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SURVEY OF POSTHARVEST HANDLING, PRESERVATION AND PROCESSING PRACTICES ALONG THE CAMEL MILK CHAIN IN ISIOLO DISTRICT, KENYA

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ABSTRACT

Despite the important contribution of camel milk to food security for pastoralists in Kenya, little is known about the postharvest handling, preservation and processing practices. In this study, existing postharvest handling, preservation and processing practices for camel milk by pastoralists in Isiolo, Kenya were assessed through cross-sectional survey and focus group discussions. A total of 167 camel milk producer households, 50 primary and 50 secondary milk traders were interviewed. Survey findings showed that milking was predominantly handled by herds-boys (45.0%) or male household heads (23.8%) and occasionally by spouses (16.6%), sons (13.9%) and daughters (0.7%). The main types of containers used by both producers and traders to handle milk were plastic jerricans (recycled cooking oil containers), because they were cheap, light and better suited for transport in vehicles. Milk processing was the preserve of women, with fresh camel milk and spontaneously fermented camel milk (*suusa*) being the main products. Fresh milk was preserved by smoking of milk containers and boiling. Smoking was the predominant practice, and was for extending the shelf life and also imparting a distinct smoky flavour to milk. The milk containers were fumigated with smoke from burned wood of specific tree species such as *Olea africana*, *Acacia nilotica, Balanities aegyptica* and *Combretum* spp. Boiling was practised by primary milk traders at collection points to preserve milk during times when transport to the market was unavailable. Milk spoilage at the primary collection point in Kulamawe was aggravated by lack of cooling facilities. At the secondary collection point in Isiolo town, milk was refrigerated overnight before onward transmission to Nairobi. The mean quantity of traded milk was 83.2±3.8 litres. The main problems experienced by milk traders in Isiolo included milk spoilage (43.0% of respondents), delayed payments—after one or two days (19.9%), loss of money due to informal courier (12.2%), low prices of fermented milk (10.9%), milk rejection by customers in Nairobi (7.1%), inadequate supply during dry season (3.5%), loss of milk due to bursting of containers (2.1%) and milk not being supplied by producers due to insecurity (1.3%). In-depth understanding of the postharvest handling, preservation and processing practices would help to devise appropriate strategies that would increase the quantity and improve the quality of marketed camel milk. Such strategies should include the improvement of infrastructure such as milk transport, collection, cooling and processing facilities of suitable capacity.

Key words: Camel milk, postharvest, handling, Kenya

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INTRODUCTION

The camel (*Camelus dromedarius*) plays an important role as a primary source of subsistence in the Arid and Semi Arid Lands (ASALs) of Kenya. It lives in areas that are not suitable for crop production and where other livestock species hardly thrive [1, 2]. Due to its outstanding performance in the ASALs of northern Kenya where browse and water are limited, pastoralists rely mainly on camels for their livelihood. In these areas, camels are mainly kept for milk production and produce milk for a longer period of time even during the dry season when milk from cattle is scarce [2]. The annual camel milk production in Kenya is estimated at 338.3 million litres, valued at USD 107.1 million, and this represents 12% of the national milk production [3]. During prolonged droughts, camel milk may contribute up to 50% of total nutrient intake of some pastoralists groups [2, 4]. These essential roles of camel milk emphasise its importance for food security to the pastoral people.

Surplus milk is sometimes sold in urban centres and the derived cash contributes to the total household cash income, which is used to purchase cereals, oil, sugar, drugs and other household requirements. Despite the important contribution of camel milk to ASAL inhabitants, little is known about the postharvest handling, preservation and processing methods for camel milk in Kenya in general and in Isiolo in particular. This study, therefore, aimed at identifying the existing postharvest handling, preservation and processing practices along the camel milk chain in Isiolo District, Northern Kenya. Understanding of these practices will help to design appropriate strategies to enhance the contribution of camel milk to food security for ASAL inhabitants, especially the poorer households.

METHODOLOGY

Study area

The study was carried out in August-September, 2009, along the Kulamawe-Isiolo camel milk chain in Isiolo district, which is situated north of the Equator at coordinates N00.35° and E037.58° and an altitude of between 1730 to 1890 m above sea level. Kulamawe is an important camel milk production cluster which supplies milk to Isiolo town, but its potential is underutilised due to remoteness and lack of supportive facilities. The area is characterised by unreliable and erratic rainfall with precipitation ranging from 237 to 698 mm per annum, high ambient temperatures (>25°C), sparsely distributed vegetation dominated by *Cactus* and *Acacia* species, and bushy woodlands. Camels are the most abundant livestock species in this area, with camel milk marketing being an important income earning opportunity for the pastoral households.

Data collection

Data were collected through cross-sectional survey and focus group discussions (FGDs). The sampling unit consisted of camel milk producers and milk traders in Kulamawe and milk traders in Isiolo. At the camel milk producers' level, the sampling frame consisted of a list of camel keeping households obtained from the local administrative personnel. To identify survey households, a two-stage sampling

procedure was used. During the first sampling stage, Kulamawe was divided into five zones (*Bulla*) representing the settlement patterns in the area. In the second stage, systematic random sampling was used to select the survey households in each *Bulla*. The main paths in the *Bulla* were used as transects. Starting from one end of the path, every fifth household on alternate sides of the path was visited and the household head, their spouses or the person responsible for making decisions on food purchases, or those directly involved in milk marketing interviewed using a structured questionnaire. A total of 167 camel milk producer households were interviewed. Focus group discussions were conducted on camel milk producers to augment data from the questionnaires. Individuals selected for the FGDs were those knowledgeable on the subject under study so as to have maximum information, and were selected with the assistance of key informants (community leaders).

Milk traders were categorised as primary (those in Kulamawe) and secondary (those in Isiolo town). Primary traders received milk from producers in Kulamawe and sold it to secondary traders in Isiolo, who further sold it to consumers in Nairobi. Milk traders were few and, therefore, all were interviewed. A total of 50 primary and 50 secondary milk traders in Kulamawe and Isiolo, respectively, were interviewed. Personal observations were made to fill the gap that might have not been captured during the survey, particularly to describe some of the routine dairy activities practiced by producers and traders.

Statistical analysis

Data from questionnaires were analysed in SPSS Statistics Version 17.0 using descriptive statistics (frequencies, means and percentages) and cross tabulation (to check for association between factor variables) [5]. Qualitative data from FGDs were transformed into thematic components and written into descriptive prose.

RESULTS

Socio-economic characteristics of producers

The characteristics of camel milk producer households are summarised in Table 1. Most (51%) of the respondents were women (spouses) while the rest were male household heads (47%) and sons (2%). All the respondents were Muslims, with 97% being of Boran and 3% of Somali ethnic origin.

Home production of camel milk

The average amount of milk a camel produced per milking was 2.0±0.1 litres. All the interviewed producers milked their camels twice a day (morning and evening). Milking was predominantly handled by herd-boys (45.0% of the cases) or male household heads (23.8%), and occasionally by spouses (16.6%), sons (13.9%) and daughters (0.7%). Because of the height of the udder, the milking process was done in a standing position with one knee raised to support the milking container—plastic container or traditional container called *damela* (curved from tree trunks) or *gorfa* (woven from grass). The milker stands on one leg, balances the milking container in his bent other leg and uses both hands for milking. Sometimes both udder halves are milked at the same time by two herdsmen. Camels were milked by hand, with the calf

allowed to suckle for a short time prior to milking to stimulate milk letdown. Udders of milking camels were not washed before milking, as the pastoralists believed that camel milk was always clean. The survey revealed that the quantity of milk produced from lactating camels in the last 30 days prior to the study averaged 379.6±20.9 litres, out of which 60.7% were sold and 39.3% consumed in the household.

Traditional preservation methods

The primary dairy products were fresh milk and traditionally fermented milk (*suusa*). The main preservation methods for fresh milk included fumigation of milk containers and boiling of milk.

Fumigation of milk containers

The main types of containers used by both producers and traders to handle milk were plastic jerricans (recycled cooking oil containers, of capacity 3 to 20 litres). These were used because they were cheap, light weight and better suited for transport in vehicles. The milk containers were fumigated with smoke from burned wood of specific tree species such as *Olea africana, Acacia nilotica, Balanities aegyptica* and *Combretum* spp. This indigenous milk preservation technology is locally referred to as *qorasum*. The milk containers were fumigated by inverting them over smoking chips until the smoke died out (about 5 to 10 minutes). The residual charcoal pieces were brushed out with special twigs, followed by rinsing with water. Fresh camel milk to be stored was then put inside. According to the pastoralists, if properly fumigated, fresh camel milk could stay for 24 hours at ambient temperatures, depending on the *qorasum* tree species used to fumigate the milk containers. Smoking of milk containers was part of a woman's daily duty, and was done regardless of whether or not the containers were in use so as to maintain them in good condition. Smoking took place before early morning milking (06.00-07.00 hours) and again before the evening milk was put in them (17.00-18.00 hours). According to the local understanding, smoking of milk containers imparted special taste and flavour to the milk, and disinfected the containers, thus reducing the numbers of microorganisms and thereby extending the shelf life of milk. The pastoralists believed that if not properly fumigated, milk would spoil regardless of hygiene measures taken.

Traditional preparation of *suusa*

Suusa was made by putting raw camel milk in a clean and fumigated container, wrapping the container with a piece of cloth and keeping it in a warm place (ambient temperature of 24–30°C) for about 12-24 hours to allow spontaneous fermentation. After one day whey comes on top, and is drawn out using a straw, and more fresh milk is added. This process is repeated daily for 3 to 4 days until the product was ready. *Suusa* has a thin consistency compared with yoghurt, and because it is made by spontaneous fermentation, it varies in taste. The whey was not discarded but consumed as a laxative (to relieve stomach upsets). Only good quality milk was used to make *suusa*.

Camel milk processing by households

Camel milk processing from the pastoralist perspective is defined to mean any methods used to transform the raw milk into better products for human consumption

or marketing. Most (76.8%) of the surveyed households processed camel milk using mainly indigenous technologies. The percentage of produced milk that was processed was, however, very small (<10%). The main product was *suusa* and all was consumed in the household. Milk processing was the preserve of women (spouses, 99.1%) and rarely by male household heads (0.9%). Decision on camel milk products to process was made by women spouse (88.0%), both spouse and male household head (10.3%) and male household head (1.7%).

Most (79.5%) of the households had received information on milk processing in the last 12 months prior to the survey. This included information on hygienic handling of milk, processing of dairy products with extended shelf life such as fermented milk using starter cultures, and ghee. The information was provided by a local non-governmental organisation promoting camel development. About 72% of those who received the information were processing milk whereas 28% were not. Some women had been trained on milk processing but no practical demonstration had been done and, therefore, had not picked up the new technology. They complained that the trainings were not consistent as different people were invited each time. All the survey respondents, however, agreed on the importance of milk processing. According to them, milk is processed so that it is clean and so it can be used as food. Processing also enables the milk to be stored for later use, feeding to children or selling to get money to purchase other household items like tea leaves, sugar, etc.

All the traders and producers sold raw milk, even though they sometimes boiled the milk to preserve it especially during times when transport was unavailable. All the interviewed households reported that they consumed camel milk raw.

Kulamawe-Isiolo milk chain

The Kulamawe-Isiolo milk marketing chain is summarised in Figure 1.

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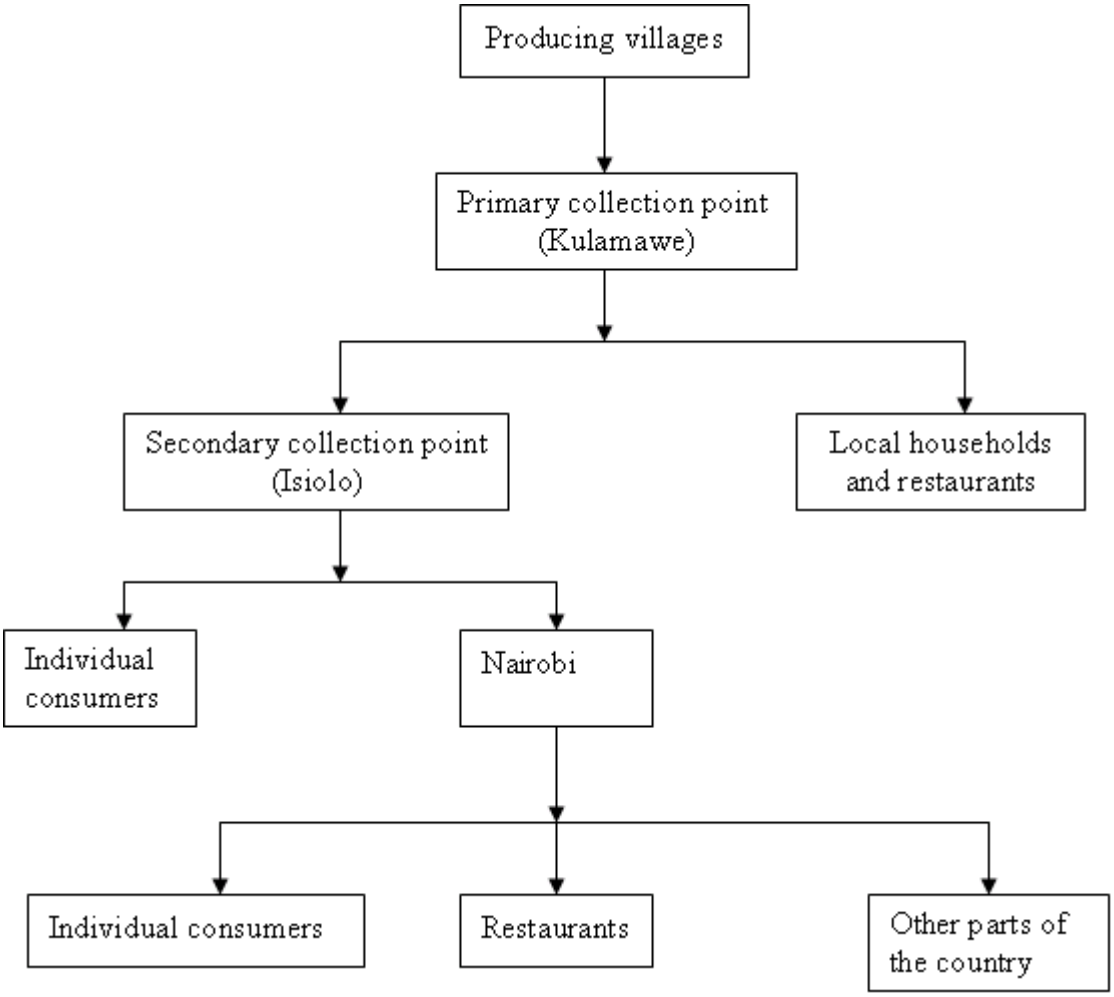

Figure 1: Flow chart for the Kulamawe-Isiolo camel milk marketing chain

Morning milking generally occurred between 06.00 to 08.00 hours at the villages (*manyattas*). After milking and collection, the milk was transported for duration of about 2.0±0.7 hours (about ten kilometres) by donkey or women on their backs to the Kulamawe milk collection point. The maximum quantity of milk transported per trip was 20 litres. The producers then sold the milk to primary milk traders at Kulamawe shopping centre. The milk was then transferred from the producer containers to the traders' containers—both containers were plastic jerricans of capacity 3 to 20 litres. The traders' containers were properly labelled with the name of the trader (or unique marks of strings tied), which enabled their corresponding clients in Isiolo town to identify the containers.

This system was highly dependent and built upon trust, as there was no written agreement. The process of milk collection and change of containers took approximately 2.5 hours in the open sunshine and was a possible source of milk contamination in the marketing chain. As a result, marketed milk was typically

exposed to high temperatures for prolonged periods of time, increasing the risk of spoilage. At the primary collection point, milk was subjected to simple quality tests based on colour, taste, and texture. During bulking, milk from different containers was mixed, further increasing the risk of spoilage due to increased microbial contamination from the various milk batches.

Transportation to Isiolo was by an old lorry which was the only means of transport along the Kulamawe-Isiolo route. This lorry made a one way trip each day and was, therefore, only able to transport milk every other day—one day to Isiolo with milk, the next day back. To make its trip to Isiolo (a distance of 82 km on rough terrain) by 16.00–17.00 hours, the lorry departed Kulamawe by 11.00 hours and, therefore, milk had to be delivered by this time from the interior *manyattas* where the camels were reared. The average time between milking and arrival at secondary market in Isiolo was about 7.5 hours. The average ambient temperatures were 24°C in the early morning at the *manyattas*, 28°C at the Kulamawe collection point and 30°C at Isiolo town by late afternoon.

Vehicular transport was inefficient and there was no opportunity for refrigeration due to lack of grid electricity. Besides, only milk produced each other day was able to access the Isiolo market. Because the lorry was the only means of transport in this route, milk was transported along with all else that needed to be taken to Isiolo—passengers, livestock, charcoal, etc, which is a public health concern. Milk spoilage was inevitable when the vehicle was not in operation. To minimise milk spoilage during such times, milk traders at the Kulamawe collection point boiled milk using firewood to preserve it for sale the following day.

Once the milk reached Isiolo, it was weighed and assessed for quality in several ways that included colour, taste, texture, use of boiling, dipped matches, and looking for milk layering or separation. Boiled milk of higher quality would yield foam, for example, and would not have a burned residue at the bottom of the cooking pot, whereas a match dipped in watered-down milk would not light. Lower-quality milk would often layer into water, milk, and solids. Fermentation was checked by dipping a wooden cooking spoon to see if the fermentation process had begun. Milk from evening milking was separated from morning milk. Fresh milk was also packed separately from fermented milk—most of it in 20 litre jerricans. Once milk was weighed and graded, records were taken (supplier, volume, grade) and, for some traders, money paid on the spot. Most of the traders, however, paid their suppliers with a one-two day lag after they received payment from their agents in Nairobi (the tertiary market). The milk was then frozen overnight before onward transmission to Nairobi by buses the following day.

The main problems experienced by traders in Isiolo town included milk spoilage, delayed payments (after one or two days), loss of money due to informal courier, low prices of fermented milk and milk rejection by their customers in Nairobi (Figure 2). Milk spoilage was the major problem and was caused by loss of power in the fridges, pooling of milk from different farmers, mixing of evening and morning milk, long distances between *manyatta* and town, exposure to high ambient temperatures during

transport, use of dirty containers, and inefficient fumigation of milk containers. Loss of milk was due to bursting of milk containers and theft during transport.

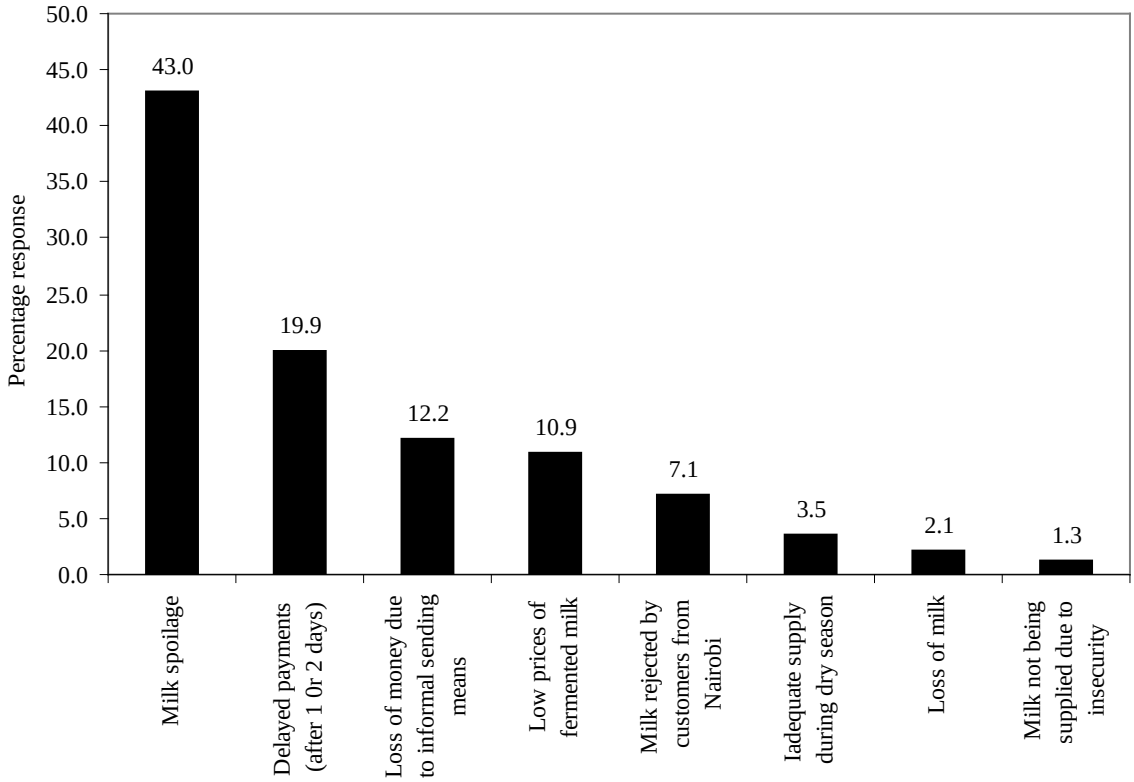

Figure 2: Problems experienced by secondary milk traders in Isiolo

Whilst refrigeration was not an option for primary milk sellers in Kulamawe due to lack of connectivity to grid electricity, it was practiced by secondary milk traders in Isiolo. An elaborate business for cold storage had, therefore, emerged in Isiolo town. There were seven cooling hubs in the town with a cold storage capacity of approximately 8,000 litres of camel milk per day (Table 2). At the time of the study which was during the dry season, only 46% of the storage capacity was being utilised due to milk scarcity.

Transportation to Nairobi had two segments. The first involved transferring the milk packed in 20 litre jerricans from the cooling hubs to Nairobi bound buses. This was done by casual labourers (usually men) using wheelbarrows, each ferrying two to five jerricans per trip. Transportation to Nairobi was by buses departing between 06.00–07.00 hours each morning and getting to Nairobi by around 11.00 hours.

Milk traders in Isiolo town

Whereas all the primary milk traders in Kulamawe operated individually, most (94%) of the traders in Isiolo town operated individually and only 6% operated in groups.

The traders who belonged to groups, however, sold their milk on individual basis and only joined into groups to benefit from economies of scale, such as acquiring skills on milk handling and business management and reduced costs of cooling milk due to group freezers. All the traders traded in raw camel milk, the quantities varying from 40 to 160 litres (mean=83.2±3.8 litres). Traders operating in groups had higher quantity of milk traded per day (103.3±8.8 litres) than those trading individually (81.9±4.0 litres). Processing was minimal due to limited value addition skills by traders.

DISCUSSION

The results in Table 1 indicate that the socio-economic status and the education level of the respondents were low. The ability to read and write would enable the producers to better utilise effectively and efficiently whatever resources exist in their area. Livestock keeping was the main economic activity (Table 1), a finding that agrees with those from earlier studies which show pastoralism as the main livelihood strategy in the ASAL regions of Kenya [2, 3]. All the interviewed producers milked their camels twice a day (morning and evening), which is similar to the milking frequency practiced in many parts of the country [2]. Camel milking was predominantly handled by men. This observation is similar to camel milking in many parts of Kenya whereby milking is predominantly handled by men, with the exception of the Turkana where milking is entirely performed by women [2]. Hygiene of milking was poor (hand milking, no udder cleaning). The reality, however, is that consumers in the region are beginning to appreciate the importance of clean milk and are even willing to pay more for higher quality milk than what is typically found in their market place, and this will compel the producers to produce and sell higher quality milk [6].

Camel milk was preserved by fumigation of milk containers and boiling of milk. Fumigation is a common traditional practice carried out by pastoralists in northern Kenya [2, 6, 7]. According to the local understanding, smoking of milk containers imparts special taste and odour to the milk, and disinfects the containers, thus reducing the loads of microorganisms, thereby extending the shelf life of milk. This corroborates with the results of an earlier study in which greater numbers and a faster development of aerobic mesophilic microorganisms occurred in milk kept in non-smoked as compared to smoked containers [8]. This practice, however, negatively affects the market because majority of potential consumers of camel milk, especially those from non-pastoral background, do not prefer the smoky flavour in camel milk. To reach a wider market, the traders need to meet the requirements of both market segments—by providing smoked and non-smoked milk according to customer preferences.

Suusa was a camel milk product prepared by spontaneous fermentation of camel milk, resulting into a product of varying taste and consistency. Similar products from camel milk were reported in other pastoral systems of Africa [9, 10, 11]. The quality of *suusa* can, however, be improved using selected starter cultures, resulting in fermented milk with uniform taste and longer shelf life [9].

Whereas milking was predominantly done by men, postharvest milk handling was the preserve of women. This has commonly been reported elsewhere in African pastoral systems [10, 11]. Both producers and traders used mainly plastic jerricans of cheap quality (recycled cooking oil containers) to handle milk. The obvious advantages of plastic containers (cheap, light weight, better suited for transport in vehicles) coupled with the small volumes of traditional containers led to the increasing use of these containers in the camel milk trade. However, the plastic containers are difficult to clean, wear out frequently, and harbour bacteria which cause milk spoilage. To improve the situation, milk traders should use aluminium containers which are easy to clean and which are specifically designed for milk handling.

All the interviewed households reported that they used camel milk when it was raw, which agrees with an earlier finding that camel milk was predominantly consumed raw in most camel rearing societies [4]. Consumption of raw camel milk is, however, of major public health concern. Recent studies from Kenya indicated that higher levels of total bacterial count, *Salmonella* and *Streptococcus* were detected in raw camel milk, which suggests the potential health hazard associated with consumption of raw camel milk [12, 13, 14]. Consumption of pasteurised camel milk should be encouraged since heat treatment destroys these microorganisms without affecting the nutritional value of camel milk, which is an advantage in relation to the commercial production of camel milk [15, 16].

Boiling of milk is already practiced by primary milk traders at Kulamawe collection point to preserve milk during times when transport to Isiolo is unavailable. In Somalia, where milk was boiled at collection points prior to transportation, it was observed that substantial volume of milk that would otherwise get spoiled was marketed daily in a hostile environment [11]. Using firewood to boil milk, however, places intense pressure on woody resources on the already fragile environment [17]. Therefore, renewable energy technologies such as solar energy should be explored for their suitability for milk processing in the ASALs.

Milk is kept at higher ambient temperatures (24-30°C) and this accelerates spoilage due to increased microbial activities. The reduction in temperature (maintenance of cold chain) is the most important factor in reducing loss and maintaining milk quality [20]. Low temperatures decrease physiological, biochemical and microbial activities, which are the causes of quality deterioration [20]. The milk transport system (by lorry and passenger buses) is not suitable especially when important hygiene and food-safety considerations are taken into account. The continued transportation of milk by lorry and buses, therefore, undermines the emergence of specialised transportation business for milk, which would be capable of handling increased volumes and offering high quality standards in hygiene and food-safety, as is practiced in refrigerated trucks for milk transport in the high potential areas of Kenya.

CONCLUSION AND RECOMMENDATIONS

This study has shown that the camel milk chain in Isiolo District, Kenya is characterised by poor milk handling infrastructure, including poor roads and lack of cooling facilities. Milk spoilage was a major problem. Camel milk is marketed raw under unhygienic conditions with minimal value addition and, therefore, risks of milk spoilage are high. Most of the milk is consumed raw, pausing a major public health concern, hence the need for processing to enhance safety and quality.

Therefore, the primary intervention strategy should be to address milk spoilage at the producing villages and the collection points, especially when transport is unavailable. Provision of appropriate and affordable cooling facilities at milk collection points should be explored. To minimise environmental degradation, renewable energy technologies such as solar energy should be explored for their suitability for heating milk in the ASALs. At secondary milk collection points, there is need for processing and value addition to diversify products to respond to consumer demands, as has been demonstrated in other parts of the ASALs [18, 19]. Producers and traders could be mobilised and linked to creditors in order to acquire credit to purchase the coolers and milk processing units. These efforts should be coupled by continuous training of all actors in the marketing chain on hygienic milk handling.

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Table 1: Socio-economic characteristics of camel milk producer households in Kulamawe (n=167)*

Continuous variables	**Mean±SE****
Average household size (persons)	5.9±1.8
Average age of household head (years)	52.5±1.7
Average age of spouse (years)	42.4±1.3
Camel milk production per day per household (litres)	4.0±0.1
Categorical variables	**Percentage**
Male headed households	49.0
Female headed households	51.0
Education level of household head:	
No formal education	76.2
Some formal education	23.8
Education level of spouse:	
No formal education	79.7
Some formal education	20.3
Marital status:	
Married	86.8
Single	1.9
Divorced	3.3
Widow/widower	7.3
Not applicable (<18 years)	0.7
Primary economic activity:	
Livestock keeping	66.9
Business	9.3
Salaried employment	2.6
Labourer	2.0
Pupil/student	0.7
Unemployed	18.5

*n=number of producer households, **SE=Standard error

Table 2: Cold storage capacity for camel milk in Isiolo town

Cooling hub No.	No. of freezers	Storage capacity (litres)	Current (dry season) utilisation, litres	Percent utilisation (%)
1	12	1440	800	56
2	12	1440	700	49
3	12	1440	600	42
4	12	1440	600	42
5	10	1200	400	33
6	5	600	400	67
7	4	480	200	42
Total	**67**	**8040**	**3700**	**46**

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