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MILK HANDLING PRACTICES AND UTILIZATION AT DAIRY FARMS AND COLLECTION CENTERS UNDER RURAL AND PERI-URBAN MILK VALUE CHAIN SYSTEMS IN NAKURU COUNTY, KENYA

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ABSTRACT

There are increasing expectations on the compliance of food products to safety and quality standards due to consumer demand for high-quality food. The aim of this study was to determine the quality tests that are carried out on raw milk and its utilization at three milk collection centers in Olenguruone and Dundori regions of Nakuru as well as some selected dairy farms. Using a semi-structured questionnaire, data were collected from milk collection centers' staff and farmers. Milk sampling for quality control testing was done at both the cooperative delivery points and farm level. The quality of milk handled and stored in different containers was assessed. Descriptive statistics, Chi-square and logistic regression analysis were carried out on the data. Results indicated that the average quantity of milk received at all milk collection centers was about 3687 liters per day. It was noted that most of the milk collection centers' staff (operators) had certificates or diplomas in dairy science. Their average job experience period in the milk sector was 7 years. Majority of the farmers (90%) and transporters (94%) used plastic containers for milk handling and storage. Farmers who used plastic containers for milking were approximately three times more likely to have their milk rejected compared to those who used mazzi cans, aluminium or stainless-steel containers ($p<0.05$; Odds ratio =3.20). The alcohol and lactometer tests were carried out on milk received at all collection centers studied. Resazurin test was only carried out in one collection center at Olenguruone that had the required laboratory equipment. Milk quality assessment was not done at the farm level. Traditional fermented milk was the common dairy product produced from evening milk in most dairy farmers' households. Regular education programs and seminars on milk safety and quality should be provided to both collection centers' operators and farmers.

Key words: Milk quality, Milk utilization, Milk collection centers, Alcohol test, Lactometer test

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INTRODUCTION

There is a huge demand for safe, high-quality foods with a long shelf-life. However, milk and milk products are perishable, that is, they deteriorate very quickly. Milk quality control is the use of various tests to ensure that milk and milk products are safe, healthy, and meet the standards for chemical composition, purity, and levels of bacteria and other microorganisms [1]. A quality control system will ensure that milk collectors, processors and marketing agencies follow the correct methods of milk handling. As stated in the Milk Processing Guide series, Volume 2, published by GOV/FAO/TCP/KEN/ 6611, it is important to have a good system, because it will provide benefits to everyone involved.

Raw milk quality remains an important component in assessing the performance of dairy value chains. It is generally based on chemical components particularly, fat; SNF (Solid Non-Fat) and protein contents that are influenced by feeding practices [2], breed and lactation stage [3]. The most important factor in milk, however, is its safety. Jayarao *et al.* [4] observed that milk producers and cooperatives viewed bulk milk tank analysis as an important part of milk quality assurance program. Besides, Bonfoh *et al.* [5] concluded that the health of dairy herd and milking conditions are basic determinants of milk quality. Vasavada [6] concluded that pathogenic bacteria in milk have been a major factor for public health concern since the early days of the dairy industry. Many diseases are transmissible via milk and milk products. The hygienic quality of milk affects its shelf-life [7] and its eventual acceptability to consumers [8]. Dairy products' quality defects have been attributed to the poor microbiological quality of raw milk and heat-resistant enzymes [9, 10, 11]. Milk from a healthy udder contains very few numbers of bacteria (<3x104 cfu/ml), but may become contaminated by microorganisms from the surrounding environment during milking and milk handling, from water and milk equipment [12].

The production of high-quality milk is not easy to achieve in developing countries due to factors such as poor hygiene and sanitation during milking and milk handling, unclean water, high ambient temperatures, lack of cooling facilities and inadequate infrastructures for milk transportation to the processing facilities [13, 14].

Farmer groups and operators of milk collection centers usually have systems of quality control for the milk they receive from individual farmers, therefore segregating poor quality milk. The centers play an important role between the dairy farms and the dairy industry in terms of supplying high-quality, safe and adequate raw milk [15]. Their main role is to collect adequate milk volumes to meet the processing industry's demand; however, the industry demands good milk quality and adequate quantity. Commonly reported quality control tests that are carried out include organoleptic test, alcohol test, and lactometer test. The alcohol test, which is the most common quality control test carried out, analyses milk based on the stability of milk casein micelles. Development of acidity in milk causes disintegration of these micelles [16].

Acid development in milk results from microbial activity as it is being transported from farms or stored under uncooled conditions. The microorganisms sour the milk by

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converting the milk sugar, lactose to lactic acid [17]. At low levels of pH, casein is destabilized due to acid generated from fermentation [18]. The destabilization of casein is detected upon subjecting milk to the alcohol test. The milk is rejected upon failing the test. Milk rejection contributes to post-harvest losses at the farm level that can be more than 6% of total production [19]. Within the cooperative or collection center and milk market chain, milk loss is estimated at between 1 to 5% on average, but can go up to 10% in the wet season when delivery rejections are common. Milk rejection is mostly done after failing the alcohol and lactometer tests because of developed acidity and adulteration with water or solids, respectively.

This study sought to determine raw milk quality tests carried out in selected dairy farms and collection centers. Differences between farmer practices as well as milk collection centers' characteristics and practices were determined. The types of milk handling containers used also influence raw milk quality. The types of containers used for milk handling and storage by farmers and transporters were, therefore, studied and an experiment set up to compare milk-keeping quality in four commonly used containers. The utilization of the milk at both the collection centers and dairy farmers' households was also assessed.

MATERIALS AND METHODS

Study area

The study was conducted in Dundori (peri-urban area) and Olenguruone (rural area) Divisions of Nakuru County in the Rift Valley region, Kenya.

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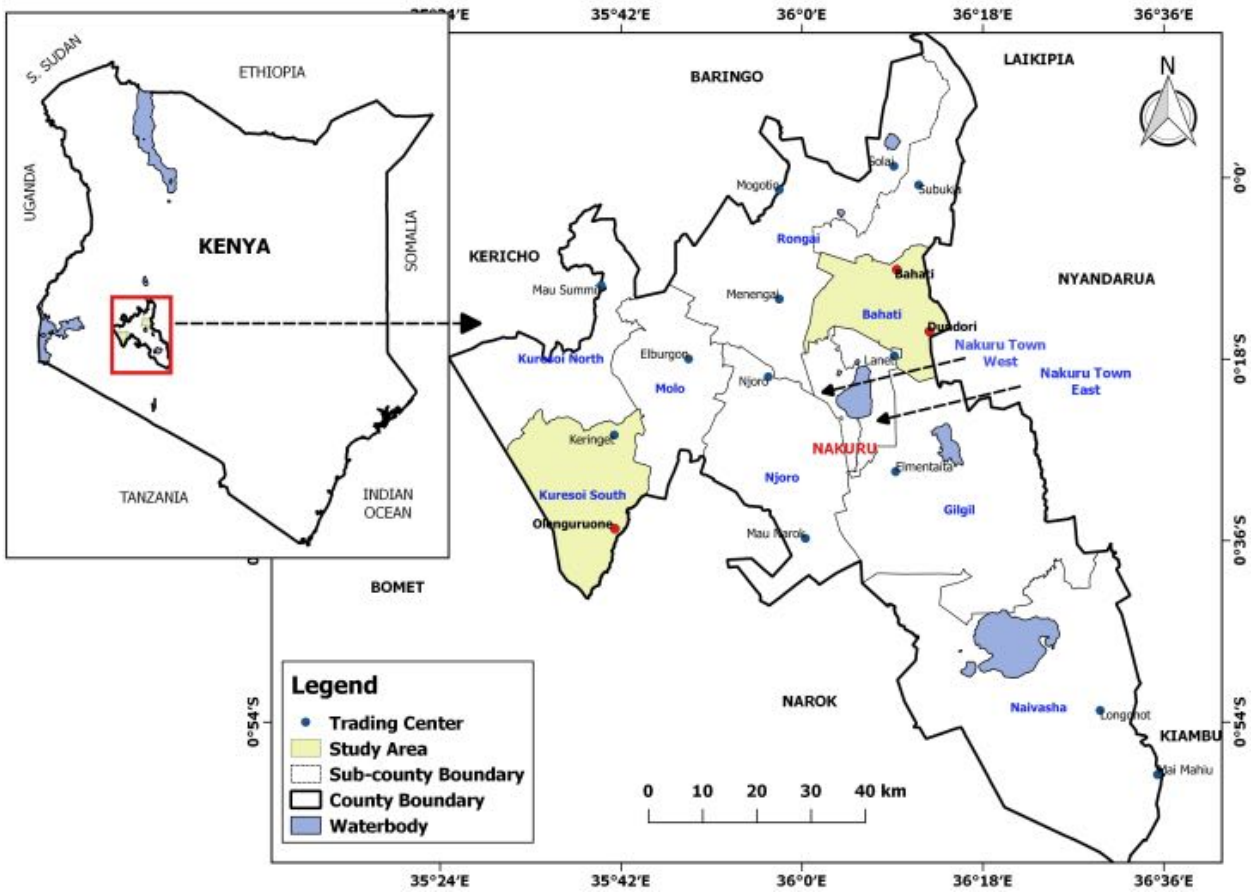

Figure 1: Map of the study areas

Selection of the Dairy Cooperatives (milk collection centers) and the study farms

The study regions were selected purposively based on the two dairy farming systems, peri-urban and rural systems. Milk collection centers were then selected purposively based on the study region. Three collection centers were picked, two in Olenguruone (rural region) and one in the peri-urban region, Dundori. These included Wanyororo Dairy Cooperative Society collection center in the peri-urban region and Olenguruone dairy cooperative society collection centers, Olenguruone and Kaplamai branches in the rural region. Simple random selection of smallholder farmers was then done from the lists derived from the records of the collection centers (dairy cooperative societies). The sampling frame was made up of active society members who were delivering milk at the time of sampling. Active membership referred to a member who was presently producing milk and consequently had an active account at the collection center. The calculated sample size was 177 farms. These farms were proportionately distributed to the three collection centers and randomly selected for the study.

Methods of data collection

Data were collected on raw milk quality assessment. Staff in the milk collection centers provided information on quality control tests performed at the centers, amount of milk that failed either of the tests performed and frequency of milk rejection. The farmers provided information on raw milk quality assessment and utilization at the farm level.

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Both quantitative and qualitative data collection approaches were used. The quantitative data were collected using the semi-structured researcher administered questionnaire, while qualitative data were obtained from Focus Group Discussions (FDGs), Key Informant Interviews (KIIs) and observation checklist. Focus Group Discussions were held with groups of 10 farmers from each region; the discussions explored milk production, collection and bulking as well as quality control of the milk. Key Informant Interviews were held among extension workers from the two study regions and the milk collection centers staff/operators. Key Informant Interview guides were used to document information on milk quality assessment, rejection and processing. The observation checklist consisted of a list of areas/ topics of observation that included quality control tests performed at the collection centers, milk rejection, utilization of rejected raw milk, milk value addition activities and any processing methods and steps involved. An experiment was set up to compare milk-keeping quality in four commonly used containers by farmers and transporters in the study regions. Milk sampling for quality testing at the cooperative delivery points and farm level was also done.

Statistical Analyses

Data were analyzed using the Statistical Package of Social Sciences computer software (SPSS) version 20.0. Appropriate descriptive analyses were done. The focus group discussions and key informant interviews were transcribed and coded, therefore, converting most of the qualitative descriptions into quantitative data. Frequency distributions were then generated based on the quantitative data.

Differences between farmer households in the rural and peri-urban regions, as well as milk collection centers characteristics and practices were assessed using the Chi-square statistic and the strength of the association determined using the odds ratio. The farmer and collection center characteristics indicated the factors that affect milk quality. Factors with $p>0.05$ were considered insignificant, while those with $p<0.05$ were considered significant and were, therefore, included in the logistic regression [20]. After the univariate analysis, a multiple logistic regression, using the stepwise procedure was used to screen variables that could determine low milk quality, hence rejection at 5% levels of significance. Interaction and confounding between the factors/variables were controlled analytically in the logistic regression modelling.

Descriptive analyses were carried out on the results of titratable acidity, alcohol and resazurin tests carried out on milk in the different milk handling containers. Differences between the test results were determined by carrying out ANOVA.

Prevalence of low-quality milk was calculated as the number of milk samples testing positive to 68% alcohol divided by the total number of milk samples tested. Prevalence of sub-clinical mastitis was calculated as the number of milk samples testing positive to California Mastitis Test (CMT) divided by the total number of samples tested.

The level of agreement between the 68% and 80 % ethanol tests was calculated using Kappa Test. Usually, a qualitative assessment of Kappa suggests that if it is high, the tests are measuring what they purport to measure. If Kappa is low, much uncertainty

exists and in the absence of sensitivity and specificity data, it is difficult to say which test provides the more valid answers.

RESULTS AND DISCUSSION

Milk collection centers' characteristics

Olenguruone dairy cooperative society collection center, Olenguruone branch had the highest number of registered active farmers, about 372 farmers. The Kaplamai branch had about 52 registered active farmers while Wanyororo Dairy Cooperative Society had about 40. Most of the studied farms (90.3%) benefited from the various services offered by dairy societies with artificial insemination being the most commonly utilized service (80.1%). Others included feeds on credit (44%) and loan acquisition, by only a small proportion of the farmers (4.4%). The average age of the milk collection centers' staff members was 30.8 years and the average tertiary education period of the staff members in all the centers was 3.3 years. Most of them had certificate or diploma in dairy science. Their average job experience period in the milk sector was 7 years. There was no significant statistical difference found between these collection centers personnel characteristics ($p>0.05$). The average experience period spent by staff members at the same collection center was 5.4 years. There was a statistically significant difference among the different staff members' working experiences in the different collection centers ($p<0.05$); the staff working in larger size collection centers had more years of working experience in the same center. Significant differences were also found between the collection centers averages for the number of employed staff ($p=0.001$) and for storage tanks size ($p=0.000$). The number of staff members employed in larger centers was higher and the tank sizes were larger. When the capacities of the farmer milk production with respect to the collection are considered, Olenguruone Dairy Cooperative Society collection center, Olenguruone branch collected about 2847 liters/day from 372 farmers. The Kaplamai branch on the other hand collected about 430 liters/day from 52 farmers. Wanyororo dairy cooperative society collected about 400 liters/day from 40 farmers.

Collection and bulking of raw milk

Collection and bulking of raw milk were done by 90.3% of the farmers in the study areas who were all members of cooperative societies that owned the collection and bulking centers. The collection and bulking usually depended on the intermediaries and the road network. Some farmers (9.7%) reported that the road network and the cost of transporting milk were the main reasons why they never took their milk to the collection center. The transporters taking milk to collection centers reported an average transport time as 3 hours in both study regions. These transporters picked milk from different farmers, hence explaining the many hours taken to deliver the milk at the centers. The same transportation time was reported during the farmer's interviews. Operators of the collection centers reported similar time for the arrival of transporters. The transporters taking milk to all centers reported an average of 10 km, 13 km and 15 km distance to deliver milk for Wanyororo, Olenguruone (Olenguruone branch) and Olenguruone (Kaplamai branch) cooperative societies, respectively.

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By virtue of being members of the cooperative societies and the centers being a source of good market price for milk, the collection and bulking of milk was considered important in these study regions.

Milk quality assessment

Milk quality assessment was not done at the farm level. The farmers reported just checking for any objectionable smells, particles and abnormality of colour in raw milk. Most of the commonly performed quality-control tests carried out at collection centers were the alcohol test and lactometer test. It was reported during the interviews that these two tests were effective, rapid and required minimal resources to carry out. Resazurin test was only carried out in Olenguruone Dairy Cooperative Society collection center that had the required laboratory equipment. Testing of milk using 68% alcohol was done in all the dairy societies. The milk processing plants that collected milk from the dairy cooperative societies dictated the alcohol concentration used for carrying out an alcohol test. It ranged between 72% and 80%. Physico-chemical composition and safety (microbial load) of both accepted and rejected milk were not determined. Table 1 shows quality control tests performed at the selected milk collection centers (dairy societies). Based on the quality control tests carried out, larger volumes of milk were rejected during the rainy season in the peri-urban region (Table 2 and Table 3). The respondents at the dairy cooperative societies listed adulteration, poor hygiene and mastitis as the main reasons for milk rejection. Other causes were delay by the processors in collecting milk and lack of cooling facilities, which led to milk spoilage. The farmers whose milk was frequently rejected were stopped from further deliveries and advised to seek professional advice on how to improve milk quality. Their milk was accepted after it was certified to be fine.

Figure 2:Filling alcohol gun with alcohol

Figure 3: Scooping milk to be tested

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Figure 4: No coagulation observed

Figure 5: Coagulation observed

The alcohol test carried out does not measure the number of bacteria present in milk but rather the concentration of acidic compounds in milk. A high acidity implies a high lactic acid content which, in turn, could imply a high bacterial count [21] or a high solid contents in milk. Generally, the assessment of raw milk quality cannot be defined based on one or two variables. If a high bacterial count is suspected, the milk should not just be rejected or diverted to other users until the presence of high bacterial count has been confirmed by approved methods such as Standard Plate Count or Direct Microscopic Count [1]. Bacterial quality of raw milk must be monitored since high-quality milk is in the best interest of all segments of the dairy industry. Thus, the use of milk acidity measures such as the use of alcohol test to grade and reject milk is not sufficient for quality control. More tests like resazurin were required for quality control.

Utilization of milk in farmer households and collection centers

Once milk had passed the platform tests at the collection center, it was stored in the cooler (storage tank) awaiting collection and transportation to the processing factories. The rejected milk was returned to individual farmers or transporters. Most of this milk was fermented naturally, that is, stored in containers and left to ferment for 2 to 3 days, to make traditional fermented milk. Majority of the farmers in both the study regions (60%) developed fermented milk from this milk. Other farmers (15%) reported disposal of the milk, while others (25%) fed it to animals and/or sold it to neighbours. There was a difference in the utilization of rejected milk between the peri-urban and rural regions. Majority of farmers (80%) in the rural region mostly disposed the rejected milk and some reported feeding it to animals (20%). Besides the use of good quality milk to make tea and drinking it as boiled raw milk, traditional fermented milk was a preferred form of milk consumption in the households. Evening milk was mostly used for the production of this kind of fermented milk, particularly in the rural regions. In the peri-urban region, the evening milk was preserved by storing it in aluminium cooking pots that were placed in cold water, then taken to the collection center in the morning or utilized within the household. The extension workers reported offering safety and quality training as far as hygienic raw milk production and handling is concerned. Training to the persons who prepared milk products, mostly the fermented milk, was

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minimal. The home-made fermented milk was produced based on indigenous knowledge and empirical processes without standard procedures or investigation of the steps that occur during the entire process. Traditional fermented milk, *mursik,* developed in the rural region was different from that made in the peri-urban region. *Mursik* is a traditional fermented milk variant of the Kalenjin people of Kenya. It can be made from cow or goat milk and is fermented in a specially made gourd calabash locally known as a *sotet*. Locally made fermented milk in the peri-urban region did not constitute the use of the specially made gourd calabash but plastic containers.

Influence of milk handling containers on raw milk shelf life

The commonly used milk handling and storage containers were plastic containers. Results of the experiment set up to compare milk-keeping quality in the commonly used containers indicated that milk in the plastic container took the least amount of time to fail all the three tests carried out. Table 4 shows the initial and final test results for titratable acidity, alcohol and resazurin test. Lactic acid values of 0.17, 0.175, 0.23 and 0.195 indicated developed acidity in the milk. Failed alcohol test was indicated by milk coagulation as shown in figure 5. For the resazurin test, the quality of the milk was judged by noting the degree of colour change from blue through mauve, purple, pink, and finally colourless. Final colour change to pink and white as shown in table 4 indicated poor quality milk.

Milk in the plastic container placed in the open, under a shade also took the least amount of time to fail all the three tests carried out. Figure 6 shows time taken for milk in containers placed in the open to fail tests and test results, respectively.

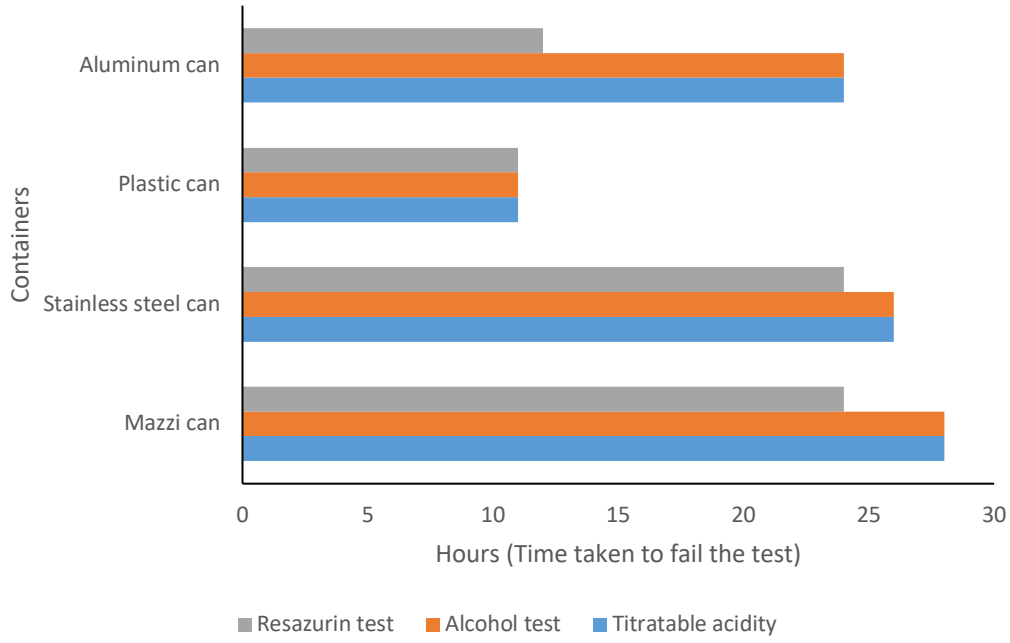

Figure 6: Time taken for milk in the different containers to fail tests (Containers in the open)

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The use of plastic containers for milking and storing milk increased the likelihood of milk rejection by three-fold. These containers were significantly associated ($p<0.05$; Odds ratio =3.20) with milk rejection. Commonly used containers included the plastic containers, mazzi cans (recommended food-grade container), aluminium cans and stainless-steel cans. The utilization of the recommended food-grade container was reported to be hindered by some factors including transporters' preference, where the plastic containers were most preferred, because they were lighter to carry than the stainless steel and aluminium cans. The terrain (bad road network) also contributed to plastic containers' preference, since they could be closed tightly compared to the aluminium and stainless-steel cans that were loosely covered leading to milk spillage. The mazzi can (recommended food-grade container) came in small carrying capacity of a maximum of 10 liters, a great disadvantage to the transporters who preferred to carry a large volume of milk using the 20 liters' plastic containers in one trip. Another factor was that most of the farmers used plastic containers in the pretext that they were more affordable while at the same time they knew the importance of using aluminium containers. The common practice of use of plastic containers was unhygienic because these containers could not be thoroughly cleaned. This was due to the difficult- to-clean areas that haboured micro biofilm in plastic containers. These areas were situated around the container handle and neck (Figure 7). According to Orregård [23], plastic jerry cans are impossible to clean and are often used for transporting milk by most motorcycle transporters. This results in a less hygienic handling compared with the use of aluminum cans whose only limitation is the acquisition cost. This is in line with Gemechu *et al.* [24] who found out that milk producers use plastic containers which are difficult to clean and disinfect and thus, it might contribute to poor quality of the milk.

Figure 7: Plastic container

Milk quality testing at the collection centers and farm level

68% Alcohol Test results

Of the pooled milk samples collected at the collection centers, 44 were positive on 68% alcohol test, converting to an apparent milk rejection prevalence of 24.9% (44/177). A total of 26 pooled milk samples (14.7%) were positive on both 68% alcohol and California Mastitis Test (CMT). More milk samples from the peri-urban region tested positive for both 68% alcohol and California Mastitis Test, compared to the rural region.

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Sub-clinical mastitis evaluation

Of the pooled milk samples taken at the collection centers, 16.9 % (30/177) were positive on CMT. Positive results on CMT testing varied from traces to strong positives. Samples with CMT scores of positive 2 and 3 did not have any definite visible changes like clots. This was because farmers usually sieve their milk before delivering it to the dairies, hence low chances of seeing any changes in milk at delivery. Out of the 177 farmer households visited, one cow per household was sampled for sub-clinical mastitis using CMT testing. About 60% of these cows (106 of 177) tested negative on CMT. Of the positive quarters tested 19%, 15%, and 6% were Trace, 1+, and 2+, respectively, on the CMT scale. Therefore, based on the CMT screening test, quarter-level prevalence of sub-clinical mastitis was 40% (283 of 708). More farms and collection center milk samples from the peri-urban region tested positive for CMT compared to the rural region.

Comparing Alcohol Tests (80% and 68%)

Kappa test was used to compare these two tests (68% and 80% Alcohol tests) and it usually incorporates the observed level and expected (chance) level of agreement. Calculations are as described by Martin *et al.* [25].

Dairy cooperatives use 80% ethanol concentration to test for milk acidity levels in order to reject or accept delivered milk. Kenya Bureau of Standards (KEBS) has, however, set the standard at 68% ethanol concentration. Out of the 90 milk samples collected, 70 and 54 tested positive, while 20 and 36 tested negative at 80% and 68% alcohol concentrations, respectively. The apparent prevalences were 0.78 and 0.60 for the 80% and 68% alcohol tests, respectively.

Some of the milk samples testing positive to alcohol test were likely due to sub clinical mastitis and unhygienic milk production and handling practices at the farm level. Abnormal milk such as colostrum, milk from diseased udders and from diseased cows, also produced a precipitate with.

In the comparison of tests (68% and 80% Alcohol tests), a Kappa of at least 0.4-0.5 indicates a moderate level of agreement [25]. In this case, the Kappa test result was 0.4 therefore indicating moderate level of agreement. This meant that both tests were agreeable and could be used for milk rejection without any bias. The processing plants dictated the alcohol percentage, which was usually between 72% and 80%. Some of the reasons for this included, the collecting milk of higher quality which could be processed into liquid milk, used to manufacture other milk products and also to reduce the rate of milk spoilage. During the rainy season when milk production was high, a higher alcohol concentration was used to control the amount of milk collected.

Multivariate analysis

Out of all the studied farmers and collection center characteristics (risk factors), only four had a P-value <0.05, hence included in a logistic regression model. The four comprised use of reusable towels, plastic containers, CMT positive samples and lack of testing of milk for mastitis at farm level. Use of plastic containers and CMT positive milk were the significant variables that explained the occurrence of milk rejection in

the collection centers both at the rural and peri-urban study regions ($p<0.05$). Farmers who used plastic containers for milking were approximately three times more likely for their milk to be rejected compared to those who used aluminium/stainless steel containers ($p<0.05$; Odds ratio =3.20). Farmers whose bulk milk was CMT positive were also three times more likely to have their milk rejected ($p<0.002$; O.R = 2.9) as compared to those whose milk was CMT negative.

The associations between milk rejection and milking practices were determined. Milk rejection by use of 68% alcohol test was significantly ($p<0.05$) associated with CMT positive milk and type of milking container. The use of reusable towels to clean the udder was also significantly associated with milk rejection ($p=0.051$). Cloth towels have the advantage of being more absorbent than paper towels, but should be disinfected by washing with chlorinated water or very hot water and dried at high temperature [26]. In this case, the use of reusable towels was significantly associated with milk contamination. The presence of moisture was an important growth requirement for bacteria and wet towels did not adequately remove moisture [27]. The use of the same cloth in different milking cows could also lead to building up of dirt and bacteria hence milk contamination.

CONCLUSION

Many transportation hours and uncooled conditions under which milk was transported led to deterioration of milk quality. The main reasons for milk rejection were sub-clinical mastitis and milk testing when subjected to 68% alcohol test, indicating poor milking practices like unhygienic milk handling techniques at the farm level. Other reasons contributing to milk rejection were adulteration and lack of cooling facilities both at the farm and cooperative level.

The physico-chemical composition and chemical safety of the milk that failed the alcohol test was not understood since no analysis was being done with this respect. This might have led to disposing off milk that could be diverted to other usage. The study, therefore, concluded that determining safety and physico-chemical quality of the rejected milk was important.

Raw milk quality could not be defined based on a particular variable. Quality referred to factors such as flavour, solids level, freezing point, absence of antibiotics and other inhibitory substances, somatic cell content and sediment content. Quality also referred to the magnitude of the microbial population and to the types of organisms present. Thorough quality assessment involving the determination of all these factors, would ensure only good quality milk was collected for processing. This could be only achieved, if support was given to the collection centers so that they are able to procure the equipment needed to perform sufficient raw milk quality analyses. A test like resazurin which was essential in determining microbial activity hence microbiological quality would then be regularly carried out in all milk collection centers. The results of the resazurin test might be used to pay farmers for microbiological quality. Education programs and seminars on milk safety and quality should be regularly provided to both

collection centers' operators and farmers including those involved in products development.

For the milk to pass the 80% alcohol test, hygienic practices both at the farm level and at the cooperative societies should be improved to meet the standards set by the processors and hence reduce the rate of milk rejection. Extension services to the farmers focusing on the production of high-quality milk through the efficient cleaning of vessels, hands, udder and the housing are recommended.

Milk quality deteriorates faster for milk handled in plastic containers than in stainless steel, mazzi and aluminium containers. The resulting milk post-harvest losses can be avoided through education and promotion of the use of food-grade milk containers.

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Table 1: Milk quality tests performed in the selected dairy societies

Name of the collection center	Organoleptic test	Alcohol test	Lactometer test	Clot on boiling test	Resazurin test
Wanyororo Dairy Cooperative Society	Yes	Yes	Yes	Yes	No
Olenguruone Dairy Cooperative Society (Olenguruone)	Yes	Yes	Yes	No	Yes
Olenguruone Dairy Cooperative Society (Kaplamai)	Yes	Yes	Yes	No	No

Table 2: Monthly amount of milk that fails tests performed and frequency of milk rejection

Name of the collection center	Amount of milk that fails tests (Liters)		Frequency of milk rejection.	
	Rainy season	Dry season	Rainy season	Dry season
Wanyororo Dairy Cooperative Society	50[a]	20[a]	Weekly	Monthly
Olenguruone Dairy Cooperative Society (Olenguruone)	100[b]	150[b]	Weekly	Weekly
Olenguruone Dairy Cooperative Society (Kaplamai)	5[b]	10[b]	Monthly	Weekly

Mean values in the same row with the same letter are not significantly different

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Table 3: Monthly percentage milk losses at the various milk collection centers

Name of the collection center	Milk losses (%)	
	Rainy season	Dry season
Wanyororo Dairy Cooperative Society	0.41%	0.17%
Olenguruone Dairy Cooperative Society (Olenguruone)	0.12%	0.18%
Olenguruone Dairy Cooperative Society (Kaplamai)	0.04%	0.08%

Table 4: Results of titratable acidity, alcohol test and resazurin test in the various milk containers monitored in the laboratory

CONTAINER	**TEST PERFORMED**	**Initial test results (reading)**	**Final test results (reading)**
Mazzi can	Titratable acidity (lactic acid)	0.13	0.17
	Alcohol test	Pass	Fail
	Resazurin test	Purple colour	Light pink colour
Stainless steel can	Titratable acidity (lactic acid)	0.13	0.175
	Alcohol test	Pass	Fail
	Resazurin test	Purple colour	White colour
Plastic can	Titratable acidity (lactic acid)	0.13	0.23
	Alcohol test	Pass	Fail
	Resazurin test	Purple colour	White colour
Aluminium can	Titratable acidity (lactic acid)	0.13	0.195
	Alcohol test	Pass	Fail
	Resazurin test	Purple colour	White colour

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