MILK QUALITY ANALYSIS IN SOUTHWESTERN UGANDA

by

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ABSTRACT

As the dairy industry faces the future, consumers' demand for better milk quality and safety is increasing. Milk quality is of major interest to both consumers and dairy farmers alike. However, scientific data on milk quality in terms of somatic cell count (SCC) in Uganda and most developing countries has been lacking. This study used SCC to compare Southwestern Uganda's milk quality against international standards. The study also sought to assess dairy farmers' perceptions about milk quality. Milk samples were obtained from 100 farms in Mbarara and Kiruhura districts, the major cattle corridor in Uganda. The milk's SCC was analyzed using a DeLaval DCC. A structured questionnaire surveyed farmers on milking procedures and milk-quality perception. Descriptive statistics and qualitative analysis was used to characterize and compare milk quality against the international benchmark.

The study found that the 100 farms had an average SCC of 507,000 cells/ml. About 34% of farms in the study had SCC under 200,000 cells/ml, an indication of high-quality milk. Excluding 7% of the farms with SCC over 1,000,000 cells/ml, the remaining 93% had an average SCC of 276,000 cells/ml, a level comparable to international standards, well below the EU threshold of 400,000.

The study also revealed that 98% of farmers considered milk quality as important or very important both to them and to the milk buyers. However, all farmers reported that they currently do not receive a milk-quality premium and are not penalized for poor quality. Seventy-nine percent of farmers reported the cooperative they belong to as their main source of information on management practices.

An improved perception of milk quality both domestically and internationally will benefit Uganda's dairy farmers and its dairy industry at large. Consumers must be assured that Uganda's

dairy industry, its government, industry stakeholders such as the Dairy Development Authority, the Uganda National Bureau of Standards, and the private sector place the utmost importance on the quality and safety of milk and other dairy products. New technologies to measure for SCC and strict food safety regulations will help improve the country's milk-quality image, allowing Uganda's dairy industry to tap into major milk export markets. Most developed countries have seen increased raw-milk quality or reduced SCC as a result of strong regulatory pressure.

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CHAPTER I: INTRODUCTION

1.1 Background

A vibrant dairy sector is crucial to Uganda's economic development. Dairy offers a pathway out of poverty for a large number of households (Staal and Kaguongo 2003). Although Uganda's economy has steadily improved in recent years, a large proportion of its rural population (about 90%) remains among the poorest in the world. Smallholder dairy production offers opportunities for rural income generation and improved nutrition through milk consumption. It also provides an opportunity to generate useful manure for fertilizing the cropland of smallholder producers in rural communities.

The dairy industry in Uganda plays a prominent role in the livelihoods of approximately 1.7 million farming families, close to 10 million people or almost one-third of the entire population (Dairy Development Authority 2012). Dairy production is a priority sector for promotion to meet local and regional milk export market demands, given the favorable soil and climatic conditions in most parts of Uganda.

In 2012, annual milk production stood at 1.86 billion liters. The value of the marketed milk was estimated at US $514.3 million. In terms of milk marketing, 70% of the produced milk is marketed and 30% consumed at household level. There are 308 rural milk-collection centers country-wide with an installed capacity of 1 million liters per day. The southwestern region has 67.2% of the capacity; thus the reason for choosing the southwestern region as the focus of the study (Balikowa 2011).

Dairy export value increased by 235% from $3.436 million to $11.527 million in fiscal year 2011/2012 (The Ministry of Agriculture, Animal Industry and Fisheries 2012). In 2013,

Uganda's total dairy exports grew to $11.8 million, with 89% exported to Kenya, 4.6% to DR Congo, 3.2% to Zambia and 2.3% to Sudan (Nakaweesi 2015).

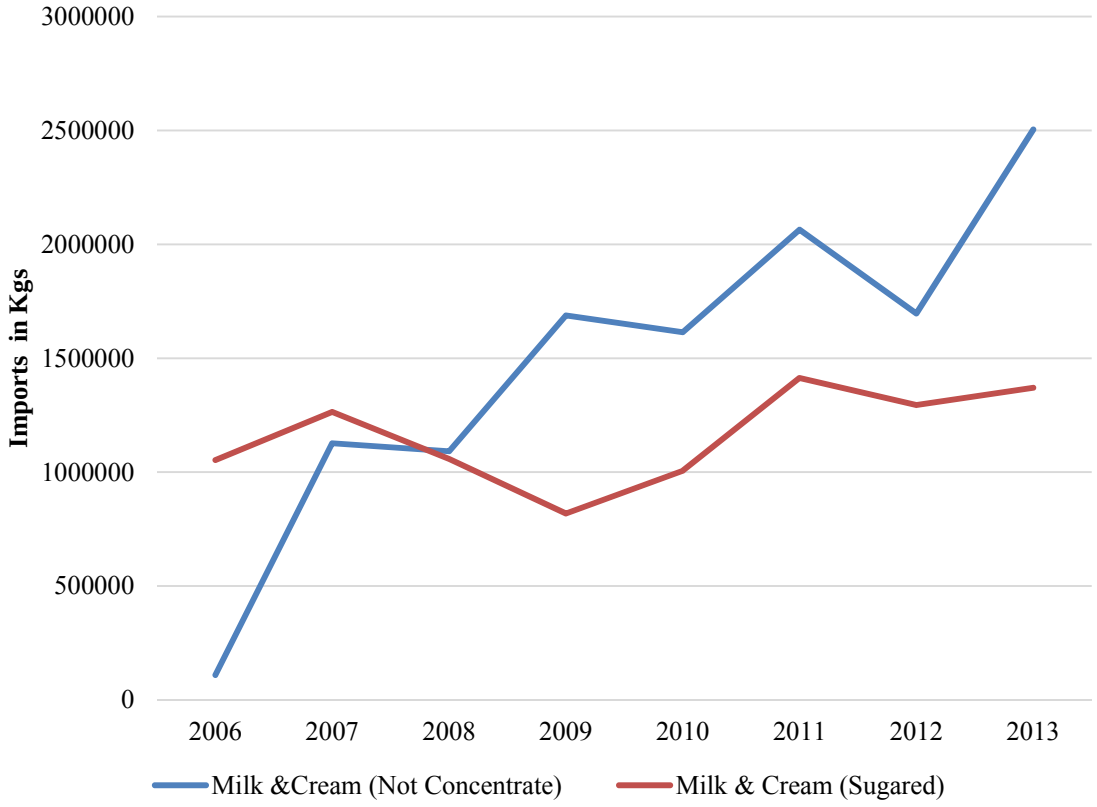
The dairy sub-sector contributes about 20% to Uganda's food processing industry while the food industry as a whole contributes about 4.3% to the national gross domestic product (Central Intelligence Agency n.d.). Though small, this contribution has been increasing steadily at about 8% to 10% per annum over the last 10 years (Dairy Development Authority 2012). The dairy sub-sector contributes about half of the 7.7% contribution of the livestock sector to the agricultural segment of the economy, which accounts for 23.1% of Uganda's GDP (Dairy Development Authority 2012). Thus, the importance of the dairy sub-sector in the Ugandan economy cannot be overemphasized. Furthermore, the dairy sub-sector as a whole has a positive growth outlook buoyed by increasing domestic and international demand as income increase in Uganda and in the East African region.

1.2 Problem Statement

Despite the aforementioned attractive potential for the dairy sub-sector in Uganda, smallholder dairy farmers in Uganda are faced with major challenges, including livestock diseases, seasonal fluctuation in the quality and quantity of feed and water, low genetic potential for milk production, inadequate milk collection and marketing infrastructure, limited knowledge and skills, and milk-quality issues. For example, the milk quality is perceived to be low, putting the domestic industry at a disadvantage against imports. The perceived low quality is exacerbated by low production. This low production partly contributes to processors not enforcing quality improvements in their quest to achieve all the milk they can procure. The lack of incentives to differentiate on the basis of quality may contribute to farmers not making the necessary investments to enhance their milk quality. This creates a vicious cycle of domestic production

losing out to imports in the higher-value processed dairy-products market. Figure 1.1 below shows milk imports to Uganda from 2006 and 2013. The trend shows that the dairy imports (non-concentrate milk and cream) into Uganda have been increasing over time. The imports (non-concentrates) increased by 267,387 kg each year from 2006 to 2011. The figure also shows that imports of both products have been increasing over the period, suggesting an increasing market opportunity for the domestic dairy and dairy products industry to increase production to replace some of these imports.

Figure 1.1 Milk Products Imported into Uganda 2006-2013



(United Nations 2015)

The current milk supply chain (Figure 1.2) also makes regulation complicated because both formal (milk collection points or Cooperative, milk processors) and informal (milk vendors) milk marketing channels are used at different points in the supply chain.

Figure 1.2 Milk Supply Chain in Uganda

(Source: May 2012)

A major indicator of milk quality is somatic cell count (SCC), a measure of white blood cells in the milk, measured as the number of leukocytes per milliliter of milk. The lower the SCC, the lower the count of leukocytes in the milk, and the higher the milk quality. The extent and distribution of SCC in Uganda is unknown due to lack of investment in research to track quality. As a result, it is impossible to identify the production areas with the greatest quality challenges and the factors that contribute to low quality on the farms. This study represents a step toward addressing this gap in knowledge about milk quality in Uganda, toward strategies for the dairy

supply chain to address the problem, and toward effective solutions to its quantity-of-production challenge.

1.3 Significance of the Study

Improved milk quality and perceptions about milk quality in Uganda will open up markets that the Ugandan dairy sector cannot currently access. Therefore, analysis of the SCC distribution is important for assessing the milk-quality situation and for providing, at the minimum, a baseline from which to begin the conversation about improving milk quality in Uganda.

The research will also inform policy makers and development partners about potential solutions to the milk-quality challenge in Mbarara and Kiruhura districts and Uganda as a whole.

The study will provide information on milk-quality-based premiums that can help reward dairy farmers based on the quality of their product.

Improved milk quality ensures that the quality standards for public health are satisfied by having different certified milk-grade levels based on quality.

The information from this study will be a factor when developing a dairy-herd improvement (DHI) program in Uganda. Such a program would help provide the data for monitoring dairy-improvement strategies, like improved genetics, and feeding strategies whose progress can be better measured and calibrated through use of DHI records.

1.4 Objectives

The overall objective of this study was to assess the quality of marketed milk in Southwestern Uganda in terms of somatic cell count (SCC).

The specific objectives are as follows:

1. Estimate the milk quality in the study area, using SCC to compare the study area's quality against some of the international standards.
2. Determine the extent to which milk producers are aware of milk quality.

1.5 Thesis Outline

The remainder of the thesis is presented as follows. Chapter 2 will cover the literature review and show the importance of measuring milk quality and how somatic cell count defines trade eligibility around the world. In Chapter 3, we discuss the methods and the data that were used in the analyses while Chpater 4 presents the results. The summary, conclusions and recommendations are presented in Chapter 5.

CHAPTER II: LITERATURE REVIEW

In this chapter, we present an overview of milk quality: its measurement, factors influencing it, and how it may be enhanced. This is accomplished through a review of the literature. We also explore the literature for information about the milk-quality situation in Uganda and attempt to understand the uniqueness of the Ugandan production environment, with the view to contextualizing the results of this study.

2.1 Milk Quality

Most research done on milk quality has emphasized SCC, milking routines, drug residues, total bacterial count, and several other sanitary factors. However, the emphasis on SCC is not the case in Uganda, probably due to technology limitations. Thus, despite SCC being a long-established barometer of milk quality (Eberhart, Hutchinson and Spencer 1982), it has not pervaded the dairy industry in Uganda as a standard operating practice.

Somatic cells in milk provide an indication of the inflammatory response in the mammary gland and can be used as a proxy for measuring intra-mammary infection and milk quality at cow, herd, and population levels (Schukken, Wilson, et al. 2003). Milk with lower SCC is considered of better quality than that of higher SCC.

SCC is accepted as the international standard measurement of milk quality (Harmon 2001). Somatic cell counts are essentially white blood cells (leukocytes) plus occasional sloughed epithelial cells in milk. It is the white blood cells that are quantified as SCC, measured in cells/ml of milk. SCC below 200,000 cells/ml is usually considered normal, and many cows maintain SCC values less than 100,000 cells/ml (Ruegg and Reinemann 2002).

2.2 Factors Influencing Milk Quality

Somatic cells originate inside the animal's udder; however, the bacteria are usually from external contaminations, such as insufficient cleaning of the milk transport equipment or insufficient external cleansing of the cow's udder and teats prior to milking. The primary factor affecting SCC is infection status (Campbell n.d.). When the cow's udder is infected with bacteria, the cow's immune system sends white blood cells to fight the infection. Bacteria initially affect tissues lining the large milk-collection ducts and cisterns by inflicting damage to small areas of tissue, eventually progressing to the glandular tissues where they affect alveolar cells (the milk-manufacturing cells). Toxins produced by bacteria cause damage to the milk-producing epithelial cells. This results in increased permeability of blood vessels and thus the white blood cells (leukocytes) move from the blood into the alveolus where they function by engulfing bacteria. The leukocytes also cause further damage to the milk-producing cells as part of the inflammatory response. The presence of bacteria, bacterial toxins and leukocytes in the affected tissue area may cause the remaining healthy milk-producing cells to revert to a resting state called involution. Alveoli shrink in size and no longer produce milk. If bacteria and their toxins remain in contact with alveoli, milk-producing cells are destroyed and the structures are replaced by scar tissue. As a result of the inflammatory process, the milk secretory tissues in the infected quarter are replaced with scar tissue and the quarter produces less milk or becomes nonfunctional.

Milk quality in Uganda is influenced by several factors along the milk supply chain that fall into two major categories: on-farm factors and post-milking or post-farm gate factors. Grimaud, Sserunjogi, and Grillet (2007) presented a number of milk-quality factors associated with poor milking routines on farms: Not using milking gloves, no washing of hands before milking; not covering milk pails/buckets or tying cows' tails during milking; lack of potable water for washing

milking utensils; and not practicing pre- and post-milking dipping of udders to reduce bacterial contamination. Some of the factors influencing milk quality in the post-milking environment are lack of cooling facilities on farms and during transportation to milk collection centers (Grimaud, Sserunjogi and Grillet 2007).

2.3 Why Milk Quality

Enzyme systems in milk can influence milk product quality. The enzyme plasmin is of particular concern for exported dried products when these products are reconstituted and later used. Plasmin is a milk protease that serves the role of clot breakdown, but in milk it is active against the casein proteins and can cause bitter flavors and gelation of milk (Bastian, Brown and Ernstrom 1991). The quantity of plasmin activators in milk increases in direct proportion to the number of damaged cells that exist in milk with high SCC. Heat treatment of milk results in the inactivation of inhibitors, and some of the activator enzymes are extremely heat stable, so the reconstitution of dried pasteurized milk products results in increased enzymatic activity by plasmin (Ismail, Choi and Nielsen 2006). One result of this increased activity leads to proteolysis of caseins in UHT aseptic milk, which leads to precipitation, or gelation of the proteins in the milk during storage at room temperature (Chavan et al 2011).

Nearly all developed countries' dairy have adopted SCC standard limits to define milk as either suitable or not suitable for human consumption (Harmon 2001). Similarly, the importance of milk quality has been greatly emphasized in Europe, where milk over 400,000 cells/ml is not acceptable for human consumption. In the US, the legal limit is 750,000 (Schukken, Wilson, et al. 2003), but from a global market perspective, the practical limit is 400,000 cells/ml because milk or milk products exported to the European Union must meet the EU's 400,000 limit. In terms of regulation in the US, the 750,000 threshold is mandated by the Food and Drug Administration

(FDA) but the U.S. Department of Agriculture (USDA) requires a 400,000 level or below before issuing export certificates to processors.

SCC has a direct correlation with milk quality and mastitis (inflammation of the udder typically due to udder infection) (Schukken, Wilson, et al. 2003). Mastitis is considered the most costly disease in dairy cattle, with subclinical mastitis being the most economically important type of mastitis. Production losses due to subclinical mastitis cost the dairy industry an estimated $1 billion annually (Ruegg and Reinemann 2002). Other losses due to high SCC (poor quality milk and/or mastitis) include but are not limited to negative effects on reproduction, antibiotic treatment that may increase the risk of antibiotic residues in milk, culling of productive animals, market loss due to quality restrictions, and reduced casein or milk manufacturing properties. Several other studies have shown the impact of SCC on milk fat, casein, and overall productivity of the dairy cow. A study on Ontario's Bulk Milk Somatic Cell Count (BMSCC) Reduction Program showed that most dairy farmers were willing and able to decrease BMSCC, an important change of attitude in the average dairy farmer (Schukken et al 1992).

Additionally, as is the case in many countries, raw-milk safety is a major public health concern in Uganda. Public health becomes a greater concern when the milk has very high SCC. Any improvement in the quality of milk could contribute to the improvement of public health while at the same time having positive economic consequences. Therefore, the quality of raw milk in Uganda is fundamental for social, economic, and public-health improvement (Grimaud, Sserunjogi and Grillet 2007)

The U.N.'s Food and Agriculture Organization and the World Health Organization recommend the Hazard Analysis Critical Control Points (HACCP) process (Whitehead and Orriss 1995), a widely accepted method of risk analysis for industrially processed foods. In most

developing countries, market channels for milk range from direct sales of liquid milk or processed dairy products from producers to consumers, to a long chain involving combinations of private traders on bicycle, public or private transport, milk bars and kiosks, dairy farmer groups, and small-scale and industrial processors. With most of the milk in Uganda being marketed through the informal channel, the application of HACCP is a major challenge there and in most developing countries (Mwangi, et al. 2000). Incentives based on quality (SCC) will increase farmers' attention to quality assurance, thus utilizing the formal marketing channel.

According to Balikowa (2011), Uganda's Dairy Development Authority (DDA), established by the Dairy Industry Act (1998), put many reforms into place in the handling and marketing of milk in Uganda, including the following:

- Organization of the informal sector by mobilizing milk traders through their umbrella body, the Uganda National Dairy Traders Associations (UNDATA), to undertake small-scale milk pasteurization using locally fabricated batch pasteurizers;
- Advising and encouragement of milk traders to acquire and use aluminum or stainless-steel milk cans;
- Intensification of regular inspection and monitoring of milk-processing facilities and retail outlets by the DDA;
- Registration of milk processors, traders, transporters, importers, and input suppliers;
- Widespread training of dairy farmers and milk traders on hygienic milk production and handling; and
- Establishment of a functional analytical laboratory and regular sampling of milk and dairy products on the market and analyses of their quality and composition (Balikowa 2011).

Although the above initiatives by the DDA contributed to improved milk quality, there was no specific measure of milk quality using, for example, the globally accepted SCC. Data on SCC is an additional tool the DDA could use to further promote milk quality.

2.4 The Importance of Lower SCC

Lower SCC implies lower total bacterial count, lower incidence of mastitis, reduced antibiotic usage, and reduced antibiotic residues in milk. These indicators suggest a lower cost of production because producers do not need to expend resources on treatment and medication. Several studies have shown a negative correlation between SCC and milk fat and casein production. There is also a correlation between SCC and mastitis (Schukken, Wilson, et al. 2003). As SCC climbs from 100,000 to 1.3 million, cheese yields drop by at least 2 percent. Cheeses made from milk with high SCC may also have a higher incidence of off-flavor and shorter shelf life. Lowering SCC, therefore, improves productivity through the dairy-processing chain, especially the cheese industry, which is growing with demand.

Nearly all developed dairy countries have adopted SCC standards to classify milk as either suitable or unsuitable for human consumption (Harmon 2001). The European Union, New Zealand, Australia, and some other countries have adopted a maximum SCC standard for Grade A milk of 400,000. Canada's SCC limit is 500,000, while the U.S. has a legal maximum of 750,000. The US has adopted the 400,000 limit to meet export requirements to the EU.

The differing SCC standards are not independent of the inherent challenges of maintaining SCC levels in dairy production. Various governments, therefore, establish the levels that allow their dairy farmers to maintain some level of competitiveness in their domestic and international markets. Fristad et al. (2014) observed that when standards are in place, producers who do not meet them have difficulty competing in established markets (Fristad, Raasch and Breiner 2014).

Given that milk quality affects milk's safety as a food product, it is not surprising that policymakers are seeking to do something about milk quality and food safety. Dr. David Balikowa, manager of Uganda's Dairy Development Authority (DDA), stated that "economic improvement and consumer safety is what we wish for in this country, as we are now taking a regional look at marketing and exporting our dairy products" (Zvomuya 2007). One interesting but not surprising observation is that consumers are willing to pay for such safety. A recent study in Kenya noted that 67% of consumers were willing to pay more for improved milk safety and quality attributes (Fadiga and Makokha 2014).

As a result of SCC's importance in providing an objective measure of quality, many jurisdictions have implemented incentive systems to encourage lower SCC levels. Most incentive programs focus on several aspects of bulk milk quality, including presence of bacteria, inhibitors, and SCC. Incentive programs for bulk tank milk SCC (BTSCC) typically operate through one or more thresholds that must be met in a monthly sample of bulk milk to obtain a premium price for milk or to avoid price deductions. In a province-wide program beginning in 1989, Ontario was successful in implementing a gradual step-wise process that contributed to the reduction of its BTSCC regulatory threshold from 800,000 cells/ml to 500,000 cells/ml (Schukken et al 1992).

Efforts in developed countries such as Canada and Australia show that milk-quality improvement is a collective action. All stakeholders involved need to understand their individual roles in reducing and maintaining quality as measured by SCC and achieving higher milk quality in developing countries such as Uganda. As in developed countries, Uganda requires education and awareness of how each individual's actions contribute to overall quality, and a careful facilitation of appropriate incentives to minimize negative externalities, adverse selection, and moral hazard in the dairy chain from milk production to dairy-product retailing. This research provides some

foundational information to begin the process of incorporating greater quality awareness into Uganda's dairy sub-sector.

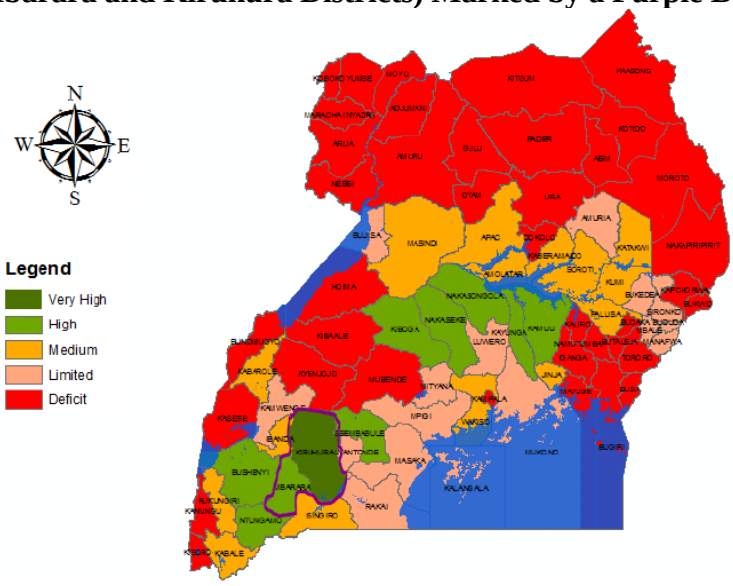
CHAPTER III: DATA AND METHODS

This section presents a description of the methods applied in this study, beginning with a description of the study area and the sampling process used to collect primary data for analysis. The chapter is divided into three main parts. Part 1 of this chapter describes the study area, providing some of its demographic characteristics a rationale for its selection. Part 2 explains the sampling process used. Part 3 provides an overview of the analytical methods used in the study.

3.1 Study Area

The study was conducted in two major cattle-corridor districts in Southwestern Uganda. Mbarara and Kiruhura Districts are located in the cattle corridor, and livestock is the backbone of economic activity in the two districts. The estimated population of the two districts combined is 802,688. This region is Uganda's major milk source and center for milk processing, with the most milk-processing plants in the country; making it a logical choice as a study area. Kiruhura district has the highest milk production in the country (Figure 3.1) and the Southwestern region contributes more than 33% of Uganda's milk supply (Figure 3.2).

Figure 3.1 Map Showing Surplus Milk Production Districts in Uganda. Study Area (Mbarara and Kiruhura Districts) Marked by a Purple Boundary



(William Matovu May 2012)

Figure 3.2 Map of Uganda Showing Different Milk Sheds. Study Area Marked by a Blue Boundary in the Southwestern Region.

(Balikowa 2011)

3.2 Sampling and Data Collection

The study focused on dairy producers in Mbarara and Kiruhura Districts in Southwestern Uganda. The sampling process involved purposeful selection of two of the major milk-collection centers, one in Mbarara and one in Kiruhura District.

Abesigana Kashari Dairy Farmers' Cooperative Society is located in Biharwe, Mbarara District (Figure 3.3); Kanyaanya Farmers' Cooperative Society in Kiruhura District (Figure 3.4). Kanyaanya center in Kiruhura is approximately 40 miles northeast of Biharwe center in Mbarara. Each of the two centers has approximately one hundred farmers that bring milk to the center every day.

The data-collection process comprised two independent but related activities: The first, a structured questionnaire (see Appendix A), collected information about farmers' perceptions of quality and information about their dairy operations with respect to quality management. The second involved the collection of milk samples from farmers for SCC analyses. During SCC analysis, milk samples may be collected from individual cows or from bulk tanks, i.e. farm output, on particular days. Given the purpose of this study and resource constraints, farm-level analysis was sufficient.

The study purposefully selected fifty farms from each of the two milk-collection centers. As the farmers brought their milk to the collection centers in milking cans, 20 ml-samples were taken using a dipstick and deposited in a sample vial. If a farm had more than one milking can, the milk from all the cans was mixed and agitated to obtain a composite sample for the farm. Each sample was given a unique identification number, which was also associated with the farm producing the sampled milk. The milk samples were analyzed for SCC using a DeLaval Direct Cell Counter (DCC) within an hour of sample collection to ensure sample integrity and accuracy of

results. Field staff were trained on how to use the DeLaval DCC (Figure 3.4). The DeLaval DCC delivers an SCC result in less than one minute after loading a milk sample (Figure 3.5).

Figure 3.3 Sample Collection and Interviews: Abesigana Kashari Dairy Farmers' Cooperative Society in Biharwe-Mbarara District

Figure 3.4: Training Field Staff to Use the DeLaval DCC for SCC Analysis

Figure 3.5 Reading an Instant SCC Value From the DeLaval DCC Machine

We interviewed 25 farmers from each of the two milk-collection centers to obtain a sample size of 50 famers. We received introductions and other logistical assistance from the chairperson for each of the collection centers. The farmer interviews occurred either in their homes or at the collection center. Figure 3.6 shows the author interviewing the Chairman of Abesigana Kashari Dairy Farmers' Cooperative Society, Captain Dick Kajugira, on January 07, 2015.

Figure 3.6 Interview in Process

The Author (Left) Overseeing an Enumerator Interviewing the Chairperson of Abesigana Kashari Dairy Farmers' Cooperative Society, Captain Dick Kajugira, on January 7, 2015.

3.3 Data Analysis

Data was entered into Microsoft Excel and coded, then cleaned to ensure that it captured and presented the information the survey required. Upon completion of the cleaning, eight surveys were excluded from analysis due to incompleteness, leaving 42 respondents whose results were used in this research. As a result of the smallness of the sample, the results are treated as a case study of milk quality in Uganda. The insights derived from them, while they may not be statistically representative of the country, would be helpful in identifying perceptions about milk quality among farmers and provide for altering to enhance milk quality and in the process improve dairy farm economics.

The survey responses and the SCC data were analyzed with the help of Statistical Package for Social Sciences (SPSS 17) software to generate descriptive statistics. Small Stata 13.1 was used for regression analysis. The descriptive statistics covered the demographic characteristics: gender, education, number of employees at the farm, total cows, total milking cows, total daily production, and breed of cows. They also included the farmers' membership in a farmers' cooperative, the nature of their milking facilities, and milking methods. Finally, we gathered information on milking procedures, udder health management, distance from the nearest milk collection center, and milk cooling and storage facilities and processes.

CHAPTER IV: RESULTS AND DISCUSSION

4.1 Section Overview

This chapter presents findings obtained through various research data collection techniques. This chapter includes a detailed presentation of dairy farmers' demographic characteristics, their perceptions of milk quality, and milk quality in the study area. Research findings are presented by the use of tables, pie charts, pictures and graphs.

4.2 Demographics and Farm Characteristics

Respondents were surveyed about their own demographics and their farms' characteristics. The demographics included gender, level of education, number of employees at the farm, total cows, total milking cows, total daily production, breed of cows, membership to the cooperative, milking facilities, milking methods, milking procedures, udder health management, distance from the nearest milk collection center, and milk cooling and storage facilities and processes.

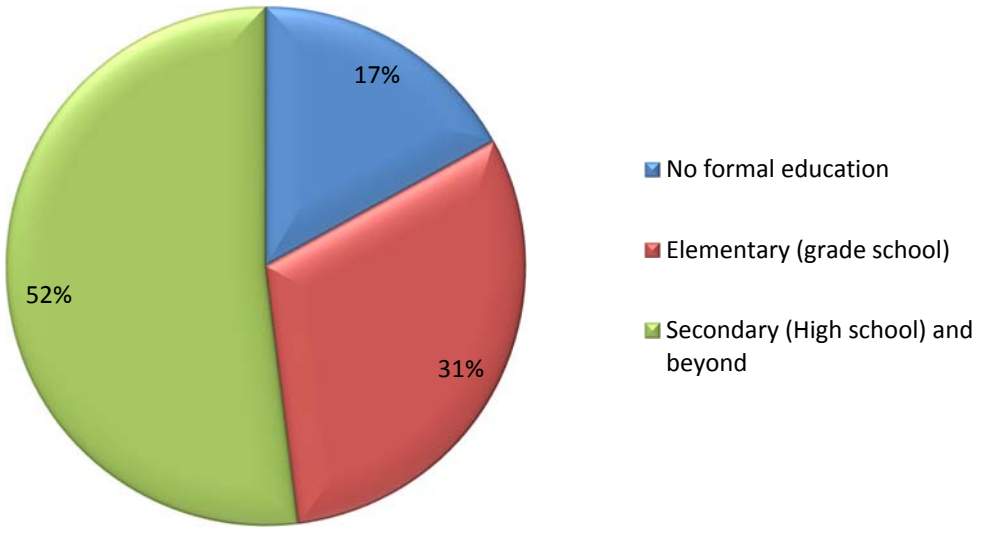
Table 4.1 shows a summary of the responses to the survey. The average age of the farmers in the sample was 54 years; the average farm size was 91 cows, with an average daily milk production per cow of 6 liters. The farms that used milking shades averaged about 2 liters more per cow than the farms that milked in the open. One farm outside the study area, which was surveyed but not included in this study's data, had a milking parlor, indoor housing for the cows (all Friesian), which averaged 19 L/cow/day.

Table 4.1 Summary of Respondents' Demographic and Farm Characteristics (N = 42)

Descriptive Characteristic	Average	Max	Min	Standard Dev
Age in years	54	76	20	14
Number of Full time Employees	3	15	1	3
Total number of cows	91	800	5	128
Frequency of milking	2	2	1	0
Avg milk/cow/day (liters)	6	12	2	2

In terms of gender, 98% of the respondents were male; 52% had received formal education beyond elementary school level (Figure 4.1); however, there was no significant statistical difference in milk quality among the different education levels.

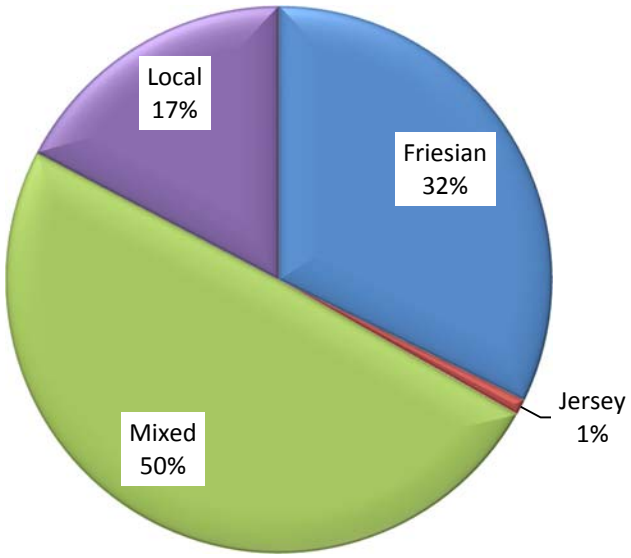
Figure 4.1 Education Level of Principal Farm Owner



Regarding breed distribution, the predominant breed was mixed (Figure 4.2). The mixed breed is mainly a cross breed between Holstein and the local indigenous breeds (Nganda, Zebu, both of

which are not dairy breeds and thus the low average production). The relatively average low production may also be explained by the low genetics, feeding, management practices like once/twice a day milking and mastitis/disease prevalence.

Figure 4.2 Distribution of Cows by Breed

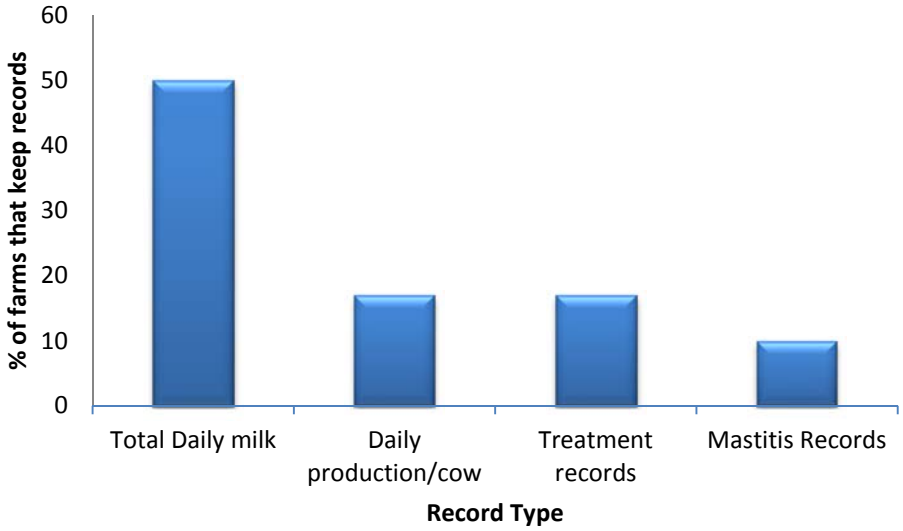


When surveyed about milking facilities, 81% of the farms in the study area reported that they milk in the open, 19% had a milking shade, and none in the study area had a parlor system. Only 52% of the farms wash/clean the udders before milking and only 26% strip out foremilk while only 2% performed a pre-milking teat dip and none performed a post-milking dip. None of the farmers in the study area wore milking gloves. Though not statistcially significant, research findings showed a positive correlation between farmers who reported that milk quality was important and the 52% that reported cleaning udders before milking. One possible reason for a lack of udder-prepping procedures is that most farmers let the calves to suckle. All the farmers in the study area reported they milked by hand, though none of them wore milking gloves. None of the

farms in the study area had a bulk tank at the farm; they all relied on the milk-collection centers. They used milking cans and took the milk to the collection center for cooling.

When surveyed about their record-keeping methods, about 50% of respondents reported keeping some form of dairy records, but whole-farm records, not individual-cow records, was the dominant recording approach used by respondents. Exactly half of the respondents kept records on the total daily output of milk from their farms, 17% recorded average milk produced per cow per day, and only 10% kept mastitis-related records. There was a positive coefficient between farms that kept records and those that regarded milk quality as important, showing that those who kept records considered milk quality important. There was no SCC information kept on individual cows or monthly whole-farm data on any of the farms in the sample (Figure 4.3).

Figure 4.3 Proportion of Farmers that Keep Records



4.3 Milk-Quality Perception

4.3.1 Milk-Quality Perception to the farmers

The study revealed that 98% of the respondents considered milk quality important or very important both to them and to milk consumers. The study also found a negative coefficient

between those who considered milk quality important and their farm's actual SCC. The same negative but higher coefficent also existed between farmers who reported taking pride in milk quality and the actual farm SCC. So the farmers that considered milk quality important and took pride in milk quality had lower SCC and therefore better milk quality.

A majority of the respondents (97.6%) also reported that they would find it easy or very easy to make changes to help improve milk quality, with 95.2% reporting they would find it easy or very easy to improve staff training if the training helped to improve milk quality. About 79% and 67% of respondents reported that they would find it difficult or very difficult to record milk temperature and improve milk cooling, respectively (Table 4.2). None of the study area's farmers had electricity connected to the national grid; most rely on solar power, so cooling at the farm would still be a challenge in the long-term. About 83% of the respondents reported that they would find it easy to purchase screening tools like CMT, but that such tools are currently not readily available on the market. This level of willingness shows how dedicated the smallholder dairy farmers in Southwestern Uganda are to improving milk quality.

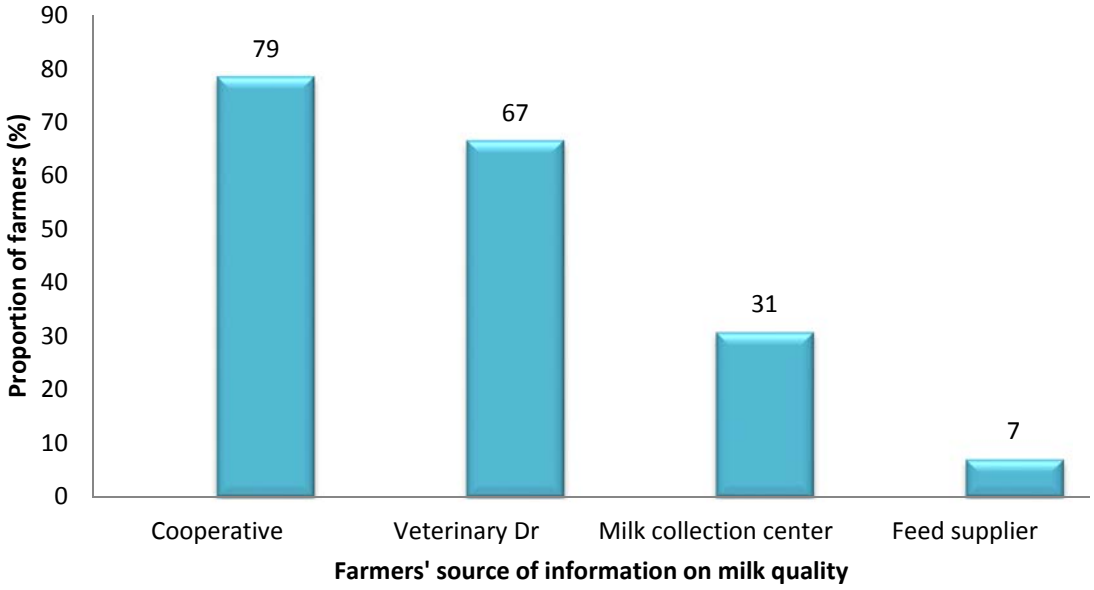
Table 4.2 Farmers' Willingness to Make Changes that Improve Milk Quality (N=42)

Area of Improvement	**Difficult/Very Difficult**	**Easy/Very Easy**	**Not Sure**
Milking procedure	2.4	97.6	
Recording temperature	78.6	21.4	
Milk cooling	66.7	26.2	7.1
Procuring screening tools such as CMT	11.9	83.4	4.8
Training/staff knowledge	2.4	95.2	2.4

4.3.2 Farmers' Source of information on Milk Quality

The study found that most farmers depend on their cooperative, a Veterinary doctor, and or an NGO like Land O'Lakes or Send a Cow for information on milk quality and mastitis-related issues (Figure 4.4).

Figure 4.4 Major Sources of Information on Milk Quality to the Dairy Farmer



4.4 Milk Quality in the Study Area

The study revealed that 34% of the farms surveyed had SCC levels less than or equal to 200,000 cells/ml (Figure 4.5) which is indicative of high milk quality, and higher than initially hypothesized. The average SCC for all 100 farms was 507,000 cells/ml with a standard deviation of 967,000 cells/ml. However, treating seven farms that had SCC above one standard deviation from the entire study population as outliers, the average SCC for the rest of the farms was 276,000 cells/ml with a standard deviation of 159,000. The average SCC of 276,000 is very much comparable to the rest of the developed world; it is, for example, very close to the US-producer average SCC for the period from 2006 to 2011 (Figure 4.6). This shows that Uganda's milk quality in terms to SCC is much better than the general perception. The low SCC could probably be partly explained by the fact that all farms in the study area have grazing herds, which is expected to have lower SCC than farms with confined housing.

Figure 4.5 Milk Quality by Farms (N = 100)

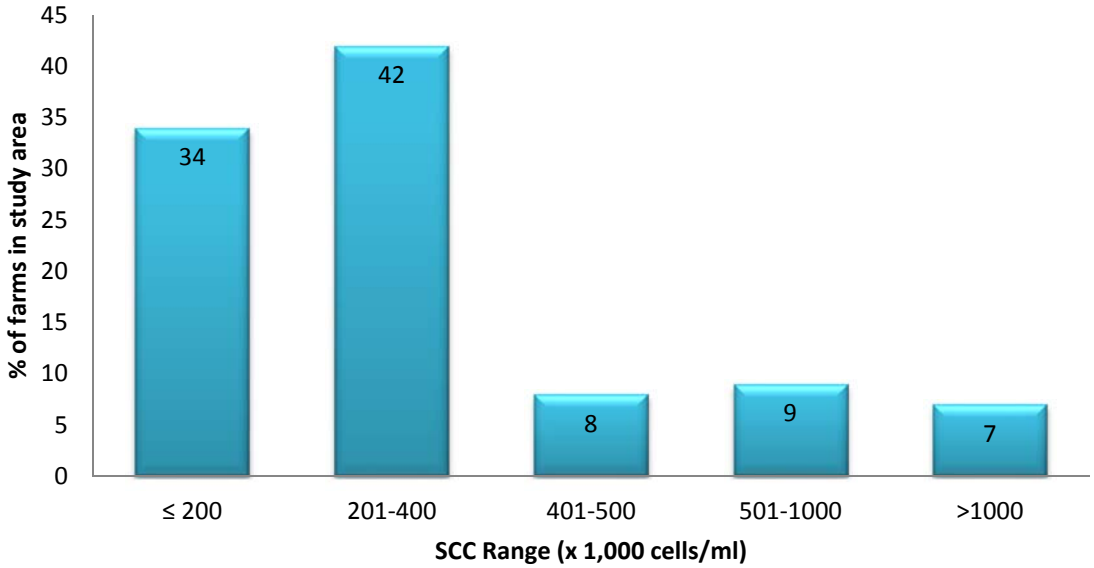
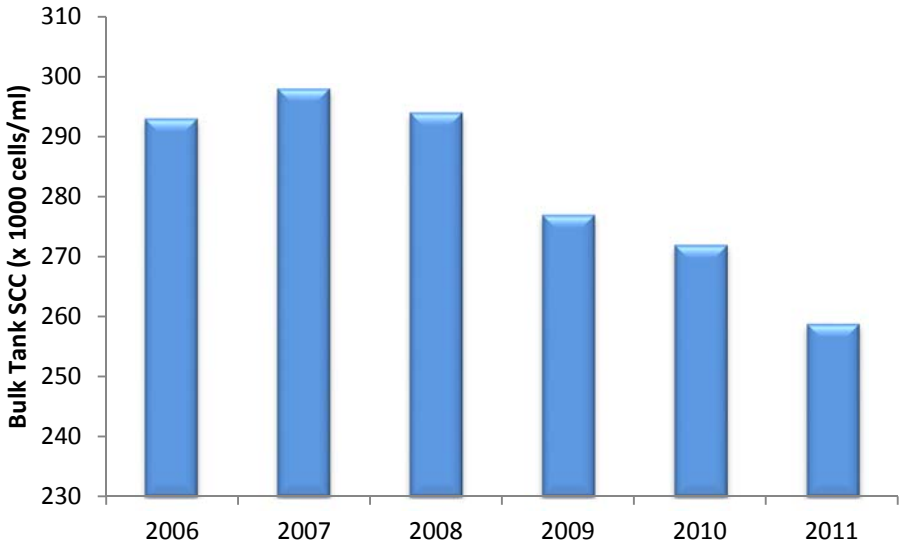


Figure 4.6 US Average Producer BTSCC, 2006-2011



(USDA 2012)

CHAPTER V: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary and Conclusions

The purpose of the study was to provide information on milk quality in terms of SCC by assessing the quality of marketed milk in Southwestern Uganda. This was important because the Ugandan dairy sector has an attractive potential yet is hindered by several challenges, including livestock diseases, seasonal fluctuation in the quality and quantity of feed and water, low genetic potential for milk production, inadequate milk-collection and marketing infrastructure, limited knowledge and skills, and milk-quality issues.

Addressing the information gap on milk quality and providing information on SCC will not only be beneficial to improving Uganda's milk-quality image to both domestic and international markets but will also provide data that is important in addressing other farm-management issues, such as dairy production and reproduction.

There are many reasons why it is important to assess and reduce SCC in the dairy cattle population. SCC can result in serious economic losses resulting from mastitis, reduced milk production, reduced reproductive efficiency in dairy animals, increased treatment costs, reduced milk-processing efficiency and product quality, as well as increased antibiotic use that may lead to increased antibiotic residues in milk, leading to increased public-safety concerns. Understanding the SCC situation in Uganda is therefore important not only for improving milk quality, but also for improving the productivity and profitability of the Ugandan dairy farmer.

The study focused on Southwestern Uganda because this region is the major cattle corridor; it is the hub for milk processing, with the most milk processing plants in the country.

The specific objectives of this study were to estimate the milk quality in the study area using SCC to compare the study area's quality against some of the international standards, and to determine the extent to which milk producers are aware of milk quality.

The study revealed that the dairy producers in the study area produce good-quality milk, with 34% of the farmers producing high-quality milk under 200,000 cells/ml. About 93% of the farms in the study area had an average of 276,000 cells/ml, a level that is very comparable to SCC levels in most develpoed countries and well below the EU threshold of 400,000 cells/ml, which has been essentailly adopted as the international export standard. The average for all the farms in the study area was 507,000 cells/ml.

In terms of milk-quality awareness, the study revealed that 98% of the farmers believe milk quality is very important both to them as producers and to the buyer, and that they would find it easy to make any changes to improve milk quality. Based on the SCC results, the study shows that dairy farmers produce good milk quality at least to the point of delivery and any changes in milk quality probably take place along the milk supply chain.

The study also revealed that dairy cooperatives, organizations like Land O'Lakes, and veterinary doctors were the main sources of information regarding milk quality and other good farming practices; hence the need to strengthen cooperative development and the veterinary fraternity.

To understand the milk-quality perspective from the processor standpoint, some of the major processors were also interviewed; they reported that quality is important to them, and one of the processors reported that they would be willing to pay a premium to farmers based on quality. One quality concern expressed by one of the major processors was drug residues. This was also

revealed by a few farmers who reported that they do not withold milk after treating a cow with antibiotics.

5.2 Recommendations

The competitive economic pressure on milk production in Uganda derives, at least in part, from competition from imported products. Dairy producers will improve their profits by striving to produce dairy products of higher quality while keeping costs as low as possible. In order to remain competitive in the market, Ugandan dairy farmers must increase their work efficiency and produce milk products that are acceptable to domestic and international consumers (Muslie et al 2009).

Improving the image and perception of milk quality both domestically and internationally will benefit the dairy farmers and the dairy industry at large. Consumers need to be assured that the dairy industry and the government are continually placing the utmost importance on the quality and safety of milk and other dairy products. By taking a proactive approach, which includes adopting new technologies, the Ugandan dairy industry, the Dairy Development Authority, and other government agencies will effectively meet new quality and safety demands and challenges as they arise.

It is therefore recommended that the Ugandan dairy industry, government, and stakeholders such as the Dairy Development Authority, the Uganda National Bureau of Standards, and the private sector continue to place the utmost importance on the quality and safety of milk and other dairy products. A proactive approach that includes technologies to measure for SCC and drug residues, along with strict food-safety regulations, will help improve the country's image in terms of milk quality. This will help Uganda's dairy industry tap into major milk export markets.

A thorough milk-grading system that accounts for total bacterial counts and SCC would further improve the milk-quality image in Uganda. Milk-quality certification should be emphasized and a Pasteurized Milk Ordinance (PMO) established. The PMO should mandate parameters for somatic cell count, antibiotic residues, bacterial counts, and temperature. The PMO should be constantly revised based on the latest research and technology, with input from the industry, dairy cooperatives, milk processors, academia, and regulatory agencies.

This study also revealed that most of the dairy farmers surveyed did not follow strict milking procedures that would help improve milk quality at the farm level. It is therefore recommended that producers follow good milking procedures. The following milking practices check list is provided for reference; it outlines good practices that may contribute to reducing SCC and improving quality:

1. The milking environment should be clean and dry. A calm environment is ideal. For hand milking, a shady or roofed milking place is recommended.
2. Cow cleanliness should be observed. Is there manure on the udder and teats? Is the cow properly restrained, with tail tied?
3. Equipment cleanliness (milking can or parlor) should be observed.
4. Proper milking technique should be observed; if milking by hand, do not strip milk, as this will cause injury to the teat. If milking by machine, make sure the milking unit is square on the udder.
5. Employees should use milking gloves.
6. Pre-milking teat dip should be properly applied.
7. Teat dip should remain on teat the correct length of time before drying (15-30 seconds).

8. The employee should strip each teat vigorously and get good milk flow.
9. A strip cup should be used to detect early cases of mastitis and decrease the spread of pathogens.
10. A CMT test should be performed on animals that are suspected to have an infection.
11. Proper milking preparation procedure should be observed; for example, dip-strip-dry. Apply milking unit or start milking by hand. (Dry must be the last step before starting to milk.)
12. Teats should be thoroughly dried (including teat ends) before milking starts.
13. Proper lag time is observed. Lag time is the period from first contact with the teat until the unit is fully attached or hand milking starts, and should be 60-90 seconds.
14. If using a milking machine, units should be properly adjusted to squarely hang under the udder.
15. If using a milking machine, employees should properly use the automatic take-offs, and should not be switching to manual.
16. If using a milking machine, proper unit-on time should be observed. Unit-on time is the length of time from until attachment to unit removal, and should be 3.5-5 minutes with proper milking stimulation.
17. Teat ends or tops of teats should be examined for damage or purple ring.
18. Employees should get proper post-dip teat coverage?
19. All employees should follow the same procedure to maintain consistency.
20. If using a pipeline to take to take milk to the bulk tank, observe milk filter after milking for dirt or mastitis.

Dairy cooperatives can be a good source of training and refresher courses on good milking practices.

Dairy farmers bear the most responsibility for milk-quality assurance. If the milk they supply is of low quality, no one else downstream in the supply chain can do anything about it. It is, therefore, only prudent that those who do a better job at ensuring quality are credited for their performance as an incentive to promote better quality, while those who produce poor quality are penalized. For example, the 34% of the farmers in the study that had SCC levels below 200,000 cells/ml deserve a premium for good quality, and they could serve as model farmers to help others improve milk quality.

Currently, all dairy farmers are paid based on volume and receive no quality premiums, according to all the producers in the study. Stakeholders should introduce a quality-based incentive, allowing certain thresholds for SCC (for example, less than 350,000 cells/ml) to generate a premium and those above 350,000 cells/ml to generate a penalty.

Because most farmers reported that they received most of the information on milk quality from cooperatives, cooperative development and growth should be emphasized if the dairy sector is to continue growing. Cooperatives will not only offer services to help farmers regarding milk quality and improved genetics, but will also allow dairy producers to generate economies of scale, increase efficiency along the value chain, and improve quality and value of products by allowing members to learn new skills, increase access to knowledge, help educate the farmers on the importance of record keeping, encourage innovation, and leverage technologies among themselves. Well-organized cooperative business allows increased bargaining power through collective action.

In the long term, the government should invest more into research in the dairy sector, especially in terms of establishing a database of dairy records that can be used to monitor and calibrate future progress made in the dairy sector. This can be done through support of DHI services in the country. Data from AgSource Cooperative Services shows better SCC on farms that use DHI services (Table 5.1).

Table 5.1 Benchmarks from AgSource Holstein Farms April 2015

	<100 Cows		**100-249 Cows**		**250-499 Cows**		**500-999 Cows**		**>= 1000 Cows**	
	Avg	**Top 25%**	**Avg**	**Top 25%**	**Avg**	**Top 25%**	**Avg**	**Top 25%**	**Avg**	**Top 25%**
# Herds	1892	473	728	182	274	69	139	35	83	21
# Cows	59	66	153	166	350	361	672	670	1843	1563
Milk lbs	67	82	77	88	85	96	90	99	88	97
Fat lbs	2.7	3.2	2.9	3.3	3.2	3.6	3.3	3.7	3.3	3.5
Protein lbs	2.1	2.5	2.4	2.7	2.6	2.9	2.8	3.0	2.7	3.0
SCC	244	181	191	156	185	160	171	163	179	160

The government must develop the infrastructure necessary for a strong dairy industry, especially roads and electricity. All farmers in the study area reported having no access to electricity, a limiting factor for not only cooling milk but for technology use.

Future research done over a longer period of time and analysis not only for SCC but also for drug residues in milk, total bacterial counts, and milk components like fat and protein would be more comprehensive. All these are important variables that were left out of the study due to resource contraints.

There is no doubt how important milk quality is both to dairy producers and consumers alike. The study focused on addressing the information gap on milk quality and providing

information on SCC in Southwestern Uganda. Study findings make an important contribution about milk quality in Uganda. Information on SCC is not only important as indicator for milk quality but a very important tool in management of mastitis which if not managed leads to fundamental economical losses in terms of reduced milk production, reduced reproductive efficiency in dairy animals, increased treatment costs, increased antibiotic use that may lead to increased antibiotic residues in milk, leading to increased public-safety concerns. Milk with high SCC also leads to reduced milk-processing efficiency and product quality. The data from the study is a crucial foundation the government and stake holder should continue to build on and establish a dairy records service that will provide data for monitoring and calibration of both genetic and nutritional progress made in the daiy industry.

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APPENDIX A: Producer Questionnaire

I am Dr Hamid Rutaro, working with US dairy farmers with AgSource Cooperative Services. I am also a student in Master of Agribusiness Management program at Kansas State University. This survey is part of my Master's research to help the Ugandan dairy sector improve milk quality and enhance the farmers' profitability. This information is necessary to analyze the region's milk quality (SCC) and to understand milk-quality perception. Please complete the survey completely. Any personal information will be kept strictly confidential.

DESCRIPTIVE CHARACTERISTICS

1.	Farm ID	

2.	Principal Owner's Gender		Female		Male

3.	Principal Owner's Formal Education (√)	None	Elementary	Secondary	Post-Secondary

4.	How old is the principal owner?	

5.	How many people work on this farm?	Full time	Part time

6.	Please, how many cows do you have on your farm?				
7.	How many of them are currently being milked?				
8.	How many times a day do you milk your cows?				
9.	On average, how much milk (liters) do your milking cows produce per day?				
10.	Do you belong to a dairy cooperative?	Yes		No	

11.	Please indicate the number of cows you have by breed				
Friesian	Jersey	Mixed	Local	Other	

12.	Please indicate the type of milking facility you have. (Check)								
In the open		Milk shade		Pit Parlor		Stall Barn		Flat Barn	

13.	Please indicate (√) if you milk by hand or by machine.		Hand milking		Machine milking

14.	How long does it take from the farm to the collection center/nearest bulk tank for cooling?		Hrs

15. How far is your farm from the milk collection center you use most frequently?		km

MILKING PROCEDURE

16. Please check which of the following procedures you follow in your milking process.					
Milkers wear gloves	Udders washed/cleaned	Strip out foremilk	Pre-milk dip	Dry teats	Post-milk dip

17. On average, how long does it take to milk one cow at your farm? (time in minutes)	

18. Do you keep records on your milking cows?		Yes		No

19. If you answered yes above, which of these milk-quality-related records do you keep? Check all that apply.	
a) Daily records of total milk produced	
b) Daily milk produced by cow	
c) Clinical mastitis incidence	
d) Somatic cell count by cow	
e) Treatment records (medication, duration, etc.)	
f) Monthly farm average somatic cell count	

UDDER HEALTH MANAGEMENT

20. How frequently do you inspect your cows for udder health? (Please check)			
Never	Daily (at Milking)	Weekly	Monthly

21. Do you use a California mastitis test (CMT) Paddle?		Yes		No

22. When you discover your cows have udder health issues, do you use intramammary antibiotics?		Yes		No

23. If Yes above, please indicate how long before you consider the milk to be good for sale/consumption?	
a) Immediately (no waiting)	
b) 2-3 days	
c) We follow the withhold time indicated for the antibiotic	

COOLING AND STORAGE OF MILK

24.	Do you have cooling tanks on your farm?		Yes		No
25.	If you answered no, how do you ensure the right milk temperature is maintained?				

26.	If you answered yes, please answer the following questions:		Yes		No
	a) Do you take temperature of the bulk tank before and after milking?				
	b) Do you **take** temperature of the milk before sending to it collection center?				
	c) Do you **record** the temperature of the milk before sending it to the collection center?				

27.	Do you have an electricity supply on the farm?		Yes		No
28.	Is your electricity supply on the national grid?		Yes		No

MILK QUALITY PERCEPTION

29. Please indicate your agreement with the following statements about milk quality on a scale of 1-5, where 1 = Completely Disagree and 5 = Completely Agree.

Milk Quality Related Issue	1	2	3	4	5
a) Milk quality is important to me as a producer					
b) Milk quality is important to my milk buyer					
c) I get a price premium for high-quality milk					
d) I get a price penalty for low-quality milk					
e) Farmers producing high-quality milk receive recognition among their peers					
f) Farmers producing low-quality milk lose respect among their peers					
g) I take pride in producing high-quality milk					
h) It really doesn't matter what my milk quality is, I get the same price at the collection point					

30.	Do you regularly train your staff on milking procedures?		Yes		No

31. On a scale of 1-5, where 1 = Unimportant and 5 = Very Important, please rank the importance of the following issues related to mastitis to your business.

Mastitis Related Issue	1	2	3	4	5
a) The cost of treating mastitis					
b) The cost associated with losing cows because of mastitis					
c) Milk production losses resulting from mastitis					

d) Reducing Bulk Milk Somatic Cell Count (BMSCC)					
e) Reduction in milk quality					
f) Reduction in milk grade					
g) Reduction in or loss of milk quality premiums					

32. How easy would it be for you to make changes in the following activities in order to improve quality of milk produced on your farm? Please use the following scale: 1 = Very Difficult and 5 = Very Easy

Activity	**1**	**2**	**3**	**4**	**5**
a) Improving the milking procedures					
b) Taking proper care of the milk after milking					
c) Taking proper care of the milk during transportation					
d) Recording the temperature of milk before sending it to the collection center					
e) Improving milk cooling facilities/installing bulk tank.					
f) Getting a higher price for higher quality milk					
g) Treating mastitis as soon as it is discovered					
h) Procuring mastitis testing equipment, e.g., California Mastitis Test, Testing individual cows for somatic cell count					
i) Getting knowledge about how to improve milk quality					
j) Improving the knowledge of my staff about milk handling to ensure quality					

33. Please indicate which of the following people/professionals you typically depend on for help with milk quality issues. Check all that apply.

a) Veterinarian (at the farm)	
b) Veterinarian (at the drug shop or clinic)	
c) Dairy equipment dealer	
d) Nutritionist	
e) Collection center staff	
f) Feed supplier	
g) Processor	
h) Producer cooperative	
i) Naads agent	
j) Extension Agent	
k) Other (please specify)	