camel milk was a possible cause of diarrhoea, the Meru group was the least to relate raw camel milk to diarrhoea/ vomiting which is contrary to the incidence of the illness. None of the groups associated boiled or fermented milk to gastrointestinal illness (Table 21). The level of knowledge on the risk associated with consuming contaminated milk or products increase with increase in age (Table 22).

Table 21: Risk awareness to food poisoning by ethnic groups and its association with consumption of different foods in Isiolo District

Food	Somali n=301 (%)	Boran n=165 (%)	Turkana n=186 (%)	Meru n=94(%)	Others n=84(%)	Total n=830(%)	p-value (wald test)
Fruits/vegetables	126(41.9)	75(45.5)	84(45.2)	47(50.0)	28(33.3)	360(43.4)	0.204
Meat	49(16.3)	30(18.2)	39(21.0)	15(16.0)	11(13.1)	144(17.4)	0.524
Raw cow milk	143(47.5)	61(37.0)	66(35.5)	34(36.2)	31(36.9)	335(40.4)	0.039
Boiled cow milk	4(1.3)	1(0.6)	2(1.1)	1(1.1)	1(1.2)	9(1.1)	0.971
Fermented cow milk	31(10.3)	9(5.5)	8(4.3)	8(8.5)	10(11.9)	66(8.0)	0.064
Raw camel milk	132(43.9)	59(35.7)	62(33.3)	25(26.6)	27(32.1)	305(36.8)	0.014*
Boiled camel milk	3(1.0)	2(1.2)	12(6.5)	4(4.2)	0(0)	21(2.5)	0.001*
Fermented camel milk	16(5.3)	20(12.1)	16(8.6)	8(8.5)	15(17.9)	75(9.0)	0.005*
Raw goat milk	137(45.5)	50(30.3)	57(30.7)	26(27.7)	27(32.2)	297(35.8)	0.001*
Boiled goat milk	2(0.7)	3(1.8)	3(1.6)	2(2.1)	1(1.2)	11(1.3)	0.753
Fermented goat milk	26(8.6)	8(4.9)	10(5.4)	10(10.6)	12(14.3)	66(8.7)	0.048
Water	211(70.01)	97(58.8)	113(60.8)	55(58.5)	42(50.0)	518(62.4)	0.005*

Level of significance; ** P<0.001, * p<0.05

Table 22: Risk awareness to food poisoning by age groups and its association with consumption of different foods in Isiolo District

Age category/food	3-5 yrs n=97	6-15 n=372	16-25 n=360	Total n=829	p-value (Wald test)
Fruits and vegetables	45(46.4)	180(48.4)	135(37.5)	360(43.4)	0.0102*
Meat	19(19.6)	73(19.6)	52(14.4)	144(17.4)	0.1518
Raw cow milk	33(34.0)	164(44.1)	137(38.1)	333(40.3)	0.1232
Boiled cow milk	2(2.1)	6(1.6)	1(0.3)	9(1.1)	0.2153
Fermented cow milk	14(14.4)	38(10.2)	14(3.9)	66(8.0)	0.0006**
Raw camel milk	28(28.9)	141(37.9)	136(37.8)	305(36.8)	0.2455
Boiled camel milk	7(7.2)	8(2.2)	6(1.7)	21(2.5)	0.0230*
Fermented camel milk	14(14.4)	37(10.0)	24(6.7)	75(9.1)	0.0372*
Raw goat milk	26(26.8)	148(39.8)	122(33.9)	296(35.7)	0.0551*
Boiled goat milk	2(2.1)	6(1.6)	3(0.8)	11(1.3)	0.5369
Fermented goat milk	11(11.3)	34(9.1)	20(5.6)	65(7.8)	0.0820
Water	51(52.6)	243(65.3)	223(61.9)	517(62.4)	0.0837

Level of significance; **p<0.001, *p<0.05

The results varied among different ethnic groups and age category due to the diverse socio-cultural differences among the pastoral groups and non nomadic groups. When respondents were asked rank foods starting with food most likely cause for diarrhea and vomiting to the least likely cause, water was ranked first followed by milk and meat third. Fruits and vegetables were ranked the least risk for diarrhoea/vomiting

(Table 23). Most of the respondents (70.2%) thought dirt was a leading cause of diarrhoea and/or vomiting (Table 24), others included water (40.8%) foodstuffs 20.4 (%) while only 6% related milk to gastrointestinal infection. About 7% of the respondents did not any idea on the causes of both diarrhoea and vomiting.

Table 23: Ranking of foodstuffs in terms of the most to the least likely cause for diarrhoea and/or vomiting by community members in Isiolo District.

Foodstuff	3-5(%) n=111	6-15(%) n=407	16-25(%) n=399	Total (%) n=917	p-value
Water	57(51.4)	254(62.4)	254(63.7)	565(61.6)	0.190
Milk	32(28.8)	118(29.0)	162(40.6)	312(34.0)	0.003
Meat	30(27.0)	143(35.1)	150(37.6)	323(35.2)	0.124
Fruits & vegetables	40(36.0)	132(32.4)	160(40.1)	332(36.2)	0.007

Table 24: Causes of diarrhoea and/ or vomiting that were identified by camel milk consumers in selected divisions of Isiolo District, Kenya

Cause	Total n=894	Percentage
Dirt	627	70.2
Water	379	40.8
Foodstuffs	190	20.4
Fruits and vegetables	176	18.9
Milk	64	6.9
Environment	62	6.7
Dirty hands	53	5.7
No idea	45	4.8
Utensils	32	3.4
Meat	13	1.4
Will of God	11	1.2
Allergy	6	0.6
Malaria	3	0.3

5.4 Discussion

Pastoralist communities living in the peri-urban zone of the Isiolo town were increasingly consuming fruits and vegetables mainly bought from the local market. Income from milk sales or camel milk trading is one of the major source of income for the women in this region. Other studies have described camel milk as a major source of protein, vitamin and minerals for pastoralist communities lacking access to fruits and vegetables.

In the current study, raw camel milk has been shown to be significantly associated with diarrhoea and/or vomiting with or without fever unlike cow and goat milk. As cited in Muehlherr et al. (2003), the public health problems associated with consumption of unpasteurized cow's milk and raw-milk products have been well documented in several epidemiological studies such as (Barrett 1986; Keene et al. 1997; Cody et al. 1999; Kalman et al. 2000; De Buyser M-L. 2001; Harrington, et al. 2002; Oliver et al. 2005).

In other studies, raw and fermented camel milk have been identified as a cure for various illnesses including cleansing the gastrointestinal tract and treating of diarrhoea (El-Sayed and El-Agamy 2006; Agrawal et al. 2007; Agrawal et al. 2003). The results of this study are difficult to interpret since camel milk has laxative effect on first time consumers (Farah, personal communication) which could be construed with diarrhoea. The study design did not control for the first time consumers of camel milk but majority of the respondents consumed camel milk frequently and raw camel milk was significant for vomiting without fever. Confounding due to other external factors cannot be excluded since milk is mostly consumed as an accompaniment to other

foodstuffs. Washing hands with soap, boiling water, boiling milk and presence of proper drainage in this current study appear as protective factors. Like in other studies soap washing can be used as an intervention for diarrhoea and vomiting in the community (Curtis et al. 1997).

Similar to (Hetzel et al. 2004) study, multiple logistic regression with backward-stepwise selection analysis allows adjusting for certain confounders, however, testing too many factors also bears the risk of encountering an association at the 5% significance level which is because of chance. The recall period of 14 days may lead to a certain misclassification in areas with high incidence of gastrointestinal diseases due to underreporting but this could be offset by reliance on the respondents personal perception of the symptoms (Baqui et al. 1991; Boerma et al. 1991; Ramakrishnan et al. 1999; Hetzel et al. 2004) at the same time increase confounding because of unidentified variation in individuals experience. Mothers of young children and young adults were interviewed to reduce decreased reporting due to shame of reporting disease symptoms.

Diarrhoea and vomiting are the main symptoms of a food-borne toxi-infection and a major health burden in developing countries (Murray and Lopez 1997; WHO 2000; Kosek 2003). Like many pastoralist communities raw camel milk consumers in this region are oblivious of the risks associated with the consumption of raw or inadequately pasteurized/boiled milk. It is of essence that consumer education be encouraged in order for the consumers to choose wittingly between the benefits of consuming unprocessed animal products such as raw milk and the risks associated with their consumption. As indicated in Sissoko et al. (1990) study, milk consumption

depends strongly on the socio-economic status of the household, with those who can afford it consuming regularly. In the current study, children are mainly fed on boiled camel milk while the adults consume the milk in raw or fermented form. Majority of the subjects consumed milk bought from the market while a small percentage own camels and consume milk obtained from their farm. The source of raw milk and the time elapsed between milking and consumption is very crucial in determining the incidence of food poisoning from milk consumption (M. Younan, personal communication) especially if cold chains and basic hygiene are lacking.

It is widely accepted that cow milk has to be consumed boiled unlike camel milk which is consumed raw mainly due to the strongly rooted cultural norms. Some pathogens might not be inhibited by the acidity of the fermentation process. Therefore it is important that the raw milk for preparing *suusac* to be boiled before traditional fermentation. Other studies (Bonfoh et al. 2003; Hetzel et al. 2004) indicated a relationship between products known to be safe for consumption such as boiled/ pasteurized milk and diarrhoeal illnesses. Apart from other foodstuffs and water, milk has repeatedly been identified as a vehicle for these bacteria (De Buyser M-L. 2001; Leclerc 2002). As reported in chapter 3, Younan and Abdurahman (2004); Farah et al. (2007) the bacteriological laboratory analyses have revealed a poor general hygienic quality of locally produced and informally marketed raw camel milk at final market in Nairobi. Total count of bacteria from camel milk obtained from the market was up to 10^7 CFU/ml, and 10^5 CFU/ml for *Enterobacteriaceae* count. Unlike camel milk, cow and goat milk were not significant for diarrhoea and vomiting. However, milk and dairy products are not the only transmitters of toxi-infection bacteria and therefore levels of potentially pathogenic bacteria in the environment (e.g. dust), in drinking

water and in other foodstuff may also be considerable (Saidi et al. 1997; Bonfoh et al. 2003).

Craun et al. (1998); Hunter & Quigley (1998) and Hunter (1999) raised issues on the role of population immunity on the epidemiology of food-related disease. The exposure to diarrhoeal pathogens is far more common than observable disease, the difference being due to pre-existing immunity. Evidence for this comes from the investigation of outbreaks of waterborne diseases which have shown lower attack rates in residents compared to visitors (Hunter 1999). Thus the evidence presented here would support the hypothesis that local people build up a substantial immunity to those enter pathogens prevalent in their communities. Many studies have shown high incidence of food-borne related illness to be relatively low in the first few months of life, then peaks at about 24 months before declining towards adulthood (Schorling et al. 1990). Whilst the entire range of potential food-borne hazards are of concern world-wide, relative risk and perceived importance differs according to a range of factors including levels of economic development, climatic conditions, cultural and social norms, prevailing infrastructure etc. Thus, certain risks are greater in developing countries, for example because of poor sanitation and/or inadequate access to potable water (Unnevehr and Hirschorn, 2000).

5.5 Conclusion and recommendations

At present status, consumption of raw camel milk should be discouraged irrespective the source of milk. This study reaffirms the need for adapted interventions to improve the camel milk hygiene quality and safety. Suitable and feasible interventions need to be developed to meet the specific needs of the ASAL regions. There is need for

consumer education on workable risk mitigating strategies, improved water availability and quality, and hence issues surrounding hygiene and sanitation. The need to consider food safety within the wider context is inescapable, if any interventions are to be successful in curtailing food-borne disease burden. Such interventions require a transdisciplinary and an holistic approach to be adopted that not only considers the risks associated with a particular food but the wider context in which they occur and the constraints on efforts for their control. For example to recognize the connections between disease and socio-economic factors such as poverty and malnutrition and the wider economic, social, physical and the cultural environment in which people live.

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Chapter 6: General Discussion and Conclusion

This research had three objectives as follows; to determine the microbiological profile of raw camel milk along the informal market chain from the producers to the final market in Nairobi (chapter 3), determination of shelf life of pasteurized milk (chapter 4), and assessment of the risk factors in symptoms of food poisoning and the role of camel milk. The role of camel milk in the diet of the camel nomadic pastoralists was also assessed (chapter 5).

In chapter 3, raw camel milk and milk container samples were assessed for the following microorganisms; total bacterial counts, presumptive *Staphylococcus aureus*, presumptive *enterococci, enterobacteriaceae*, and yeast and mold. Microbiological load of the risk factors associated with contamination such as water at the herd level, environment at the milking yard by exposing Plate Count Agar and Yeast Mold growth media for 5 minutes, containers used for storing and transporting milk were analysed for the different microorganisms. The results of the TBC are similar to Farah 2007 and Younan 2004 and confirm the observations made by the same authors that camel milk in the informal market chain is handled in an unhygienic manner. The findings of the current study indicate high bacterial contamination of raw camel milk during harvesting, handling, collection, storage and transportation along the market chain. Unlike other studies, this current study also investigated the level of *enterobacteriaceae*, Yeast and Mold, and presumptive *Streptococci/ enterococci*, and presumptive *Staphylococcus aureus*. The levels of *enterobacteriaceae* are up to 10^5 in the final market. The presumptive *Staphylococcus aureus*, presumptive *enterococci* increase along the market chain while yeast and mold do not change significantly along the market chain.

The findings of this study should raise serious public health concern, since the results of the microbiological analysis study (chapter 3) are beyond the recommended milk standards by the KEBS 2006 and the EU commission 2000. Camel milk is predominantly consumed raw or as *susac* which is as a result of unsold overstayed raw milk of marketed milk. Thus consumer health education should be fundamental to discourage milk consumers from consuming the milk in raw form. Instead they should be encouraged to boil milk before consumption or before making of *susac*. Drinking milk which is not processed is risking the consumer's health. The shelf life study is paramount in this case because the process of pasteurizing milk destroys pathogenic organism present in milk such as the *enterococci*, presumptive *S. aureus*, pathogenic *enterobacteriaceae* and yeasts and mold in raw milk. These were destroyed on pasteurizing camel milk at 65°c for 30 minutes (chapter 4). Washing of hands with soap, treating drinking water, boiling milk and presence of proper drainage emerged as protective factors against gastrointestinal illnesses (chapter 5). The effect of pasteurizing milk in extending the shelf life of milk is undoubtable. The documentation on the shelf life of camel milk is very scanty except Kamau PM 2007 study which assessed the effect of activation of LPS of camel milk on the shelf life of raw and pasteurized camel milk at 4, 10, and 20°c. Pasteurized camel milk stored under refrigeration keeps for about 49-56 days while under 25 and 30° kept for less than 24 hours (chapter 4).

The findings of the milk-borne illnesses (chapter 5) and baseline microbial profile along the informal market chain (chapter 3) should reinforce the need to put in place interventions to improve camel milk hygiene and safety along the market chain.

General recommendations:

As indicated in previous chapters, the findings of this study should be a warning to stakeholders involved in the development of the camel milk industry in the ASALs regions. The benefits of consuming camel milk are tremendous. Apart from nutritional value it also provides therapeutic benefits to consumers and supports the livelihoods of many households being probably the sole source of income especially to the women in these regions. From the current study, future studies should look into a detailed contribution of the camel milk in the wellbeing and the nutrition of agro-pastoralist who have little or no access to fruits and vegetables. A comprehensive study on their dietary habits would strengthen any future interventions to improve the livelihood and wellbeing. Studies on the market access should also be carried out to enhance the sale camel milk and other products from the camel. A thorough analysis should be done to assess why earlier interventions failed to achieve their objectives before feasibility and sustainability of new interventions are evaluated.

Studies to evaluate the effect of improving the milking practices at the herd level and use of appropriate container and proper sanitizing procedures should be paramount to guiding development of appropriate interventions for improving the camel milk microbiological quality and safety.

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Annex 1: Questionnaire for the food poisoning study

1. Demographic information

Questionnaire No ..... Household No.....

Date of interview: .....(d/mth/yr) **Village name:**.....

Name of interviewer;..... **Name of respondent:** .....

Ethnicity.....

Kindly let me know the names of the people who have been living with you for the last three months.

No.	Age (yrs)	Sex	Residence Time	Relation to HH head	Marital Status	Education level	Occupation
1							
2							
3							
4							
5							
6							

Codes

Sex
1= male
2=female

Residential time
1= full-time
2= regularly absent
3= non-resident
4=other (spec.)

Educational level
1= none
2= 1-4 years
3= 5-8 years
4= secondary school
5= college
6= university

Rel. to hh head
1= hh head
2= spouse
3= son
4= daughter
5= other relative
6= friend
7= other (spec)

7= N/A

Occupational status
1=regularly employed
2=temporarily employed
3=Self-employed
4= casual labourer

Marital status
1= single
2=married monogamously
3=married polygamous
4= divorced
5= widowed
6=N/A

5= unemployed
6= N/A
7= H/wife
7= others (spec.)
Comments

2. Food consumption frequency questionnaire

1. How often do you consume the following foods?

Food consumption frequency questionnaire for respondents

Food eaten		Frequency of consumption
English name	Local name	
raw camel milk	Dey	
Boiled camel milk		
Fermented camel milk	Susac	
Cow milk	Ano loo	
Goat milk	Ano ari	
Maize	Geley	
Spaghetti/pasta		
Rice	Bariis	
Sorghum		
Wheat	Dakik	
Arrow roots		
Cassava		
Irish potatoes	Barado	
Beans	Digiir	
Chicken pea		
Cow pea		
Green gram	Dengo	
Pigeon peas		
Soya bean		
Indigenous vegetables		
Cabbages	Kabeech	
Kales	Sukuma	
Cassava leaves		
Cow peas leaves		
Pumpkin leaves		
Spinach		
Carrots	Carrot	
Onions	Basal	
Pumpkin	Garo	
Tomatoes	Nyayo/ tomato	
Avocado	Avocado	
Lemon	Lindaanan	
Mango	Ambe	
Orange fruit	Liinmaan	
Pawpaw	Papay	
Pineapple	Ananas	
Guavas		

Continuation of table 25

Food eaten		Frequency of consumption
English name	Local name	
Eggs	Ukun	
Beef	Hilib loo	
Camel meat	Halib gamia	
Goat meat	Halib ari	
Sheep meat	Hilib dho	
Fish	Kaluun	
Sugar	Sonkur	
Bread	Rodi	
Fats/oils	Saliid	
Tea	Shah	
Coffee	Bun	
Cocoa	Coco	

Options for the food consumption frequency questionnaire

1= once a year	5= once in two weeks	9= daily
2= four times a year	6= once a month	N= never
3= Once a month	7= 2-3 times a week	
4= Twice a month	8= 4-6 times a week	

3. Method of preparation of camel milk for consumption

Fill in the description of methods of preparation of camel milk for consumption

Form camel milk taken	Description of the method of preparation

4. Sanitation and hygiene [circle the correct answer appropriately]

2. What is your main source of water?

   1) Tap or pump 2) Delivery or buying 3) Open well or dam. 4) Other (specify).....

3. Do you treat your drinking water? 1) Yes 2) No

4. If yes, which method do you use? 1) Boiling 2) Chemicals 3) Other (specify).....

5. Do you treat your milk before consumption? 1) Yes 2) No

6. If yes, how do you treat your milk 1) Boiling 2) Fermentation 3) Other (specify).....

7. Do you always use soap when washing your hands? 1) Yes 2) No

8. Does the household have any toilet facility? [Observe] 1) Yes 2) No

9. If yes, what is the type of toilet? 1) Improved ventilated latrine 2) Pit latrine 3) Water in closet toilet.

10. How many households use the same toilet facility?.....

11. Where do you throw your organic waste materials? 1) In the compound 2) In a pit 3) Burn ...4.)Bury in a pit 5) Other (specify).....

12. [Observe and circle appropriately]

    1) Proper drainage system 1) present 2) absent

    2) Municipal sewerage system 1) present 2) absent

    3) Littered compound with hips of garbage 1) present 2) absent

5. Morbidity patterns with regards to diarrhea and vomiting.
[circle the correct answer]

13. In your opinion, what are the causes of diarrhea and vomiting?.....

14. Do you think that the following items could be a cause of diarrhea and vomiting?

    1. Fruits and vegetables 1) Yes 2) No
    2. Meat 1) Yes 2) No
    3. Cow milk 1) Yes 2) No
    4. Camel milk 1) Yes 2) No
    5. Goat milk 1) Yes 2) No
    6. Water 1) Yes 2) No

15. Rank the following in terms of the most to the least likely cause of diarrhea and vomiting.

The first box represents the most likely cause and the last represents the least important cause of diarrhea and vomiting.

1) Fruits and vegetables, 2) meat, 3) milk, 4) water.

16. in the last 14 days have you experienced fever 1) Yes 2) No

17. In the last 14 days, have you experienced any diarrhoea?

1) Yes 2) No

18. If yes, which symptoms/signs accompanied the episode?

1) Vomiting 2) Fever 3) Lack of appetite 4) Thirst 5) Nausea 7) Malaria

6) Other (specify).....

19. In the last 14 days preceding this interview, have you experienced vomiting without diarrhoea 1) yes 2) No

20. If yes in question 18, were there other conditions experienced with vomiting

1) Dizziness 2) Nausea 3) malaria 4) fever 5) dry mouth/ dehydration 6) upset stomach 7) other (specify).....

21. if yes for questions 16 and 18, how long did the illness last? 1) <2 days 2) 2-3 days 3) 4-7 days 4)>7 days 5)other (specify).....

22. Did you seek treatment somewhere outside your home at anytime during this diarrhea episode? 1) Yes 2) No

23. If yes, where did you go to seek treatment?

1) Dispensary Clinic 2) Hospital 3.)Chemists 4) Traditional healer

5) Other (specify).....

24. What drugs were you given? Could you show me the package or the container of the drugs or a sample of them?.....

25. How long does it take to get to the health facility? 1) < 15 minutes walk 2) 1/4 to 1 hour walk 3) > 1 hour walk.

Annex 2: Recruitment and training of field assistants

Training protocol for the field assistants

1. Training objectives

The objectives of this training include the following:

- To elaborate the objectives of the study to the enumerators.
- To give enumerators a brief overview of topic of study
- To familiarize the recruited field assistants with the survey protocols
- To explain on data collection procedures
- To train enumerators on how to administer the questionnaire
- To equip them with practical skills on questionnaire administration
- To equip them with interview techniques
- To educate the enumerators on the ethical considerations and enumerators to avoid getting emotional about information given by the subjects.

2. General assumptions

- The trainees have some knowledge of nutrition and health programmes, but not necessarily have engaged in this kind of surveys.
- The training also involves a general introduction of the enumerators to toxi-infections and food consumption assessment.
- The field assistants have some prior knowledge on community work.
- The training to be provided will be adequate for a successful study.

3. Preparation to be done by the trainer

- Arrange for a suitable hall/under-shade for the training to take place.
- To prepare the training curriculum which include among other aspects subject matter, length of sessions and training methods to be used e.g. discussions and role playing etc.
- Preparation off training materials such as flip charts/ blackboard, stationeries and questionnaires photocopying.

- Proper preparation to familiarize with subject matter and equipments before training sessions.

4. . Coverage and style

The trainer will determine the scope of the training programme. Trainees will be highly encouraged to participate actively to facilitate substance comprehension. The trainer will encourage participation through asking questions, encouraging discussion, demonstrations and role-playing.

5. The training session planTraining protocol for field assistants on day one

Objective	**Activity**	**Time**	**Materials**
To give a brief explanation on the overall objectives of the study.	A lecture	½ hr	Summarized handouts, flipcharts, marker pens, pens, note books, pencils, erasers, paper wallets, sample questionnaires etc
To give a brief introduction of the topic	A lecture and discussion	2 hrs	
Tea/coffee break		¼ hr	
To familiarize the enumerators with survey protocols and reaffirm on the importance of proper data collection.	Lecture and discussion and demonstrations	2 hrs	
Lunch break		1 hr	
To go through the questionnaire to be conversant.	Lecture and discussion	1 hr	
To equip the enumerators with interviewing techniques.	Brainstorming, discussions and role-playing	2 hrs	

6. Training protocol for field assistants on day two

Objective	Activity	Time	Materials
Recap from the previous day session	Briefly revisit the topics covered	½ hr	Summarized handouts, flipcharts, marker pens, pens, note books, pencils, erasers, paper wallets, sample questionnaires etc
To edify ethical issues to be observed during and after the study to ensure that subjects rights are protected.	Discussion and lecture.	1 hr	
To equip the enumerators with practical interviewing skills..	Demonstrations and role playing	2 hrs	
Lunch break		1 hr	
To equip the enumerators with practical interviewing skills.	Demonstrations, role playing and pre-testing of questionnaires	4 hrs	
To discuss practical constraints during the survey and experiences sharing	Discussion	1hr	
Conclusion	Summing up and preparation for the actual survey scheduled for the next day.	½ hr	
Note: hr stands for hour and hrs stands for hours.			

Annex 3: Camel milk sample collection sheet at various contamination points

Sample Nr. (+100)						
Sample taken on/at						
Date/time Dd/mm/yyyy 24:00h	Location L1 = Isiolo L2= Nanyuki	Visit	Herd (owner) and description (size of herd, managing system, breeds, milking method, frequency, teat tying practices)			
Animal (name/Nr)	Animal description (age, breed, calves, lactation, illness, treatments)		Pooled milk (herd, morning/eve)	Sample type (raw, susac, water, canister flushed)		
Middleman (name)	Market sample market description		Transport system, duration	Progressing fermentation step(hour)		
Canister type (plastic, guard, aluminium)	Hygiene practices			Storage facilities		
	Source of water					
	Observed container sanitizing practices					
	Reported container sanitation practices					
Sample characteristics	Temperature °c		pH		Storage conditions(type, °c)	
Environment	Temperature °c		weather			
Any other comments regarding sample, conditions, calabash sample, water etc.						

Annex 4: The Kenya specifications on microbiological limits for raw whole camel milk

Microbiological limits for raw camel milk as per the Kenya Bureau of Standards for raw camel milk (KEBS 2006).

Microbiological limits for total bacteria count for raw whole camel milk as per the Kenya bureau standards of raw camel milk

Grade	Bacterial counts per ml
I	0-500,000
II	500,000-1,000,000
III	1,000,000-2,000,000
IV	2,000,000 and over

Microbiological limits for coliform plate count for raw whole camel milk as per the Kenya bureau standards of raw camel milk

Grade	Counts per ml
I	0-1,000
II	1,000-50,000
III	50,000-500,000
IV	500,000 and over

Annex 5: Satellite map of Isiolo town