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ABSTRACT

This study determined the seasonal fluctuations in camel milk yield, consumption, spoilage and spillages, explored the forms of its consumption and acceptability of its powder in Isiolo County Kenya. Moreover, the utilization of non-marketed milk, preservation technologies and strategies for milk loss reduction employed along the camel milk supply chain were explored. Quantitative data was collected from 216 respondents (producers, traders, transporters) using a structured questionnaire while qualitative data was collected through participant observations, key informant interviews and focus group discussions involving the camel milk supply chain actors.

For quantitative data, descriptive and inferential analyses were conducted whereas for qualitative data thematic analyses was utilized.

Camel milk yield, consumption, spoilages and spillages increased by 45.5%, 40%, 81.0% and 79.1% respectively in the wet season. Camel milk was often consumed as smoked, boiled or as tea but never pasteurized or in powder form. Transportability, affordability and storability were mentioned as important attributes for camel milk powder acceptability. For non-marketed milk, 28.8% and 9.0 % were discarded in the wet and dry seasons respectively while 11.2% and 22.4% were processed.

The main strategies employed for milk loss reduction were: maintenance of hygienic practices (88% producers, 61% traders), smoking of the milk handling equipment (68% producers, 10% traders), and simple cooling (13% producers). High cost and limited technical feasibility limited the utilization of preservation technologies (chilling, refrigeration). These findings show the need for appropriate milk preservation technologies for longer shelf life milk products in arid and semi-arid areas.

Key Words: Seasonal dependency, loss reduction strategies, preservation technologies, non-marketed camel milk, Isiolo.

1.0 INTRODUCTION

The world camel population is estimated to be approximately 27 million heads, of which 85.2% are in Africa, 14.7% in Asia and 0.1 % in Europe. Kenya's 3.1 million dromedary camel population is estimated to be the third-largest camel herd in the world after Somalia and Sudan (former) (FAO, 2014). Camels belong to the family *Artiodactyla*, suborder *Tylopoda* and genus

Camelus which has two main species: *dromedarius*, one-humped, that live in desert areas such as South West Asia, Africa & Australia and *bactrianus*, two-humped, which occupy cooler areas such as Northern China, Mongolia, Kazhakstan & Russia (Farah, 1986; Yagil, 1982). Camels are often referred to as the 'White gold of the desert' as it can thrive in areas where crop production is limited and other animals cannot withstand the harsh climatic conditions (Bornstein et al., 2013; Werney, 2006).

Camels are kept for milk, meat, transportation, traction, hide and tourism. Camel milk has significant nutritional properties and more health benefits compared to other types of milk (Benkerroum et al., 2004; El-Agamy 2007; Elayan et al., 2008; Agrawal et al., 2007; Singh et al., 2008). Moreover, in pastoral regions where fruits and vegetables are scarce, camel milk is often the main source of vitamin C as it contains 30 times more vitamin C than the bovine milk and six times more than human milk (Haddadin et al., 2008). The great contribution of the animal milk to the nutrient requirements of the pastoral groups has led to its acknowledgement as an important component of the pastoralists' diets across the world (Fratkin et al. 2004; Sadler et al., 2009). In Kenya, camel milk accounts for 60% of the total nutrient intake of the pastoral communities inhabiting the Arid and Semi-Arid Lands (ASALs) (Kaufmann, 2003; Simpkins et al., 1997). Consumption of camel milk is often in raw or naturally fermented form (Yagil, 1982; Agrawal et al., 2005). However, the acceptability and consumption of longer shelf milk products have not been explored in Isiolo, County Kenya.

Estimated daily average camel milk yield is between 3 and 10 litres during a lactation period of 12-18 months (Farah et al., 2007). Some factors have been reported to increase camel milk yield which includes feeding, seasonal variation, husbandry, watering and veterinary services (Cardellino et al., 2004). Of these, in systems where camel production is dependent on natural pastures such as in Kenya, seasonal variation is the major determinant of camel milk yield in tropical and sub-tropical regions (Nicholson, 1984). In these systems, the scarcity of water for camel consumption in the dry season results in decreased camel milk yield due to the decrease in the water available (Haddadin et al., 2008; Shuiep et al., 2008). However, in areas such as the Gulf, modernised units have facilitated the intensification of the camel milk production, thus less seasonal variation in milk yield occurs (Faye, 2005). There is limited information available in Kenya, on camel milk yield as influenced by seasons.

Traditionally camel milk marketing was viewed as a taboo amongst pastoral communities. Moreover, the camel herds are located in the arid and desert areas which are far from the commercial markets (Konuspayeva et al., 2004). This limited the use of camel milk to subsistence and calves consumption, with only a small percentage reaching the markets (Al Kanhal, 2010). However, over the recent years, there has been a shift in camel milk utilisation from subsistence to commercial in different parts of the globe indicating the significant role of the camel to households food basket (Adongo et al., 2013; Anderson et al., 2015; Nori, 2010). In both dry and wet seasons, pastoral households in Kenya are dependent on camel milk sales as their main income source and the volume sold is dependent on the economic and social needs of the household (Nori, 2010). For example, in 2013, Africa contributed to 32% of the world's 2.9 million tonnes of camel milk marketed. Kenya's 937,000 tonnes ranked second after Somalia (FAO, 2014). However, studies have shown that 50% of the total Kenya camel milk does not reach the consumers and 30% of the marketed milk sold in sour form (Kuria et al., 2011). Therefore, to increase the amount of milk marketed, it is vital to understand the factors contributing to less milk reaching the consumers and also to estimate the volumes and forms of milk marketed. Moreover, information on the milk losses along the camel milk supply chain and how the non-marketed milk is utilised among the pastoral communities has not yet been fully explored.

To minimise, milk spoilage different preservation technologies that increase the shelf life and strategies have been put in place to ensure limited microbial contamination along the value chain. Interventions such as use of commercial lactoperoxidase systems (LS) kits, cooling facilities, milk pasteurization, clean water provision and training on hygienic milk handling have been proposed along the Kenyan camel milk value chain in the pastoral regions (Adongo et al., 2013; Bornstein et al., 2013; Wayua et al., 2013). Different studies have reported simple cooling technologies, fermentation and smoking of camel milk in pastoral regions of Ethiopia and Kenya (Seifu 2007, Wayua et al., 2012). However, with the ever evolving camel milk trade in Kenya, there is need to document both the traditional and modern milk preservation technologies and the energy utilised by these technologies.

Moreover, preservation of camel milk has been enhanced through processing of the milk into value-added products. Among the pastoral communities in Ethiopia, Kenya, Somalia, camel milk has been processed into ghee, fermented milk (gariss, dhanaan, susaac), yoghurt, cheeses and butter (Seifu 2007; Wayua et al., 2012). These products have enabled the retention of valuable milk nutrients during the seasons of scarcity, income generation for households and also limited the losses attributed to milk glut (El Zubeir and Jabreel, 2008; Elayan et al., 2008). However, information on the amount of milk that is not marketed that is processed into these products, the seasons and at what point in the value chain have not been explored.

Therefore the objectives of the present study were: (1) To determine the seasonal fluctuations in camel milk yield, consumption, spoilage and spillages; (2) To determine how the non-marketed milk is utilized; (3) To identify the strategies and preservation technologies for milk losses reduction employed in Isiolo County, Kenya; (4) To explore the forms of camel milk consumption and the acceptability of camel milk powder.

2.0 METHODOLOGY

2.1 Study area

Isiolo County lies in the dry lands of Northern Kenya, at a latitude of 0° 21’ 0″ N and a longitude of 37° 35’ 0 ″E. The study area lies at an altitude of 200-300 meters above sea level and experiences an annual mean temperature of 23.3°C and bimodal rainfall with an annual average of 580 mm. The County covers an estimated area of 25,605km^2 (ALRMP, 2009), with a projected population of 143,294 (Government of Kenya, 2013). Administratively, the County is divided into three main sub counties: Isiolo central, Garba Tula and Merti. Ecologically, the area consists of three zones: the semi-arid (5%), arid (30%) and very arid zones (65%), characterised by variability in rainfall and vegetation types. Livestock production is the main livelihood strategy with over 80 % of the population relying on livestock Agricultural Sector Development Support Programme (ASDSP). The Borana and Somali pastoralists living in Isiolo predominantly keep a mix of livestock species with an estimated population of 40,300 camels (Obonyo, 2010). Camels are mainly kept for milk production both for household consumptions and commercial purposes (Noor et al., 2012).

The map of the study site and climatic conditions are presented in Figures 1and 2 respectively.

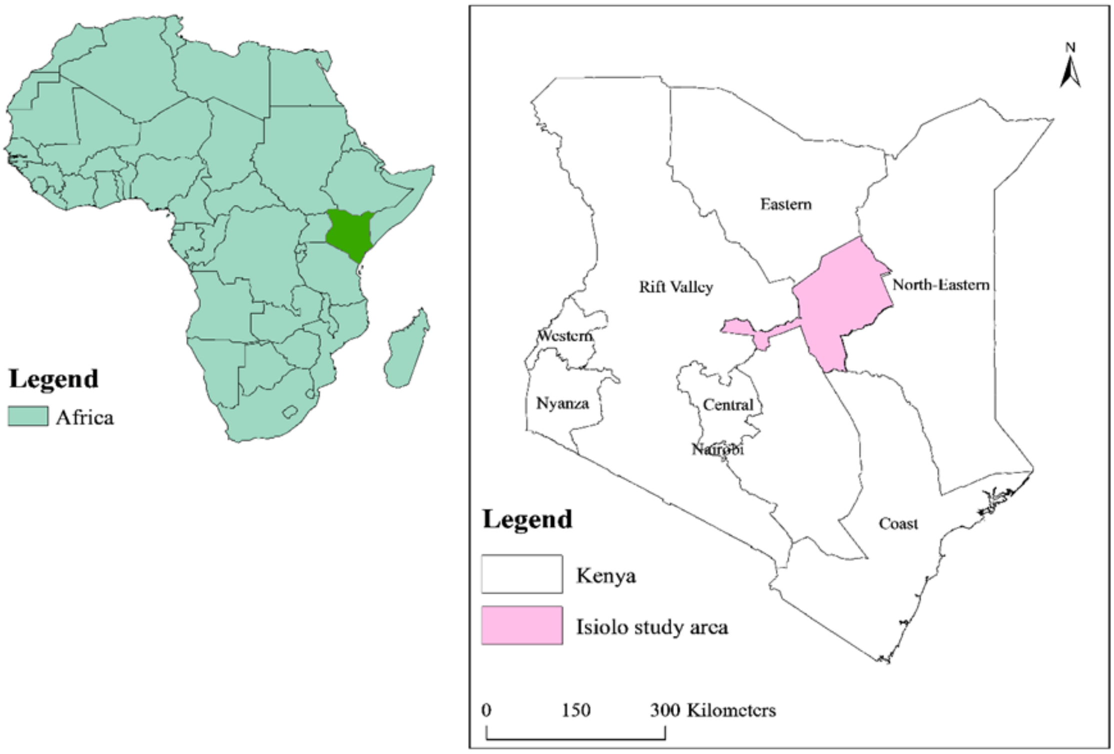

Figure 1 Map of the study area. Source: Author's own

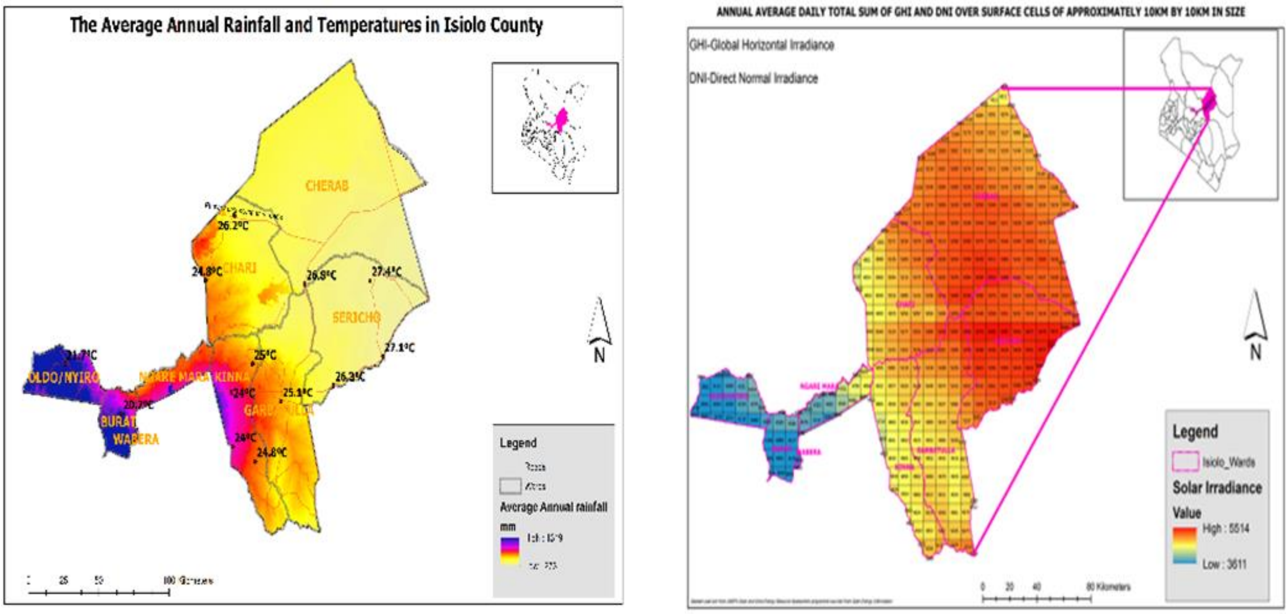

Figure 2 Climatic conditions of the Study Area: credit: kipsongokkibet@gmail.com

2.2 Sampling procedures and sample

This study employed a cross sectional (specific point in time of data collection and analysis) concurrent with mixed methods design (combination of both qualitative and quantitative methods of data collection and analysis) (Creswell & Piano, 2011).

2.2.1 Quantitative sampling procedure

A cross sectional survey using structured and semi-structured interviews between August and September 2015 was carried out in Isiolo County, Kenya. The study employed purposive and multistage sampling techniques in Garba Tula and Isiolo Central because of their higher contribution to the marketed camel milk in the County. The sampling unit consisted mainly supply chain actors comprising commercial camel milk producers, traders, consumers, transporters, Non- Governmental Organisations (NGOs), cooling hub manager and county government who were available and willing to participate in the study. Sampling of producers (N=145) was limited to the accessibility of the herd owners who were involved in commercial camel milk business and 15 villages were sampled. In each village, a landmark was identified, transect drawn and in every fifth household which was involved in commercial camel milk business the household head who consented was interviewed. If the herd owner was absent or unwilling to participate in the study, the next household was chosen and the interview carried out. The milk transporters were purposively sampled. These included transporters from the production site to cooling hubs (7 motorcycle operators); primary collection centre to the cooling hubs (6 motorcycle operators and 3 land cruiser owners) and from the cooling hubs to the main market in Nairobi (4 buses).

2.2.2. Qualitative sampling procedure

A total of 6 focus group discussions (FGDs) that comprised of 6-8 participants were held, with four FGDs conducted separately with consumers, producers, traders and transporters and two FGDs carried out with mix of actors in the supply chain. A total of 12 key informant interviews were held with representatives from non-governmental organizations (2), government representatives (4), community based organizations (2), herders (2), local leaders (1) and cooling hub manager (1).

2.3 Data collection tools and procedures

The interviews were orally administered through face-to-face interviews by four trained enumerators who were conversant with the local dialect. The semi-structured questionnaires were first pretested for clarity of questions to a group of 10 producers and five traders who were then excluded from the study. Data collected through the structured questionnaire administered to the producers and transporters was based on their past sales record for the month of June (wet season) and the actual volumes of milk in the month of August (dry season). Data on production, consumptions, sales, spoilage, spillages, preservation techniques and losses reduction and acceptability of milk powder were collected through semi-structured questionnaire administered to the producers and traders. Simultaneously, data on purchases, sales and spoilage were obtained from the main cooling hub (Anolei) for the months of January to August 2015.

To understand the supply chain, a checklist was used to collect secondary data from the Ministry of Agriculture, Livestock & Fisheries at the county level and the cooling hubs. This was complemented by participant observations at marketplace and collection centres to understand both preservation technologies and energy sources used in the camel milk supply chain.

2.4 Data analyses

Descriptive and inferential statistics for quantitative data from both the traders and producers were generated using the IBM SPSS software (SPSS version 22). The plotting was conducted using the Sigma plots software (Version 13). Qualitative data from the FGDs and KIIs recorded were transcribed by the first author verbatim from Swahili to English. Recorded interviews carried out in English and field notes from direct observations (DOs) were also compiled. These were later coded into thematic topics using RQDA (Huang 2014).

2.5.1 Data quality control

The administration of questionnaires was carried out by enumerators who spoke the local dialect and were chosen based on the minimum requirement of a university degree. They were then trained and closely supervised by the researcher in the field. Daily meetings were held in the evening for clarification on any matter that arose throughout the course of the day. The variables measured and the data analyses carried out are presented in Table 1.

Table 1 Variables measured and data analyses

Variable	**Measurements**	**Source of data**	**Analyses**
Camel milk supply chain	▪ Key actors & their activities ▪ Production functions ▪ Factors contributing to losses	▪ Producer questionnaire ▪ Traders questionnaire ▪ FGDs, KIIs, POs	▪ Thematic coding
Seasonal variation at production level	▪ Monthly yield in liters ▪ Monthly sales in liters ▪ Monthly spoilages in liters ▪ Monthly consumption in liters ▪ Volume fed to calf ▪ Prices in Kes/liter	▪ Producer questionnaire Traders questionnaire ▪ FGDs, KIIs	▪ Descriptive statistics ▪ T-tests ▪ Thematic coding
Seasonal variation at marketing level	▪ Monthly sales in liters ▪ Monthly spoilages in liters ▪ Monthly Purchases in liters	▪ Traders questionnaire ▪ FGDs, ▪ Document reviews	▪ Descriptive statistics ▪ Thematic coding
Non-marketed milk utilization (seasonal variation)	▪ Percentage fed to calf ▪ Percentage for home consumption ▪ Percentage discarded ▪ Percentage processed into other products ▪ Percentage given to neighbors	▪ Producer questionnaire Traders questionnaire ▪ FGDs, KIIs	▪ Descriptive statistics ▪ Thematic coding
Preservation technologies	▪ Capacity of the technologies available ▪ Energy sources used ▪ Shelf life of milk stored ▪ Pictorial representation ▪ Challenges in technology uptake	▪ Producer questionnaire Traders questionnaire ▪ FGDs, KIIs, POs,	▪ Thematic coding

Consumption and feasibility of milk powder	▪ Important attributes: Transportability, storability, affordability, taste, colour ▪ Mode of consumption of milk	▪ Producer questionnaire Traders questionnaire ▪ FGDs, KIIs, POs	▪ Descriptive statistics

3.0 RESULTS

This section is divided into eight subsections including characterization of the respondents; the camel milk supply chain; camel milk yield, sales, consumption and losses at production and marketing level; utilization of non-marketed camel milk; strategies employed for milk spoilage reduction; preservation techniques along the camel milk supply chain; energy sources in camel milk preservation and camel milk consumption forms and milk powder acceptability.

3.1. Characterization of the respondents

Table 2 indicates the socio-demographic characteristics of the respondents in the study area.

Table 2 Socio-demographic characteristics of the respondents in the study area

Socio-Demographic indicators		**Producers (N=145)**	**Traders (N=50)**
Gender	Male	40.0%	4.6%
	Female	60.0%	95.4%
Head of household	Male	86.2%	_
	Female	13.8%	_
Household size		9.1±2.9	_
Age in years		49. 1±11.2	34.2±7.4
Educational level	None	84.1%	63%
	Primary	13.1%	33%
	Secondary	0.7%	4%
	Tertiary	2.1%	0%
Occupation	None	2.1%	0%
	Livestock keeping	92.4%	11.8%
	Business	4.1%	87.2%
	Crop farming	0.7%	0%
	Wage employment	0.7%	0%
Years in commercial milk business		10.5±5.8	5.8±2.5
Number of Lactating camels		14.6±0.8	-
Number of Customers		-	3.5±5.04
Number of Suppliers		-	4.9±2.0

Though the respondents were majorly (60.0%) female, they indicated that the household heads were mainly male (86.2%). The producers largely (92.4%) depended on livestock as a source of livelihood compared to 84.1% of the traders who depended on business (marketing of the camel milk) as their source of livelihood. Milk pooling among the traders was common as an average of 3.5±1.0 producers supplied a single trader who in turn sold to an average of 4.9±2.0 retailers.

3.2 Camel milk supply chain

The camel milk supply chain in Isiolo County was characterised by actors who performed five main chain functions: production, primary transportation, collection, secondary transportation and retail (Table 3). Table 3 indicates the camel milk supply chain in Isiolo County, Kenya.

Table 3: Camel milk supply chain, actors and factors contributing to losses

Milk flow ↑

Chain functions	Actors	Activities	Type of loss	Factors mentioned as contributing to losses
Retail	Retailers	Selling to consumers, milk bars, and restaurants	Spoilage	▪ Unhygienic milk handling practices ▪ Delay in milk delivery
Transport	Cart and Bus drivers	Transport from cooling hubs to bus stops to urban retailers	Spoilages	▪ Mechanical problems thus delay in milk delivery
Collection	Bulking traders	Bulk, test, preserve and pack milk	Spillages Spoilages	▪ Unhygienic milk handling practices ▪ Delay in milk delivery ▪ Lack of milk preservation technologies ▪ Chemical and physical contamination
	Non-Bulking traders	Test, preserve and pack milk	Spillages Spoilages	▪ Unhygienic milk handling practices ▪ Delay in milk delivery ▪ Lack of milk preservation technologies ▪ Chemical and physical contamination
Transport	Motorcycles	Transport from producers to traders and local retailers	Spillages	▪ Poor terrains ▪ Loosely tied containers ▪ Overloading
	Land Cruisers	Transport from producers to traders and local retailers	Spillages	▪ Poor terrains ▪ Unreliable transportation
Production	Producers	Livestock husbandry, milking, packaging, transportation to the traders and retailers	Spoilages Spillages Economic losses	▪ Unhygienic milk handling practices ▪ Lack of milk preservation technologies ▪ Migration of camels during the dry season. ▪ Sickness of camels ▪ Insecurity ▪ Mixing of milk ▪ Lack of market in wet season

Analysis of FGDs, KIIs and DOs, indicated that camel milk losses varied along the supply chain. Non-hygienic milk handling practices and lack of preservation technologies characterised milk spoilage at production and marketing levels. Moreover, economic losses during the dry season as mentioned by the respondents were due to the migration of camels in search of pasture and water as the calves were allowed to feed on the dam. Thus no milk was sold. Participants in the traders FGD reported that the primary milk transporters covered vast distances between milk collection centres during the dry seasons as the camels were further apart thus delayed milk delivery at the marketing level. The exposure of the milk to high temperatures while awaiting transportation and during transit, coupled with the rough terrain resulted in the churning of milk. During the wet season, economic losses attributed to low milk prices and fewer camels milked enabled more milk consumption by the calf. Spillages, during transportation, were due to overloading of the motorcycles or loosely tied jerry cans on the land cruisers that burst or fell off during transportation.

3.3 Camel Milk Yield, Sales, Consumption and Losses

3.3.1 Variation in camel milk yield, sales and losses at production level

During the dry seasons 26.2%, 58.6% and 15.2% of the producers (N=145) reported that they milked their camels once, twice and three times daily respectively compared to 6.9%, 29.0%, 64.1% during the wet season. When the milking was conducted three times in a day, this was carried out twice in the morning (0600hrs and 0900-1000hrs) and once in the evening (1800-2000hrs). The morning milk was both for household consumption and marketing while the evening milk was mainly for the herders. During the dry season which was characterised by limited forage and water, the milk yield decreased (815.2±53.4) l. while the marketing price per litre of milk increased ($0.69±0.01). This resulted in a percentage of marketed milk increasing the yield. During the wet season, characterised by the availability of forage and water, the milk yield increased (1496.1±82.2) l, prices decreased ($0.39±0.01), and thus the percentage of the marketed milk also decreased by about 79.5% in relation to the yield. The volumes of milk spilt, increased in the wet season from 0.6% to 1.4% in the dry season. Also, the amount of milk rejected increased from 2.1% in the rainy season by about 7.5% in the dry season (Table 4).

Table 4: Variations in yield, spillages, rejects, consumption, sales and prices with the season at production level (N=145).

Monthly	Dry season	Percent of production	Wet season	Percent of production	Percentage Change (%)	t-test	p values
Production(L)	815.2±53.4	100	1496.1±82.2	100	45.5	17.4	<0.01
Spillages (L)	4.5±1.1	0.6	21.5±4.2	1.4	79.1	4.5	<0.01
Rejects (L)	17.6±3.9	2.1	111.6±12.6	7.5	81.0	8.4	<0.01
Consumed (L)	104.1±5.6	12.8	173.4±7.1	11.6	40.0	8.5	<0.01
Sales (L)	689.0±50.6	84.5	1190.1±78.5	79.5	42.1	15.0	<0.01
Price (Kes)	68.9±1.2		39.3±1.0		-75.3	-38.8	<0.01

3.3.2: Variation in camel milk purchases, sales and spoilages at marketing level

The volumes of milk traded and spoilt during the wet and dry season varied throughout the year (Fig. 3).

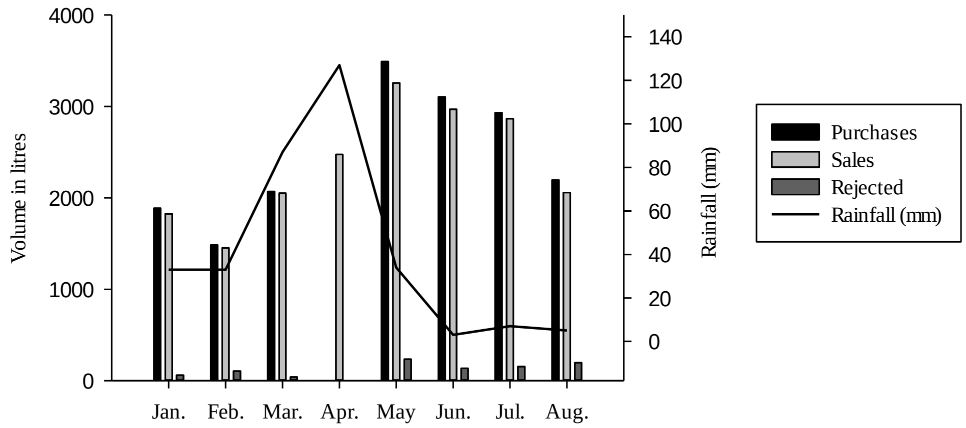

Figure 3: Monthly variation in daily milk purchases, sales and spoilages & monthly rainfall in mm in Isiolo County.

These results were supported by qualitative data from KIIs which denoted that less milk spoilage occurred during the dry season. As one of the respondents indicated:

> *“Now we receive 2000-2200 litren s per day and the milk spoilt will not reach 5%. It is approximately 2-3%. For example, today 20-30 litres are spoilt. However, during the rainy season…there is much spoilage. For 3000-3500 litres that we receive, we can get up to 200 litres of milk which are spoilt.” KII 30 years Male.*

In times of milk scarcity the fermented milk was bought by the retailers and marketed at the same price as fresh milk contrary to the wet seasons where a slight sign of natural fermentation resulted in milk rejection as explained by one key informant:

> *“You know like now the season is the peak, the milk has great demand. Now even the milk that is fermented is still being sold in Nairobi at the same price. However, during the rainy season, when the milk is plenty, any slight fermentation of milk, the milk is returned to them. During that season, they do not send the fermented milk to the retailers.” Male 43 years.*

3.4 Utilisation of non-marketed camel milk

The non-marketed milk comprised of the milk that was not sold due to either spillage, market glut or spoilages. Before accepting the milk from the producers, the traders determined the quality of the milk by carrying out either chemical tests (alcohol test) (13.7%), combined chemical and organoleptic tests (9.8%) at the main cooling hub or organoleptic tests (76.5%) (sight, taste and smell) at the primary collection points. Milk was rejected when naturally fermented and returned to the producers by the traders. By the addition of sugar, the returned milk was either sold at a lower price (48%) or consumed (52%) at the household level depending on the season. The monthly non-marketed camel milk volume accounted for 8.1% (122.1±165.0 litres) and 2.4% (20.3±45.2 l) in the wet and dry season respectively per household. Based on the prices fetched in the dry and wet season (Table 3), the monthly non-marketed milk valuation per household ranged between $14.0 -$31.2 in the dry season and $48.0-$64.8 in the wet season. If the non-marketed portion in the wet season is valued similarly to the costs in the dry season, the household on a monthly level loses approximately $84.1-$113.7. Approximately 22.4% of this milk was processed *(Suusac*- naturally fermented milk with added sugar) during the dry season compared to 11.2% during the wet season. Similarly, 28.8% of the milk during the wet season was discarded compared to only 9% in the dry season (Fig. 4).

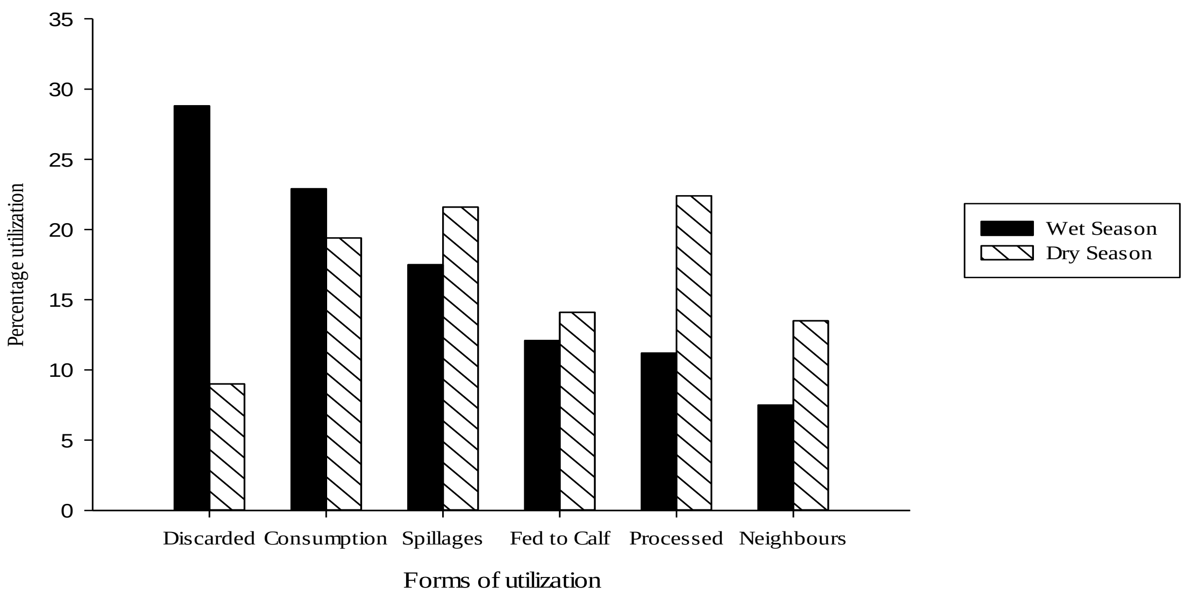

Figure 4: Utilisation of non-marketed milk during the dry and wet season at production level

3.5 Strategies employed for milk spoilage reduction

Strategies to limit camel milk losses along the camel milk supply chain in the study area entailed those that limited contamination of the milk and those that limited spoilage; thus prolonging the shelf life of milk. Strategies to limit milk contamination was the responsibility of both the producers and the traders and most important was hygienic milk handling from milking (88%) to bulking (61%) (Table 5). These comprised of milking with clean hands, cleaning of the camel udder and the milk handling equipment. The producers further ensured that during milking the milk was not contaminated with the camel urine, calf saliva or insects. The traders filtered the milk at the cooling hubs to get rid of the particles and dust. Moreover, the spoilt and non-spoilt milk were not mixed during bulking as indicated by 35% of the traders. Both traditional and modern strategies were utilised at both production and marketing level to increase the shelf life of the milk. These included smoking of the milking and storage containers, boiling of the milk and cooling of the milk.

Table 5: Strategies employed for milk loss reduction at production and marketing level

Strategies employed	Percentage producers respondents (N=145)	Percentage traders respondents (N=51)

Hygienic practices	88%	61%
Smoking the jerry cans	68%	10%
No mixing of spoilt and non-spoilt milk spoilt milk	-	35%
Simple cooling technologies	13%	2%
Boiling of milk	8%	2%
Treatment of sick camels	4%	8%
Sieving of Milk	-	10%
Timely delivery of milk	5%	-

Percentages are greater than 100% since the questions were multiple answers.

3.6 Preservation techniques along the camel milk supply chain

Preservation technologies along the Isiolo camel milk supply chain were obtained from the analysis of both the traders and producers interviews coupled with the information from key informants and FGDs. Preservation of milk along the camel milk value chain varied from production to consumption (Fig. 5). Approximately 95% of the total camel milk produced was smoked while 5% refrigerated during transit. The non-smoked camel milk was pre-ordered for the processing of value-added camel milk products such as pasteurised milk, yoghurt and fermented milk in urban areas.

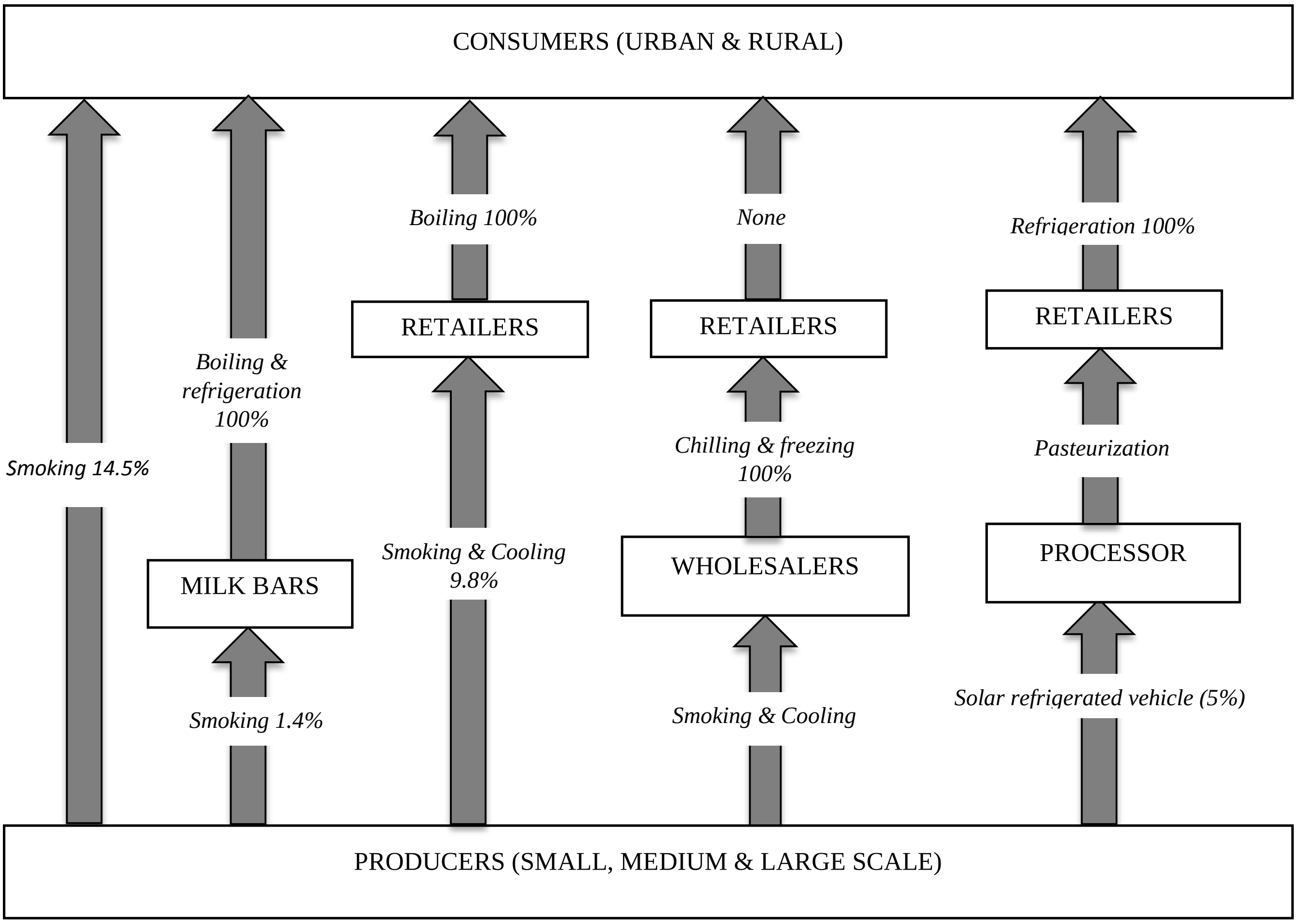

Figure 5: Preservation techniques along the camel milk value chain

The camel milk preservation technologies indicated in Fig. 5 are discussed below:

3. 6.1 Smoking (Fumigation) of the jerry cans and milking cans

Fumigation of milk was carried out by the respondents to impart flavour and increase the keeping quality of milk between 12-24 hours without refrigeration. This entailed the cleaning of the plastic milk jerricans (1 litre to 20 litres) or the *Damela* used in the milking of the camel. The shrubs were then lighted, extinguished before being introduced into the cleaned containers. The containers were closed and shaken; smoking duration was dependent on the volume of the container. The burnt particles were either removed or left in the containers after that they were sieved off at the cooling hubs or the refrigeration centres. Fumigation of the jerricans was either carried out at the household level, by herders or in Isiolo town by the traders. The main tree species utilised by the respondents were community specific and included: *Sabans* (*acacia nilotica), Cardia quercifolia* (*Madeer*), *Balanites pedicillarius, Acacia zanzibarica, Cardia ovalis and terminalia kilimandscharicum*.

3. 6.2 Boiling

Milk was boiled to a temperature of approximately 60ºC and then cooled. This was mainly carried out in areas such as Kulamawe region where traders and producers had limited access to cooling facilities and unreliable transport services. In Isiolo town, the small scale retailers handling 10-20 litres per day carried out the boiling and sold their milk to the final consumers in the boiled form. The bulkers rarely purchased boiled milk. One respondent explains,

> *'We used to boil our milk and send it to Nairobi, but every time the person whom we used to send the milk to would complain that the milk is spoilt. This continued for quite a period until it reached a point that we stopped sending the milk to him and resorted to selling the fermented (Suusac) milk.' Large scale Camel milk producer, Male 51 years of age.*

3. 6.3 Cooling Technologies

3. 6.3.1 Use of 'Qoodha.'

We identified a special traditional container (Qoodha) that could store milk for a duration of 72 hours. The Qoodha is specially woven oval-shaped container from the roots of *Ergemis sp* tree decorated on the outside side with cowries' shells (Fig. 6a). The top part of the Qoodha is made from fibres obtained from the stem of *Adonsonia digitata*. Using a metal needle, the two were woven and interwoven into a pot like a basket. The inside is later smoked using smoke from the trees of *Cordia monoica* (*Mader* in Borana) continuously until the inside of the pot becomes compact due to the more layers formed. The Qoodha is then filled with milk and tied on the roof of the grass thatched houses supported by a casing made from the dried skin of camel or cow. The preservation technique is dependent on both the cooling and the antimicrobial properties due to the smoked container. According to the FGD findings, the utilisation of this technology was reported to be fast becoming extinct among the commercial camel milk producers, but it is still optimally used in the isolated rural communities away from commercial centres.

3. 6.3.2 Simple evaporative cooling

Simple cooling technologies that entailed the use of gunny or hemp bags soaked in water wrapped around the 20-litre yellow milk jerry cans were practised in the study area (Fig. 6b). This was utilised during the transportation of the milk from the milking point to, and at the primary collection centre where they were placed in a shade under the tree awaiting transportation to the cooling hubs. Prolonged delays in the collection of milk from the primary collection centres also enhanced the utilisation of this simple cooling technology. A simple charcoal evaporative cooler (Fig. 6c) was identified in Kulamawe but was not utilised by the local communities due to the high cost of charcoal and inadequate water supply as indicated by the FGD participants.

3.6.3. 4 Chilling

Freezing and Chilling of the camel milk were extensively carried out in Isiolo town both by traders either individually or as groups destined for the urban markets. This accounted for the greatest percentage of all the marketed camel milk not only in Isiolo County but also in the country. This milk was sold as fresh to the final consumers, hotels, milk bars and some of it was pasteurised at the marketing level in the urban centres. The pasteurised milk was sold at \$2.5 per litre at the main retail outlets in Nairobi, Kenya compared to \$0.30 and \$0.69 obtained by the producers during the wet and dry season respectively. Chillers of capacities 3000 and 550 litres (Fig. 6d) were available for cooling of camel milk in Isiolo County. The capacity of the chillers was limited since the camel milk had to be sold the next morning to create space for the next lot of milk. During the rainy season, the capacity of the chillers was exceeded, and the excess milk stored in freezers. Approximately 3500 litres of milk were received daily during the wet season compared to between 2000 and 2200 litres during the dry season. It took between 4-5 hours for the milk temperature to drop to 5°C from about 30°C and this varied depending on the time of the last milk delivery which influenced the quality of the chilled milk. Rejection of the milk at the chiller was based on adulteration that was determined through alcohol test and was higher during the wet season (Fig. 3). The monthly charges of using the chiller was dependent on utilities (electricity bill, rent, water bills, employees, and permits) incurred during the month and ranged between $30 and $35 per individual

3.6.3.5 Freezing

Most of the milk at marketing level were stored in individual freezers either owned by individuals or rented. During the rainy season, the freezers operated at full capacity with an average of 200 to 220 litres compared to 140-160 litres per day during the dry season. The cost of renting a freezer was dependent on the season, with monthly charges of approximately $50 during the rainy season and $30 during the dry season. There were milk residues on the walls of the freezers due to the spillages when milk was transferred from the transportation containers to the containers in the freezers for storage. The milk was kept in the freezers in aluminium cans (10 and 20litres), polyethene bags (2 litres), plastic jerry cans (capacities 20, 10, 5, 3 litres), or plastic buckets (10 litres) (Fig. 6e). The aluminium cans were provided by the camel milk supply chain supporters such as the non-governmental bodies. According to the respondents, they were expensive to purchase and not easily portable and therefore had limited usage in the storage of milk in the freezers and transportation. Some freezing and chilling facilities are shown in Fig. 6d and 6e.

3.6.4 Value added products

According to the participants in the producer and trader FGDs, the milk glut during the wet season enabled the processing of the camel milk into value-added products such as butter (Fig. 6f), cheese and yoghurt. Most of the traders and some of the producers had been trained on milk pasteurisation though no pasteurisation of milk took place in Isiolo. This they attributed to the consideration that it was meant for the high-end market. Consumption of the naturally fermented milk known as *Susaac* which was prepared through spontaneous fermentation of fresh camel milk was common.

Figure 6a Qoodha

Figure 6b Hemp bag

Figure 6c Charcoal evaporative cooler

Figure 6d: Chillers

Figure 6e Freezer

Figure 6f Butter making

Figure 6: Pictorial representation of the different preservation technologies in Isiolo, County

3.7 Energy sources in camel milk preservation

The main energy sources that were utilised in milk preservation among the traders in Isiolo County were electricity (62.7%), firewood (27.5%) and charcoal (7.8%). On-grid electricity was utilised mainly for camel milk cooling in the freezers and the chillers in Isiolo central sub-county while charcoal and firewood were used for the boiling of the milk both at Kulamawe and Isiolo town by the retailers and the milk bars. According to the participants in the traders FGD, the main challenges in utilising on-grid electricity were; high cost of installation, high monthly electrical bills and termination of an electrical connection when payments were delayed. Only 11.8% of the traders who used electricity used a diesel driven generator during power outages while the rest depended on the ice that was frozen in the refrigerators for cooling, discarded the milk or allowed the milk to ferment naturally.

Water-logging and inaccessibility of firewood in the wet season led to increased utilisation of charcoal by 13.7% for camel milk boiling according to the respondents. From the traders FGD, they reported the main challenges in using wood fuels in milk boiling were government policies that limit the burning of charcoal and the woody flavour of the camel milk.

The residents of Kulamawe had to travel for approximately 2 km to obtain firewood. The boiling of milk by retailers took place in their households before transportation to the market. Approximately 10 kg of charcoal during the dry season cost $2.5 compared to $4 during the wet season and could be used to boil approximately 100 litres of milk which resulted in an average cost of $0.025 per litre of milk. Firewood was measured in terms of a cart carried by a donkey and traded at $25.

3.8 Camel Milk Consumption Forms and Feasibility of Milk powder Acceptability.

3.8.1: Forms of camel milk Consumption

Camel milk was often consumed as raw, boiled or smoked but rarely as fermented (Fig. 7). Neither pasteurised milk nor milk powder had been consumed by the respondents interviewed (Fig. 7). In the milk bars surveyed the milk was either sold as fresh or as tea whereby a cup (200ml) was sold at $0.50 compared to the bovine milk tea that was sold at $0.30. Most participants in the consumer FGD reported that they preferred consuming camel milk to other milk due to the long shelf life, low-fat content and the medicinal values associated with the camel milk. From the FGDs with the producers and consumers, it was concluded that camel milk scarcity during the dry season led to high prices, which resulted in the purchase of cow milk or goat milk, reduction in intake of the camel milk or non-consumption of any form of milk at all. Those who maintained their usual consumption volume were prone to credit as explained below:

> *"When the prices of the camel milk are high during the dry season, we are forced to buy a half litre of milk compared to the 1 litre that we consume. Sometimes we obtain milk on credit, and it takes us up to two weeks to pay." Consumer FGD*

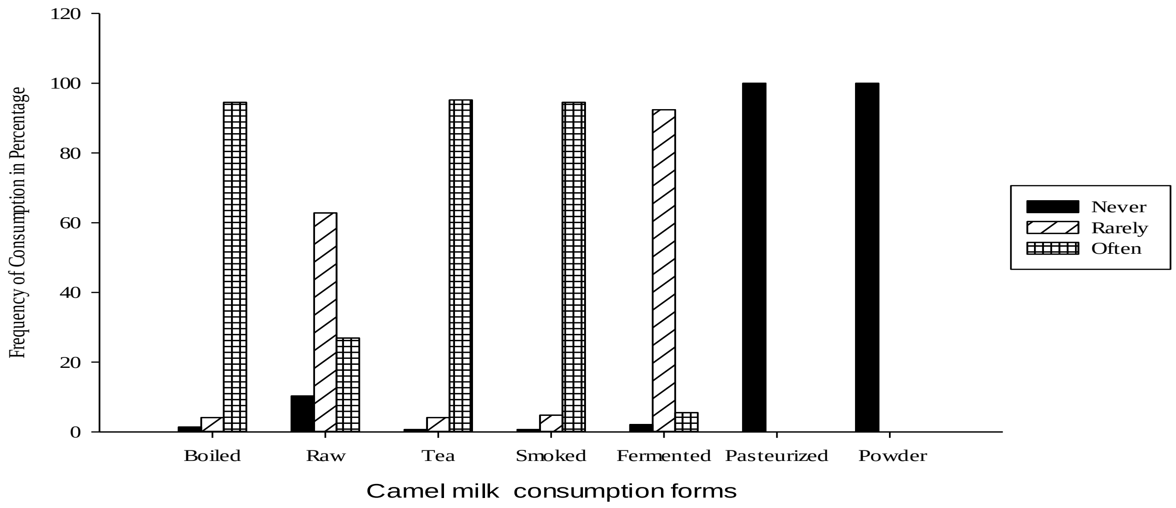

Figure 7: Form of camel milk consumption among the producers (N=145)

3.8.2: Feasibility of camel milk powder acceptability

While the respondents' acknowledged the use of cow milk powder, none had consumed camel milk powder. Among the producers (N=145), 51.7% had consumed cow milk powder. The likelihood of purchasing of the camel milk powder was higher (86.7%; N=145) among those who had consumed cow milk powder as opposed to those who had never consumed it (32.9%; N=145). About 47.1% of the respondents who had consumed the cow milk powder were neither likely nor unlikely to purchase the camel milk powder. About 70% of the respondents (N=145) ranked the milk powder attributes tested as important (Fig. 8).The participants of the FGD with all actors acknowledged the need of a stable long shelf life product similar to the cow milk powder.

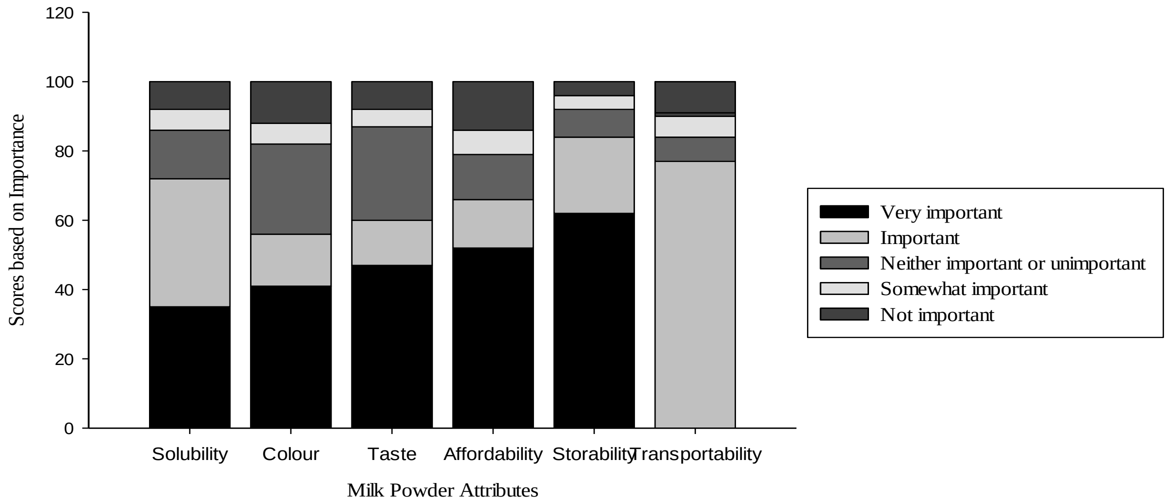

Figure 8: Important milk powder attributes (N=145)

DISCUSSION

The camel milk supply chain in Isiolo comprised of five main production functions with limited post-harvest handling technologies. Production functions were mainly the role of men both in husbandry and milking while milk handling, preservation and marketing were entirely the women's responsibility. In pastoral households with camels, the camel belongs to the man, but the milk is the property of the woman who uses it to meet the subsistence needs of the household (Anderson et al., 2012). The increased commercialization of large volumes of camel milk characterised by greater returns has encouraged pooling of milk from different suppliers to be able to meet the wholesalers' demands (Anderson et al., 2012; Nori, 2010).

From our findings, milk yield, consumption and utilisation varied between the two seasons. Similar studies undertaken in Jordan have recorded a decrease in the volume of camel milk during the dry season due to the decline of forage and water available to the camels (Haddadin et al., 2008).The decreased volume of milk results in increased demand for the available milk thus, leading to higher sales and higher market prices. This can be attributed to the need to purchase cereals and proteins for the households or as payback for outstanding arrears (Elhadi et al., 2015). In Ogaden region in Somalia, the sale of livestock milk products during the dry season contributed to greater than 80% of the pastoral households' income compared to about 40% in the wet season (Hussein, 1999).

Lack of preservation technologies and the unwillingness of the producers to sell their milk at prices (75.3%) lower than the market price fetched during the dry season contributed to a lower volume (79.5%) of milk sold during the wet season among the producers. The low market prices and high supply of the camel milk in the wet seasons also encouraged processing of camel cheese and yoghurt. This not only diversified the consumption of camel milk but also increased the milk shelf life and improved the nutritional content of the milk. Similar findings have been reported on value addition on cow and camel milk during milk glut by pastoral communities in Somalia and Ethiopia (Nori et al., 2006; Sadler et al., 2009).

Acceptability of milk by the traders was based on quality determination through chemical testing at the main cooling hub and organoleptic tests by sight, taste and smell by other bulkers. Milk that failed these tests, depending on the season, was returned to the producers to minimise economic losses among the traders. The returned milk was either processed, consumed at household level or given to neighbours similar to findings in Somalia on the utilisation of this milk (Nori, 2010). Processing was through natural fermentation into *Suusac* which was either sold at a lower price (48%) or consumed (52%) at the household level after addition of sugar (Noor et al., 2012).This represents a significant economic loss as the producers were forced to consume the milk instead of selling it to gain income for their households. Though there was no significant variation in the percentage of the non-marketed milk consumed in the wet and the dry season, the nature of the milk consumed differed. In the rainy season, fresh smoked milk was mainly consumed while in the dry season it was naturally fermented milk. This was because of the availability of lower volumes of milk in the dry season that limited consumption of camel milk to the rejected fermented milk. Different authors also documented that camel milk was offered as a gift to strengthen the rural social ties among the households and also as a sign of seeking help from wealthy households (Bush, 1995; Sikana et al., 1993). This is similar to our findings, where the non-marketed milk was given to neighbours to enhance the social relationships. Allowing the calves to feed on the dam during both the dry and wet seasons is in agreement with the importance the pastoral communities attach to herd replacement and growth as opposed to immediate economic benefit (Western and Finch, 1986; Holden et al., 1991).

Knowledge of factors that contributed to the non-marketed milk, due to spoilages or spillages, by both the traders and producers enabled them to apply strategies that counteracted these factors. This resulted in a reduced volume of non-marketed milk, thus an indication of the importance of knowledge accessibility by pastoral communities. At marketing level, qualitative milk losses were characterised by milk spoilage. This enhanced the use of milk preservation technologies such as chilling and freezing. Physical contaminants that were present in the milk were reduced through sieving of the milk at the cooling hub. Milk received by the traders when spoilt due to unhygienic milk handling at production level was returned to the producers. This in turn influenced the producers to observe hygienic milk handling practices at milking level. Delay in milk delivery due to unreliable milk transportation services enhanced the utilisation of simple milk preservation technologies such as the use of hemp bags soaked in water and boiling of milk at production and collection centres. Moreover, milk exposure time to the ambient temperatures and the degree of wetness of the gunny bags determined the extent to which the milk was cooled (Adongo et al., 2012). Evaporation of water from the gunny or hemp bag resulted in the cooling of the milk through extraction of latent heat of vaporisation from the milk. This temperature drop aided in inhibiting the multiplication of the psychrotrophic microorganisms thus delaying milk spoilage during transportation (Adongo et al., 2013). Lack of storage or cooling facilities at production and distribution level compelled the primary retailers to boil the milk so as to improve the keeping quality though it has been reported to negatively influence the vitamin C and Riboflavin content of the milk (Mehaia, 1994). Boiled camel milk when spoilt was discarded since it could neither be processed into any other product nor consumed. This is because boiled camel milk when fermented results in poor curding as opposed to fresh milk. Disposal of milk has a negative environmental impact as land, water and energy are utilised in the production and processing of this milk (FAO, 2011). Smoking (fumigation) of the milk containers was reported as the main milk preservation technology among the producers as milk could be transported over longer distances while exposed to high temperatures without spoilage. Moreover, lack of alternative milk preservation technologies at production level encouraged its utilisation. Fumigation which is a chemical preservation technique that prevents food spoilage through altering the chemical composition of the food (Ogbadu, 2014). In the pastoral regions, fumigation of milk containers using the *Olea africana* and *Balanities aegyptica* is a common practice that imparts flavour and inhibits microbial growth (Odongoh et al., 2016; Seifu, 2007; Wayua et al., 2012). Approximately 95% of the total camel milk produced was smoked while 5% was subjected to refrigeration during transit. This contrasts Blench's (2006) review that less African pastoralists are involved in milk preservation. But the smoked milk could only be kept for a short duration of time thus the willingness of the respondents to purchase the camel milk powders was so high. The non-smoked camel milk that comprised 5% was pre-ordered for the processing of value added camel milk products such as pasteurized milk, yoghurt and fermented milk as to meet the non-Cushitic population who live in the urban areas and do not appreciate the flavor imparted by smoking the camel milk (Musinga et al., 2008). Smoking of the milk was undertaken in plastic containers which were the main transportation and storage vessels along the camel milk supply chain. Plastic containers are known to be prone to migration phenomena and also flavor scalping thus may inversely affect the sensory property of the camel milk. (Kontominas, 2010).

Chilling and freezing are low temperature treatments that prevent quality deterioration by inhibiting physiological, biochemical and microbial activities (Berk, 2013). Low temperature milk storage does not destroy microorganisms but only retards their growth. Thus, the need to cool milk within 4 hours of milking to prevent the multiplication of the microorganisms. However, in the study area the milk took approximately 8 hours to reach the cooling plants and studies done have deduced that transportation time positively correlate with the milk spoilage (Odongoh et al., 2016). Depending on the time of the last milk delivery it took approximately 4-5 hours for the milk temperature to drop to 5°C from about 30°C at the chiller. Moreover, during the wet season, the capacity of the cooling facilities available was limited. Thus the producers mentioned a lack of market for their milk as the bulkers could not purchase higher volumes. This consequently, led to milk being sold at lower prices resulting in economic losses among the producers. In addition, some producers allowed the calves to feed on the dam during this season thus compounding the economic loss. These findings are similar to the findings by FAO (2011) in the horticultural industry where farmers either left excess produce un-harvested, or sold the produce to the feed industries and processors at lower price.

The utilization of firewood in camel milk processing is related to it being the main energy source used by Kenyan households for cooking (PISCES 2010). The use of firewood and charcoal contributes to environmental degradation due to the emission of carbon dioxide and carbon monoxide. Moreover, their use indoors contribute to household pollution and influences the taste and color of the camel milk. The incomplete combustion of charcoal and firewood and inhalation of the smoke by the members of the household can be detrimental due to its association with respiratory diseases. In developing countries, bio-fuels have been ranked as the second highest risk factor for ill health (Lim et al., 2012). Chilling and freezing of milk are highly energy intensive, costly and depends on conventional energy sources.

In times of milk scarcity in pastoral regions, bovine milk powder and condensed camel milk are the main source of protein for the pastoral households (UNA, 1998). It is therefore reasonable to infer that the pastoralists would be willing to purchase and consume camel milk powder if it were available. Transportability, storability and affordability of the camel milk powder were the most important attributes. This can be associated with the ease of transportation due to reduction in volume and weight, long shelf life of up to 18 months and low price compared to the fresh milk that is available in the region (Kalyankar et al., 2016). These attributes differ from those reported in Northern Kenya on acceptability of camel milk products (Akweya et al., 2012). This is because the findings were based on liquid milk products where colour, taste, packaging, aroma and thickness were considered vital. Consumption of the camel milk in Isiolo County was limited to smoked or boiled or as tea both at household level and at the milk bars. From our findings, camel milk tea fetched higher prices than the bovine milk, an indication of the great value that the camel milk is associated with. Similar findings are reported by FAO (2014).

4.0. CONCLUSIONS AND RECOMMENDATIONS

In a nut shell, the camel milk yield, consumption, losses, volume marketed and utilization of non-marketed milk were all season dependent. The milk consumption was limited to fresh, smoked and boiled forms but longer shelf life products such as milk powders were highly acceptable. The limited value addition was due to inadequate milk preservation technologies, high investment costs and technical feasibility for modern technologies. Moreover, these preservation technologies were dependent on charcoal, firewood, diesel and on-grid electricity which were unreliable. Therefore, availability of high solar irradiance and nominal radiation coupled with the long sunshine hours in Isiolo County provides a good source of energy that may be harnessed through conversion into either electrical energy or thermal energy for longer shelf life milk products processing such as milk powder. The use of Mazzi cans could be explored to limit the use of plasti containers and the heavy aluminium cans.

This study entailed the use of mixed methods. Therefore different perspectives from both the qualitative and quantitative point of view were employed. Data was collected along the camel supply chain, and the various actors and chain supports were involved.

This study utilised questionnaires and key informants who were susceptible to recall bias as it was based on reported information. Secondary documents used are prone to incomplete information. Therefore, the authors recommend longitudinal research in the long run. This study also provides an opportunity for further research on nutritional analysis of the spoilt camel milk for quantification of nutritional losses associated with milk spoilage and also the determination of willingness to pay for the long shelf value added camel milk products and possible technologies.

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