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Hygienic practices and critical control points along the milk collection chains in smallholder collection and bulking enterprises in Nakuru and Nyandarua Counties, Kenya

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Dairy value chains link the actors and the activities involved in delivering milk and milk products from production to the final consumer. In every activity, the product increases in value from production, transportation, processing, packaging and storage. The study was designed to evaluate some hygienic practices along the value chain and develop the quality control system (CCPs) in the smallholder supply chain in Nakuru and Nyandarua County, Kenya. To assess the level using critical control points of compliance to hygienic code of practice, the questionnaires were developed and pre-tested before being administered to the selected individuals in the study. Descriptive statistics was used to depict the implementation of the code of hygienic practices in milk handling by the farmers, transporters, collection and bulking enterprises (CBEs) and the processor. Among the various aspects investigated at farm level in this study was, hand washing before milking, use of reusable udder cloth while milking, use of plastic containers in milk delivery, time taken to deliver milk, cleaning of the cow shed and awareness of the antibiotic resides in milk and its effect. The results indicated poor conformance to the hygienic code of practice along the dairy value chain in the smallholder supply system. The various factors that could contribute to raw milk quality deterioration were identified as, the critical control points (CCPs) using the hazard analysis critical control points (HACCP) principles. Seven factors were identified at five critical points along the milk collection chains. The critical control points identified includes milking at the farm level, bulking milk in a fifty liters can at collection points, transportation, at the CBE platform and the cooling tank. The quality of raw cow's milk produced and marketed from the study areas was low.

Key words: Collection and bulking enterprise (CBE's), critical control points, hygienic practices and smallholder supply chain.

INTRODUCTION

Like much of Africa, milk production Nakuru and Nyandarua County, Kenya, is heavily dependent upon smallholder production. The dairy cow is one of the most important investments a farmer can make to improve their living standards because of their inherent value, the nutritional value associated with milk produced and diversification farming activities (FAO, 2011). Kenya`s dairy production sub-sector is dominated by the smallholder dairy farmers who keep an estimated 3.5 million dairy cattle and produce approximately 5 billion litres of milk annually, therefore leading milk producer in the East Africa region (Muia et al., 2011).

According to Muriuki (2011), the dairy production systems differ in their sizes of operation, level of management and use of inputs and therefore can be classified as large, medium or small scale. Dairy production is dominated by smallholders who own about 98% of the total dairy herd (Peeler and Omore, 1997). Smallholder dairying households estimated to number over 1.5 million households, account for more than 85% of the annual total milk production and 80% of the 1.8 billion litres of milk marketed annually (MoL and FD, 2003; Staal et al., 2001). The smallholders practice zero and semi zero grazing in 3 to 5 acres of land and have about 2 to 5 cattle, each yielding an average of 5kgs of milk per cow per day. The dairy processing sector creates an average of 13 jobs for every 1 000 litres of milk handled while the informal sector accounts for about 70 percent of total jobs in dairy marketing and processing which is an estimate of about 18 employment opportunities for every 1 000 litres of milk a day handled through the informal channel (Muriuki, 2011). Kenya's dairy industry is dynamic and plays an important economic and nutrition role in the lives of many people ranging from farmers to milk hawkers, processors, and consumers. Kenya is generally self-sufficient in milk and dairy products.

However, the demand for milk and dairy products in developing countries is estimated to increase 25% by 2025 (Delgado et al., 1999), mainly due to human population growth, further urbanization, increased disposable income, greater diversity of food products to meet nutritional needs, and increased opportunities for domestic and external trade. According to Muriuki (2011), the dairy sector creates employment to around 900,000 citizens in total at different stages i.e. at farm level, at the milk handling level and at processing level in the value chain. A value chain describes the chain of steps as a product, like fresh milk, passes along from production to retail down to consumption, considering the various people, places and inputs involved in this process. Poor hygiene at any point from production to consumption can jeopardize final product safety, hence, analogous to Hazard Analysis Critical Control Points (HACCP), a value-chain approach is required to assess, understand and improve food safety (Roesel and Grace, 2014).

Fresh milk is often sold unpasteurized to the public either directly from producers, via informal markets or through dairy farmer cooperatives. Resources are extremely limited and smallholder production is under-developed with low levels of hygiene and productivity. Dairy value chains link the actors and activities involved in delivering milk and milk products to the final consumer where, with each activity the product increases in value. Activities which require inputs including financing and raw materials are employed to add value and to transport dairy products to consumers. Every actor of the chain should give the product the maximum added value at the minimum possible costs (FAO, 2011), the same time ensuring hygienic handling. Therefore, the dairy industry plays a vital role in food security and enhances the livelihoods of all its stakeholders (Bebe, 2003). Milk safety is crucial for both public health and farmer income, with consumers paying more for safer food (Jabbar et al., 2010; Roesel and Grace, 2014). Furthermore, improved hygiene reduces spoilage and wastage benefitting producers, traders and consumers. When untreated fresh milk is kept at ambient temperature it rapidly turns into sour milk through proliferation of lactic acid producing bacteria (O'Connor and Tripathi, 1992). Furthermore, improved hygiene reduces spoilage and wastage benefitting producers, traders and consumers.

Despite this high volume of production and the extensive formal marketing network in Kenya, estimates show that currently approximately 85 to 90% of marketed milk is not processed or packaged, but instead is bought by the consumer in raw form. The factors driving the continued importance of the informal market are traditional preferences for fresh raw milk, which is boiled before consumption, and unwillingness to pay the costs of processing and packaging. By avoiding pasteurizing and packaging costs, raw milk markets offer both higher prices to producers and lower prices to consumers (Thorpe et al., 2000). The informal market has one main advantage over its formal counterpart; the informal market is a cash-based market, with producers being paid immediately for their goods. Within the formal chain, farmers can wait up to a month to receive payment for their milk. Therefore, smallholder farmers who are largely facing immediate cash flow need the informal market which provides an advantage (EADD, 2008). Tremendous growth in the informal milk trade was realized after milk market liberalization in 1992 which comprised of small scale operators dealing in marketing of raw milk including direct sales to consumers, hawked milk sold by mobile traders, shops and kiosks, and co-operative societies (Muriuki, 2011: Wambugu et al., 2011) and recently milk bars.

Setting up an efficient, hygienic and economic dairy chain is a serious challenge in many developing countries. Among the reasons for this are; difficulties in establishing a viable milk collection and transport system

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Table 1. Population of farmers in two CBEs in Nyandarua and Nakuru County respectively and their sample sizes.

Name of CBE	Target population of farmers (active members)	Sample size of farmers
Ngorika	600	234
Olenguruone	1600	310
Total	2200	544

because of the small quantities of milk produced per farm and the remoteness of production sites, seasonality of the milk supply, poor transport infrastructure, deficiency of technology and knowledge in milk collection and processing, poor quality of the raw milk, distances from production sites to processing units and on to consumers and difficulties in establishing cooling facilities (FAO, 2011). Normally, milk needs to be cooled within 2 to 4 h from milking. The main characteristic of the supply chain is the poor cold chain which lowers the quality of processed milk and prevents processors from producing long life products that need the high quality input. Since milk collection is conducted only in the morning, evening milk in particular is of poor quality when received by processors and hawkers the following morning (EADD, 2008). Milk safety is enforced through food safety standards and regulations, the main ones of which are the Dairy Industry Act (CAP 336) and the Public Health Act (CAP 242).

Milk handling equipment is one of the most significant sources of microbial contamination in milk. Moreover, if equipment is inadequately cleaned and milk residues are left on wet surfaces it will result in microbial growth, which could contaminate the milk. According to Orregård (2013), plastic jerry cans are impossible to clean and are often used for transporting milk by most motor bike transporters. This result in a less hygienic handling compared with the use of aluminum cans whose only limitation is the acquisition cost. Plastic jerry cans can contribute to milk quality deterioration. This is in line with Gemechu et al. (2015), 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. The collection and bulking enterprises (CBE's) critical quality control challenges in line with, milk bulking are; adulteration (both water and preservatives) of high bacterial load due to warm collection, potential for contamination with coliforms due to handling, presence of anti-microbial residues and zoonotic diseases like tuberculosis and brucellosis (Muriuki, 2011). Owing a large amount of milk that is marketed unprocessed and a weak monitoring of the market, public health risks are concern. The main public health concern is the potential risk of diseases such as brucellosis and tuberculosis (TB). Drug residues are also of concern, even in the processed milk channel. This study was carried out to investigate whether the code of hygienic practices requirements was being followed at the same time identifying the critical control points at several levels in the value chains.

MATERIALS AND METHODS

Study site

The study was carried out at New Ngorika Milk Producers Limited (Ngorika) in Nyandarua County, Olenguruone Dairy Cooperative Society (Olenguruone) and Happy Cow Limited-Kenya (HC) both in Nakuru County. The two societies are well established smallholder dairy farmers cooperatives which, supply milk to Happy Cow Limited-Kenya. For both CBE's milk from individual farmers is collected and bulked into milk-cans while warm and transported to the CBE cooler. Milk collection points are not well established and therefore milk collection takes an average of 6 h to complete the exercise.

The mode of transportation consist trucks, tractors with trailers, donkeys and motor bikes. Milk is collected in the morning with some farmers offering their evening milk separately along the routes.

Study design

Descriptive statistics was used to depict the implementation of the code of hygienic practices in milk handling by the farmers, transporters, CBEs and the processor. In order to generate the required sample units, the determination of sampling frame was essential. Simple randomization procedure was used in sample selection of the farmers in the identified populations. The sample size of the study was 544 active members from the two CBEs according to Sample Size Determination Table by Krejcie and Morgan (1970), at an alpha level 0.05 and a t-value of 1.96.

To develop the quality control system, several visits were done to the CBE's collection chains, noting the various shortcomings that could contribute to quality deterioration. The target population of the study was 2,200 farmers from the two selected CBE's (Table 1).

Data Collection Procedure

The questionnaires were developed, pre-tested and administered to the selected individuals in the study. The researcher in person visited the CBEs and contacted milk chain coordinators to help in distributing the questionnaires to the sampled farmers for filling. Use of questionnaires made it easy in the process of data collection, as all the selected respondents were reached in time. During the distribution of the instruments, the purpose of the research was explained.

Hazard analysis

Quality deterioration factors were identified by observation of

Table 2. The control level and likelihood of occurrence in risk assessment.

		Level of control		
		1 (Low)	2 (Moderate)	3(Severe)
Likelihood of occurrence	1 (Low)	1	2	3
	2 (Moderate)	2	4	6
	3 (High)	3	6	9

activities in the collection chain. The HACCP principles were employed to identify the quality deteriorating factors along with the value chain as the hazards. Table 2 was used as a key in determining the level of risk at happy cow HACCP documentation. The decision made at a certain level of risk was classified in three stages. They included; 1 to 2 where the impact was termed as negligible, 3 to 4 where the impact was referred as minor and 6 to 9 where the impact was major. The first two stages were defined as the pre- requisite programs while the last stage was defined as critical control points. According to Codex Alimentarius (2003), a decision tree was used to classify the factors as prerequisite programs or critical control points. This was to facilitate a quality control system that would curb quality deterioration at all levels in the dairy value chain.

Statistical analysis

The questionnaires were first edited and coded to ensure completeness and accuracy. The data was analyzed through the use of descriptive statistics analysis. The Statistical Package for the Social Sciences SPSS (Statistical Package for Social Sciences) version 22 (SPSS Inc., Chicago IL, USA) was used for statistical analysis to depict the implementation of the code of hygienic practices.

RESULTS AND DISCUSSION

Dairy farmers and transporters hygienic practices

The poor state of the roads was evident from this study since only 30% of the households had access to good roads and hence, could purchase inputs and market their farm produce throughout the year. During the rain seasons, most of the roads were impassable particularly in the upper highlands with firm clay and clay loam soils hence farmers were unable to sell their farm produce. Due to the poor road network and long distance to markets, cost of transportation was high rendering smallholder dairy production uncompetitive. Most of the milk produced during the wet season was not marketed due to the poor road network and long distance to the markets. Since milk is highly perishable and farmers did not have the means to invest in milk cooling equipment, the high volumes of milk produced during the wet season were therefore associated with high-post harvest losses. Only about 35% total milk production was marketed through the formal sector which is considered by farmers to be more reliable in terms of milk prices and payments for milk delivered than the informal sector.

The transportation of milk depends on the amount and the buyer. Major processors have their own collection, bulking and transportation systems. Stainless steel (seamless) cans, and occasionally plastic cans, are used for bulking milk from individual suppliers and delivering it to processors' collection, bulking and cooling centers, from where it is transported in cans or by refrigerated tanks to the main processing plants (Muriuki, 2011). In some areas, powerful milk intermediaries (traders) have positioned themselves between, the market and the milk producers. Their presence complicates the traceability of milk and brings a risk of cross-contamination and microbial overload (Muriuki, 2011). Kenyans appear to prefer raw milk. Estimates from various studies indicate that about 85 percent of marketed milk is sold raw. Recently, the Kenya Dairy Board (KDB) and others in the formal milk trade have claimed that the proportion of processed milk has increased to more than 20 percent (Muriuki, 2011).

Farmers should maintain elaborate farm hygiene in the milking parlor and sheds to ensure clean milk production (Gietema, 2002). This will facilitate maintenance of a healthy herd. Results on dairy farmer's hygienic practices (Figure 3) indicated that, 49% and 51% of the farmers in Olenguruone and Ngorika respectively did not use detergent when washing their hands prior to milking. Similarly, during transportation, poor milk handling hygiene was observed with at least 20% of the transporters from Ngorika, failing to wash their hands before handling the milk along the routes. Milking management and hygiene protocol are important to milk quality because they minimize transmission of mastitis in farms. The quality of milk is refers to milk that is free from pathogenic bacteria and harmful substances, sediment and extraneous substances, of good flavor, with normal composition, adequate in keeping quality and low in bacterial counts. Main factors that determine the quality of milk include microbial results such as somatic cell counts and bacteria contents. However, other factors like added water and solids, percentage of fat and protein, as well as antibiotics and pesticide residues, are important to producers, processors and consumers as well.

Nevertheless, 50.6 and 49.4% of the farmers in Olenguruone and Ngorika respectively, used a reusable udder cloth while milking their animals. The same udder cloth was used to dry their hands before milking. This compromises hygiene milking practices and may

Figure 1. Milk bulking at a collection point.

Figure 2. Milk transportation.

contribute to cross transmission of mastitis from an infected cow to a healthy cow. After milking, 50% of the farmers held the milk on their farms to attend to other chores in both locations. Farmers took an additional 30 min to deliver their milk to transporters at 49.2% and 50.8% in Olenguruone and Ngorika, respectively. Milk, either raw, fresh or in its various products forms gets spoilt due to poor handling and lack of cooling facilities. This additional time contributed to delays in milk delivery to the chilling plants in both CBEs. Further delays were observed during transportation where 60% and 40% of the transporters in Ngorika and Olenguruone, respectively, took more than 2 h to transport the milk from the farms to the CBEs cooling plants. Milk quality control tests were not carried out by the transporters before bulking the milk at the farm levels. This was because 60% of the milk handlers from Ngorika and 100% from Olenguruone had no basic training in milk handling and hygiene. The mixing of good and lower quality milk from different suppliers without grading led to milk quality deterioration. Plastic containers are not ideal for milk handling since they are impossible to clean.

However, the study found that 90.4% and 49.6% of the farmers in Olenguruone and Ngorika, respectively, delivered their milk using plastic containers owing to their availability and convenience (Figure 1). The milk transport modes used included; donkeys, motor bikes, lorry, pickups, tractor and individual farmer deliveries. In Ngorika, milk transportation was done using aluminum cans though their cleaning was not properly done while in Olenguruone, all the transporters used plastic containers (Figure 2). Cleaning of the plastic jerry cans involved use of hot water and detergent although its effectiveness was not evaluated. In Western Zambia, Knight-Jones et al. (2016), reported that cows were milked once a day where the time of milking varied. Milk was delivered to the cooperative immediately after milking. Milking took 35 to 90 min by hand into a bucket (plastic, metal or traditional wooden). Milk was then poured into plastic or metal container that could be sealed, mostly through a muslin cloth or a sieve, which was always rinsed between cow's. Unlike plastic buckets and containers, metal buckets and containers were designed for handling milk.

Although, contamination of the pooled herd milk with cattle hair was not seen, some visible dirt contamination was observed in 56% farms. Milking was done by one or more herd boys. Hand washing at milking was not done on farms (33%), and was subjectively scored as relatively good for one (14%) and moderate for farms (33%). However, soap was not used and the water was, untreated surface water from the wetlands. This water was also used to rinse milking equipment (bucket and sieve) at the start and end of milking.

According to Mwangi et al. (2000), use of plastic containers contribute to milk quality deterioration since they are impossible to clean especially around the handles that are not accessible during cleaning. According to Orregård (2013) study, quality analysis of raw milk along with the value chain of the informal milk market, use of aluminum cans is a more appropriate method of milk transportation unlike plastic containers. Also, he concluded that containers used in the milk value chain contribute eminently to milk contamination. Use of plastic containers, lack of cooling before delivery and long duration in transportation favours quick bacterial multiplication (Swai and Schoonman, 2011). Moreover, the later authors reported that, two-thirds of farmers transport milk to cooperative by bicycle (one sometimes used the bus), motorbike or boat and a taxi. Journeys times varied from 30 to 120min. Time from the start of

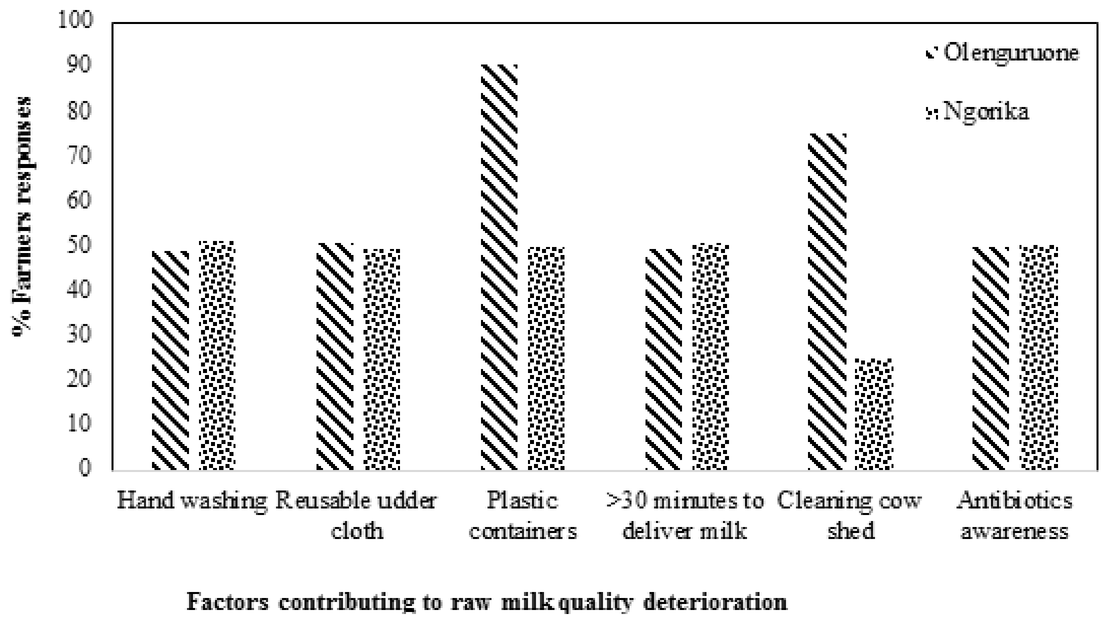

Figure 3. Dairy farmer's practices contributing to raw milk quality deterioration observed at the farm level.

milking to refrigeration upon arrival at the cooperative ranged from 100 to 223min.

Farmer's awareness concerning antibiotic residues in milk was found to be at 49.7% and 50.3% for Olenguruone and Ngorika, respectively. Additionally, half of the farmers in both CBEs were not aware of the effects of antibiotic residues in milk quality, the withdrawal period required for various antibiotics and their effects on human health. These results was compare to those of Orregård (2013), where farmers did not understand about antibiotic residues and their effect on milk quality. The same author concluded that, antibiotic residues in milk can be traced exclusively from the farms. Further findings from Aboge et al. (2000), indicated that to eliminate the challenge of antibiotic residues in milk, care should be taken at both the farm and market level.

Milk handling and preservation at the CBEs

Personnel handling the milk at the cooling plants were qualified for dairy technologist in both CBEs. Cleaning of the cooling tank was done immediately after emptying the milk to the tanker. This compares to a study done by Pandey and Voskuil (2011), which recommends that, the cooler must be cleaned, disinfected and kept in good condition after each milk collection. Maintaining hygiene in Ngorika cooling plant premise is easy. On the other hand, Olenguruone cooling plant premises was a semi-permanent building with a rough floor which compromised on hygiene. Milk at the reception platform was handled in a quality compromising situation. Dirty residues trapped by the muslin cloth used for sieving milk

Figure 4. Milk emptying from the dump tank.

were observed (Figure 4). The tippers at the reception platform (Figure 5) had dirty hands. Rain and borehole were the available sources of water. This water was not treated before use, a factor that could contribute to milk quality deterioration. Ideally, milk should be cooled within 2 to 3 hours after milking. This Quality affects both the processed and cold channel chains. However, the cold channel chain is associated with more issues than the processed one. Although standards for milk and milk products exist in the legal framework, low quality

Figure 5. Hands used in tipping the milk.

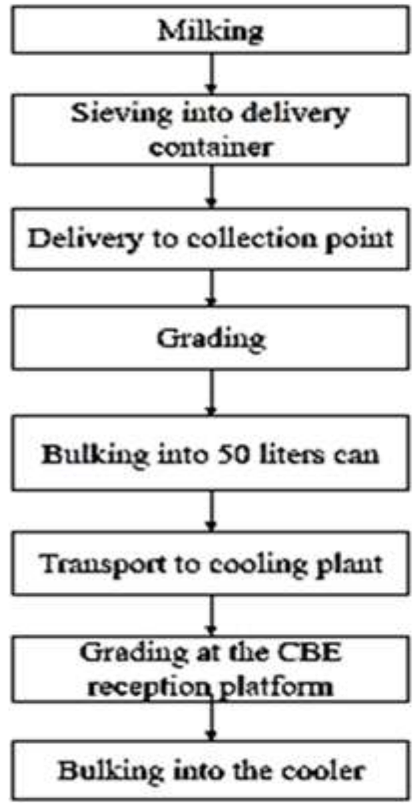

Figure 6. Flow diagram of steps for raw milk collection to cooling plant.

milk/milk products continue to find their way to consumers largely, due to low compliance by processors and traders; and poor enforcement of regulations by those charged with enforcement. While consumer awareness of standards as well as the health effects of low quality milk, which is likely that human as well as technical capacity that enforces the standards is lacking. Moreover, due to technical and cost issues, consumers are unable to seek legal redress where necessary (SNV, 2013).

Contrary, in both CBEs some milk delivery exceeded the recommended time which had a negative impact on milk quality. The cooling efficiency in both CBEs was a challenge. The coolers took more than 3h to cool the milk from 18 to 4°C. The study found that monitoring of the cooler efficiency to prompt maintenance and repair was hardly done. For instance in Olenguruone, it was done after 3 months or during breakdowns. According to Pandey and Voskuil (2011), milk must be cooled immediately to minimize bacteria multiplication and this should be protected from contamination during transportation and subsequent storage. Poor quality milk cannot be improved by cooling at a later stage (Orregård, 2013), therefore there is a need to improve and hasten the raw milk collection system.

Milk handling at the processor level

At the reception platform at Happy Cow Limited, quality control personnel cleaned exit where the milk was to be emptied before connecting the pipes. The quality control personnel are dairy technologists. A sample was then drawn from each compartment separately for quality analysis (% lactic acid, alcohol test, lactometer test, total plate count, 10 minutes Resazurin test and antibiotic residue delvo test). There was no temperature variation observed in the milk after transportation from the CBEs. The tanker was cleaned immediately after emptying the milk. The concentrations of the cleaning detergents used in the tankers were checked before each cleaning procedure in contrast to the practice in the CBEs where the concentration was never checked. Borehole water for general cleaning was treated with 3ppm chlorine while that used for sanitation was at 300 ppm. This showed that the milk processor was careful on matters of regarding milk quality and handling hygiene.

Identification of quality control CCPs

Characteristics of raw milk

During the field visits, eight steps were identified and listed in a flow diagram (Figure 6) to illustrate the occurrence of activities in the delivery of milk from the farm to the cooling plant. The steps involved three participants including farmers, transporters and graders. The farmer handles the milk from milking to the collection point where the transporter collects the milk, bulks and transports to the cooling plant. Subsequently, the milk is graded at the CBE platform and bulked in the cooler by grader.

Milk delivered at the collection chain had a lot of foreign material for instance cow dung, fir and organic matter. Contamination of milk with dirt will most likely occur at the farm level where poor and careless handling can allow mud, dung, dust or other contaminants within the milking area to enter into the milk. The dirt could have originated from poor milking procedure and failure to sieve the milk before delivery. A critical hazard to milk chain is the bacteria especially excessive load of bacteria or presence of the pathogenic ones. Most of the hazards explained above can be the source of excessive bacteria load or pathogenic bacteria in milk. A common way through which to introduce pathogenic bacteria in milk are frequent milk transfers by the market agents, contact with unclean surfaces and unclean handlers. This can happen at farm and market level, when apportioning and transferring milk from milking containers to other containers. Contamination is also most likely to occur at different market level, when transferring milk between traders and where bulking occurs. Presence of foreign material contributes to the increase in microbial contaminants, objectionable odours and appearance. Failure to observe the withdrawal period after treating the animals at the farm level will allow introduction of antibiotic residues into the milk. Critical points for antibiotics or antimicrobials are at the farm level due to none compliance with drug manufacturers withdrawal recommendations and at the market level where it has been alleged that some traders add antimicrobials in the milk to increase its shelf life.

Antibiotic residues in milk is a chemical hazard to milk consumers due the allergic reactions and development of antibiotic resistance in human. Addition of water or adulteration of milk can occur at the farm and at the market level accidentally or deliberately to increase the volume and earn more cash. At the market level, this can happen when raw milk traders may want to stretch their profitability. Adulteration with water and preservatives could be done by farmers/herders, although during transportation; chances of adulteration are also likely. These malpractices could lead to milk safety and quality concerns. The factors affecting milk quality were examined and reported in Table 3 which includes their workable corrective actions.

According to KEBS (2007), milk contains not less than 3.25% milk fat and not less than 8.50% milk solids not fat. This should have a characteristic of creamy-white colour, free from flavours, taints and objectionable matter. This should not clot during boiling and should test negative to the alcohol test. It should not contain added water, preservatives, or other added substances and no proportion of a natural constituent should be removed. The density should be within the range of 1.028 to 1.036 g/ml at 20°C and not more than 0.17% lactic acid. The freezing point depression should be within 0.525 and 0.550°C and it shall conform to maximum limits of pesticides, antibiotic and veterinary drugs residues.

Identification of critical control points

The potential milk borne hazards in the chain include dirt, additions such as water, fats or other solids, excessive load of bacteria and presence of antibiotics. These hazards can enter the milk chain at many points along the market chain, depending on handling and the ethical attributes of the actors along the chain.

The critical control points were identified in line with HACCP principles concept using the deteriorating factors identified above (Table 3). To categorize the factors as prerequisite program or CCP as in Table 4, risk assessment was carried out where the likelihood and severity was considered. The microbial contamination, hydrogen peroxide, cleaning detergents residues, exhaust fumes, organic matter and antibiotic residues were identified as factors with high risk in milk quality deterioration. The decision made at a certain level of risk was determined by likelihood of occurrence and severity. Where negligible, or if impact was minor, it will be controllable at a particular step and records will be kept. If the impact was severe, factor will be considered as CCP and therefore control factor will be determined. Based on the identified CCPs, the corrective actions were established, which would ensure the safety and quality of the milk delivered to the CBEs.

According to ISO 22000: 2005 food safety management systems HACCP has been recommended as one of the most effective ways of ensuring high quality and safe food. According to Mwangi et al. (2000), the HACCP system is a preventive approach that identifies the points in a process which are hazardous to their risk factors and potential level of risk, so that critical control points for remedial action can be implemented. Also, according to FAO/WHO (1998), risk is the likelihood of occurrence and it is a function of likelihood of occurrence and the control level (seriousness level).

The decision tree in Figure 6, assisted in identifying CCPs are as shown in Table 5. This identified 6 out of 8 of the processes as CCPs with a significance of 9. During Poor milking procedures, the health of dairy cows and delayed milk delivery are factors under the jurisdiction of the farmers. As the recommendations are presented in Table 4 outline, farmer’s keenness to hygiene milking and prompt delivery of milk should be emphasized. It was identified that due to low milk production in the farms, transporters had to bulk milk from 6 to 9 farms to fill one can. The mixing of the milk gave chance to mixing good quality and poor quality milk, leading to quality deterioration of the bulk. Due to the modes of transport and poor road networks in the rural areas serving the two CBEs, there was delayed delivery of the milk from collection points to the cooling plant. There were chances

Table 3. List of possible factors contributing to quality deterioration at each step.

Process	Description/Activities	Possible factors and their Sources	Control Measure
Milking	The cow is entered in the parlor and is restrained. Milking takes off.	Physical: Animal fur, dung, personal effects and dirt that may come with the milking procedure. Chemical: Antibiotics, milking jelly, H_2O_2, Somatic cell count. Biological: Bacterial load	Sensitizing farmers on milking hygiene, withdrawal period and mastitis treatment.
Sieving the milk into the delivery cans	The farmer sieves the milk as it's transferred into the delivery container.	Physical: cleanliness of the sieve. Chemical: detergents residues. Biological: microbial contamination	Sensitize the farmers on hygiene.
Transport to collection points	The milk is taken at the collection point.	Biological: microbial multiplication due to time lapse.	Sensitize the farmers.
Grading	The milk is graded at the collection point before bulking into 50 litres aluminum cans.	Physical: introduced. Chemical: H_2O_2, antibiotics	Proper grading, sensitize the farmers.
Bulking into 50 litres aluminum cans	Graded milk is collected into 50litres aluminum cans.	Chemical: detergents residues.	Proper rinsing of the aluminum cans before bulking.
Transport to the cooling center	The bulked milk is transferred to CBE.	Biological: multiplication of the microbes due to time lapse	Sensitization of the transporters.
CBE reception plat form	The milk is graded again for acceptance or rejection.	Biological: microbial growth due to time lapse	Sensitization of the quality control personnel at the reception.
Cooling tank	The milk is pumped into the cooling tank.	Biological: microbial multiplication Chemical: detergents residues, antibiotics and adulterants due to bulking.	Sensitization of all the stakeholders in the value chain.

of adulteration of the milk in transit by unscrupulous transporters. The last CCP was identified as the inefficiency of the cooler which would take long before cooling the milk, gave chance to further multiplication of microorganisms.

From the identified CCPs for each process, measurable parameters to ascertain quality in the delivery chain were identified as outlined in the CCP plan in Table 6. The farmer has to deliver the milk promptly and this will be evaluated by the temperature range of the delivered milk. This is done with the background knowledge that, the faster the delivery the more the milk temperature will near the udder temperatures ranges from 25 to 37°C. The thermometer reading should be carried out at collection points and the farmers are sensitized to adhere to prompt delivery practice. This will eliminate delays in the homes where farmers milk and first attend to other chores. From the transport to the collection point, there were neither measurable parameters nor any corrective action that would be concluded as a CCP.

To ensure bulking of quality milk at the collection points, milk should be tested on density

Table 4. Raw milk quality risk assessment.

Process	Factor		Likelihood (L)	Severity (S)	Risk = L × C	Significance	Recommendation
Milking	Physical: Animal fur, dung, personal effects and dirt.		3	3	9	CCP	Sensitize farmer, milkers on clean milk production
	Chemical	H_2O_2	1	3	3	PRP	Reject milk with H_2O_2
		Antibiotics	3	3	9	CCP	Sensitize farmers on the withdrawal period.
	Biological	Somatic cell count	3	3	9	CCP	Sensitize farmers on animal husbandry
		Microbial load	3	3	9	CCP	Clean milk production and delivery time
Sieving the milk into delivery cans	Physical: dirt from milk		3	1	3	PRP	Clean milk production
	Chemical: cleaning detergents		2	2	4	PRP	Proper rinsing of the milking equipment.
	Biological: microbial load		1	3	3	PRP	Proper cleaning of the equipment.
Transport to collection points	Chemical: H_2O_2, alkaline		2	3	6	CCP	Reject milk with alkaline and H_2O_2.
	Biological: microbial multiplication		2	3	6	CCP	Quick delivery to collection point
Grading	Physical: introduced		1	2	2	PRP	Hygiene
	Biological: contamination		3	3	9	CCP	Proper sanitation of grading equipment.
Bulking into 50 litres aluminum cans	Physical: introduced dirt		1	3	3	PRP	Training and extension
	Chemical: H_2O_2, antibiotics, cleaning detergents		3	3	9	CCP	Traceability
	Biological: microbial load, somatic cell count.		3	3	9	CCP	Quick delivery and good animal husbandry.
Transport to the cooling center	Chemical: H_2O_2, alkaline		2	3	6	CCP	Reject the milk with H_2O_2 and alkaline.
	Biological: microbial multiplication		3	3	9	CCP	Quick delivery to CBE
CBE reception plat form	Physical: introduced dirt		2	3	6	CCP	Proper hygiene
	Chemical: exhaust fumes		2	3	6	CCP	Sensitize transporters on GMPs
	Biological: microbial multiplication		3	3	9	CCP	Proper sensitization of the grading equipment.
Cooling tank	Chemical: cleaning detergents		2	3	6	CCP	Proper rinsing of the tanks.
	Biological: microbial multiplication		3	3	9	CCP	Proper maintenance of the cooler.

Table 5. Determination of CCPs (decision tree).

Process	Factor	Significance	Question 1	Question 2	Question 3	Conclusion
Milking	Poor milking procedure, utensils, milking bucket, cow health	9	Yes	Yes	Yes	CCP
Transport to collection points	Delayed delivery	6	Yes	No	Yes	CCP
Bulking into 50 litres aluminum cans	Mixing of 6 to 9 farmer's milk increases chances of mixing good quality milk with poor quality milk	9	Yes	No	Yes	CCP
Transport to the cooling center	Delayed delivery , adulterants	9	Yes	Yes	Yes	CCP
CBE reception platform	Delays while grading and dirt from the surrounding. Exhaust fumes collected from delivery vehicles	9	Yes	Yes	Yes	CCP
Cooling tank	Poor efficiency of the cooler	9	Yes	Yes	Yes	CCP

Table 6. CCP Plan.

Process	Measurable parameter	Critical limit	Monitoring				Correction	Corrective action	Records	Verification
			Who	What	When	How				
Milking	Delivery temperature	25 to 37°C	Farmer	Temperature	At delivery	Thermometer reading	Sensitizing the farmer	Advise	Temperature recorded daily	Quality checks
Transport to collection point	N/A	N/A	Farmer	N/A	At delivery	N/A	Sensitizing the farmer	N/A	Acceptance or rejections	Quality checks
Grading and bulking	Temperature, density, protein stability	>28°C 1.027-1.033 g/ml, alcohol negative	Grader	Lactometer reading, alcohol test	Every day	Alcohol gun, Lactometer and thermometer	Sensitize farmers	Reject non-conforming milk	Temperature, alcohol tests results and lactometer readings recorded daily	Quality checks
CBE platform	Traces of lead in milk	N/A	Quality controller/ grader	Presence of lead	When suspected	Advanced lab Analysis	N/A	Avoid grading while the motor mode of transport is running	Instances recorded	Quality checks
Cooling tank	Bacterial counts adulteration, density, temperature, protein stability, detergents residues	From 25 to 4°C	Quality controller	Cooler efficiency	Every day	Temperature, use of litmus paper.	Sensitize the quality controllers	Ensure proper cooling	Cooler efficiency records available	All tests for quality checks.

N/A –indicates not applicable at that factor/level.

using a lactometer, delivery temperature using a thermometer and protein stability using alcohol test. Milk that passes the above tests would be considered to be of good quality. To safe guard on quality, the milk should be rejected and records should keep for periodic quality monitoring. Subsequently, all the milk from the transporters at the platform and any suspected milk should be subjected to advanced laboratory analysis by the quality controller at the cooling plant. Lastly, the cooler should effectively cool the milk from 25 to 4°C in the least time possible. To verify the efficiency at the cooling plant, the measurable parameters identified were, microbial counts, adulteration, density, temperature, detergents residues and protein stability. Monitoring procedures should give an indicator of the point where quality is bound to deteriorate, who, when, what and how to monitor. The records generated could act as a reference point for corrective actions.

Milk quality encompasses prevention on each step of production. Quality control systems aimed at the prevention of defects, rather than their detection. Quality control occurs at every step in the production, as a raw material on farm condition. The developed CCP compare with those developed by Keskin and Gulsunoglu (2012), who reported on possible hazards, control and orientation of raw milk. Although he went further to elaborate several CCP at the farm level. The biological, chemical and physical hazards pose food safety and quality risks in a milk production system (Khandke and Mayes, 1998). Pre-requisites programs are recommended and proven management procedures which help prevent low risk food safety problems from occurring and are the foundation of the HACCP study. Operational pre-requisite programs and risk analysis need to be established for the effective applicability of HACCP that determine physical, chemical and microbiological hazards in dairy industry (El-Hofi et al., 2010). According to Torkar and Teger (2004), to achieve food safety and reduce risk, implementing the hazard analysis critical control points (HACCP) concept and quality assurance from the farm to the dairy plant should be considered. This study therefore agrees with (Karakök, 2007), who recommends that, it is paramount for every farm to determine and continuously control critical points of fresh milk production which will prevent possible hazards. The benefits of adhering to the CCPs comprise improved milk quality, which in turn enhance consumer confidence.

CONCLUSION AND RECOMMENDATIONS

Based on the study findings the farmers did not employ the code of hygiene practice in their routine dairy management. Milk withdrawal periods were not observed and thus the milk had traceable contents of drug residues. Milking was carried out without taking adequate measures that would guarantee quality. For instance, the farmers used a single cloth in washing the udder for several animals and did not thoroughly wash their hands during milking. Additionally, plastic jerry cans which could cause quality deterioration were used in milking and delivering milk to the collection points.

The study found that farmers are used to milking the cows, then perform other household chores which in turn delays milk delivery to the collection points. The milk was being bulked together without initial quality checks and proper recording. Some transporters were bringing the milk to the cooler either with the same farmer's container or bulked together in a bigger plastic container and no grading was done at the farm level. Factors that have likelihood to cause milk quality deterioration were identified during the research. Controlling drug residues, hygiene, water adulteration, delays in delivery and use of food grade containers would ensure milk quality. In the transportation from collection points to the cooler, there were undue delays and possible adulteration which were identified to likely tamper with milk quality.

Lastly, the coolers were a possible factor in milk deterioration due to poor cooling efficiency and ineffective cleaning. Based on the findings, the critical control points can be identified at the various levels and their subsequent monitoring would enhance milk quality in all the steps. Actions to be taken on each CCP were derived and are expected to guide the milk handlers in ensuring milk quality and safety.

Conflict of Interests

The authors have not declared any conflict of interests.

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