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Rural Women Economic Empowerment, Indigenous Fermented Milk Production, and the Challenges of Modernity

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Traditionally, women are known as producers of fermented milk in many African communities. In more recent times, the production of fermented milk using indigenous technology is more widely practiced by women in rural areas. In rendering support to small and medium-scale industries, many African governments, NGOs, and the private sector strongly encourage the use of commercial starter culture in milk fermentation, while some go as far as discouraging or withholding support for traditional fermentation. Most women in rural areas across Africa are unable to afford commercial starter cultures or do not have the knowledge and other required resources to use them. Yet, traditionally fermented milk holds prospects as a means of economic empowerment for rural women. This study examines the challenges and opportunities for women who live in rural areas of Rwanda and use indigenous knowledge and technology in their milk fermentation process. The study seeks to enhance the understanding of traditional fermentation techniques and the possibilities they hold for the economic empowerment of women in rural Rwanda. In this pursuit, emphasis is placed on the cost of production in terms of finances, ease of access to raw materials, and ease and speed of production, in addition to other production dynamics, including hygiene. Further, the research explores the health and nutritional benefits of traditional fermentation methods, as well as possible side effects. Finally, the shelf life and taste of traditional processing methods are explored alongside modern fermented milk (using starter culture), all with a view to determining how much benefits accrue to one more than the other.

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1.0 Introduction

Across the world, fermented foods have historically and traditionally been included as part of communities' staple diets. These foods, fermented using indigenous technology and products, are considered to possess a unique and distinct taste and are nutritious and helpful in maintaining health and preventing diseases. Lactic acid bacteria and yeasts have been identified as the major group of microorganisms that are generated when foods are fermented using traditional methods; indeed, in the fermentation of indigenous foods, naturally occurring microorganisms are utilized as starter cultures.

Traditionally, women are known as producers of fermented milk in many African communities. In more recent times, the production of fermented milk using indigenous technology is more widely practiced by women in rural areas. In Rwanda, *ikivuguto* is a popular fermented milk product that is produced traditionally by the "spontaneous acidification of raw milk by a microflora present both on utensils and containers used for milk preservation and in the near environment of cattle" (Karenzi et al. 2013, 383). The final product, ikivuguto, resembles yogurt. There can be slight or noticeable variations in taste and texture of traditionally fermented ikivuguto. This can result from the complexity of the flora that create the traditional sour milk, which differs based on location. In addition, up until a certain point in the fermentation process, "lactic flora lives alongside a pathogenic flora, which also varies depending on the level of the personal hygiene of those preparing the *ikivuguto*" (Karenzi et al. 2013, 384). During fermentation, lactic acid bacteria compete for nutrients with the remaining bacteria. They outgrow them and produce byproducts that inhibit growth of pathogenic and spoilage bacteria (Ananou et al., 2007). In modern fermentation, synthetic or commercial starter cultures are applied to the product to begin the fermentation process. There are different starter cultures available globally that are used in the production of fermented foods. In Rwanda, commercial production of ikivuguto uses starter cultures. Starter cultures can provide a more predictable and standardized end product; however, commercial starter cultures have also been known to have their own set of challenges, which include: lack of sufficient production of lactic acid, lack of production of required flavor, or outright defects in flavor; the use of commercial starter cultures can also result in body and texture defects in the final product.

In rendering support to small and medium-scale industries, many African governments, NGOs, and the private sector strongly encourage the use of commercial starter cultures in milk fermentation, while some outrightly discourage or withhold support for traditional fermentation processes. Most women in rural areas across Africa are unable to afford commercial starter cultures or do not have the knowledge and

other required resources to use them. Yet, traditionally fermented milk holds prospects as a means of economic empowerment for rural women.

1.1 Objective of Study and Research Questions

The general objective of this study is to determine the possibilities of economic empowerment for rural women, focusing on the use of indigenous technology used to ferment milk in Rwanda. More specifically, the study examines the challenges and opportunities these women face when using indigenous technology to ferment milk. The study seeks to enhance the understanding of traditional fermentation techniques and the possibilities they hold for the economic empowerment of women in rural Rwanda. In the pursuit of its stated objectives, the paper will place emphasis on the cost of production, in terms of finances; ease of access to raw materials; and ease and speed of production, in addition to other production dynamics, including hygiene. Further, the research will try to explore the health and nutritional benefits of traditionally fermented ikivuguto for rural dwellers, as well as possible side effects. Finally, the shelf life and taste of traditional processing methods will be explored alongside modern fermented milk (using commercial starter culture), all with a view to determine if any value chain benefits accrue to one more than the other.

The research is necessary, taking into account the minimum investment—by government, organizations, and stakeholders—in the use of indigenous technology in the production of fermented milk in Rwanda. The aim will be to establish possible economic benefits accruable to rural women and, by extension Rwanda, if indigenous technology is encouraged. The study is useful for students, policymakers, scientists, economists, agriculturists, entrepreneurs, development practitioners, and any person interested or involved, through practice or research, in the economic empowerment of rural women. Questions the research will raise include:

i. What role does indigenous technology play in ikivuguto production in rural Rwanda?
ii. What economic empowerment possibilities exist for women living in rural Rwanda involved in ikivuguto production?
iii. What possibilities exist for scaling-up production and improving the value chain of indigenously produced ikivuguto?
iv. What level of support exists for rural women involved in local production of ikivuguto?
v. What challenges exist that impede the economic empowerment of women producing ikivuguto in rural areas?

1.2 Research Methods

The study utilizes an open-ended questionnaire to gather information from women in rural areas who are involved in the production of fermented milk using indigenous technology. Consumers of these products were also interviewed, in addition to select government agencies and organizations involved in food regulation, rural development, and the economic empowerment of women.

1.3 Indigenous Technology

Indigenous technology can be characterized as that craftsmanship and science that is exceptional to a given culture and designed to address societal challenges. Indigenous technology has been characterized as innovation utilized by locals, which constitutes a critical piece of a community's heritage (EIONET 2012). Technology is considered significant towards accomplishing food security and, for the most part, development. Labe (2008) opines that indigenous technology-based innovation provides contrasting options to Western know-how, giving more alternatives for taking care of issues locally, thus fostering sustainable development. Indigenous innovation, therefore, holds many advantages for groups that have created them as it reduces dependency on imported technology, which rural dwellers are often unable to afford, fully grasp or maintain over a period of time.

1.3.1 Indigenous Technology and Rural Economic Empowerment

Dayanatha (2006) recognized five noteworthy attributes of indigenous technology in rural development. First, indigenous technology requires very little capital as every piece of equipment needed during construction is sourced locally. Second, indigenous technology sources raw materials from the local environment, therefore is easy to maintain and sustain. Third, the use of indigenous technology can sometimes be restricted to its particular area of invention as there are no universal structures for the spread of indigenous technological knowledge. Fourth, indigenous technology can diffuse from the original place of innovation and be adapted to other areas where there is availability of raw materials and environmental similarities. Fifth, indigenous technology has added to verifiable improvements in agricultural yield, especially in rural areas, and continues to contribute significantly to universal knowledge of science, innovation, and social legacy.

Local farmers often utilize indigenous knowledge-based biotechnology to deliver improved yields, while requiring less input of resources. Through indigenous knowledge-based biotechnology, such as crossbreeding, the qualities of plants and animals are improved. These improved attributes result in highly evolved plant and animal varieties and, by extension, economic empowerment for farmers and communities.

However, both indigenous and modern technologies empower farmers to build profitability. Although modern technology can empower rural people, it is often neither sustainable nor readily accessible since it is capital intensive, requires expertise to maintain or repair, and spare parts for equipment can be difficult to replace. Therefore, indigenous technologies still remain the major empowerment tools for sustainable rural development.

1.3.2 Use of Indigenous Technology in Agricultural Production

Indigenous agriculturists created different procedures to enhance or maintain soil richness. For instance, farmers in southern Sudan and Zaire noticed that the termite hills are especially useful for developing sorghum and cowpea. Biological pest control has been of increased interest lately; yet indigenous

technology practices related thereto have been in use for over a century. In China, for instance, citrus growers place nests of the predacious ant *Oecophylla smaragdini* in orange trees to reduce insect damage. In India, local farmers intentionally plant sunflowers in wheat fields to aid the biocontrol of rats by owls at the stage of grain development (Sinha 1994). Indigenous cultivating practices are an age-long practice among Nigerian farmers (Apantaku 2000), who are still generally conservative in their ways. There are other technologies that are jealously guarded by local farmers. Examples of these are the indigenous technology used for the prevention of weaver birds attacking rice and the prevention of infestations of black ants on farms.

2.0 Fermented Milk

Fermentation is the process by which the chemical components of a substance are broken down through the sustained activities of bacteria, yeasts, or other microorganisms. Fermented or cultured milk is the product that results when lactic acid is allowed to act on milk over a period of time, thereby enhancing its taste, texture, chemical components, and even shelf life. Milk is fermented differently throughout the world. In southern and eastern Africa, for instance, the general handling technique for fermented milk is to channel the raw milk into a smoked clay pot or jug gourd and move the vessel to a warm place until the milk has soured and coagulated (Kerven 1987).

2.1 Nutritional Content and Health Benefits of Fermented Milk

There are more than 3,500 traditionally fermented foods around the world (EUFIC 1999), and each is packed with a variety of macro and micro nutrients. For fermented milk, the lactose content is lower than that in the parent milk due to the presence of lactic acid. Lactic acid has a distinct sour taste that is identified with fermented products. Additionally, fermented milk may also contain more folate than regular milk since a few strains of organisms synthesize folate (Wouters et al. 2002).

Fermented milk is packed with lactic acid micro-organisms, which can have an immense impact on intestinal microflora, increasing its resistance to harmful bacteria (Gill 1998). In humans, *Lactobacillus casei* strain Shirota (LcS) preparation has been shown to prevent the recurrence of superficial bladder cancer (Ohashi et al. 2002), and a possible effect of LcS on the immune system has been suggested (Matsuzaki 1998). Further, several studies with *Lactobacillus sp.* preparation and fermented milks have been published (Kumar Verma et al. 2012) and reported alleviation of constipation using *L. acidophilus* NCDO 1748, *L. casei* Shirota, and *Lactobacillus* GG. Casein hydrolysate, delivered by an extracellular proteinase from *L. helveticus* (CP790), has been proven to have an antihypertensive effect in rats. Two antihypertensive peptides have additionally been purified from sour milk fermented with *L. helveticus* and *Saccharomyces cerevisiae*. These two peptides hinder angiotensin-changing over a compound that proselytes angiotensinogen I to angiotensinogen II, which is an intense vasoconstrictor (Maeno et al. 1996).

2.2 Fermented Milk Around the World

Kephir is a form of fermented milk, found mostly in Europe and parts of the Middle East, and is nutritionally dense. Kephir is known to contain high amounts of thiamine, riboflavin, pantothenic acid, and vitamin C (the vitamin content varies, depending on milk source), as well as protein (with a higher protein content when kephir grains are cultured in whey or soy milk) and minerals (Sarkar 2007). Kephir additionally contains more amounts of threonine, serine, alanine, and lysine than milk (Guzel Seydim 2003; Sarkar 2007). Kumys is another form of fermented milk popular in Asia, and contains (/100 g) around 90 g of moisture, 2.1 g of protein (1.2 g of casein and 0.9 g of whey proteins), 5.5 g of lactose, 1.2 g of fat, and 0.3 g of powder, in addition to the final results of microbial fermentation, i.e. lactic acid (1.8 g), ethanol (0.6–2.5), and CO2 (0.5–0.9) (Uniacke-Lowe et al. 2010). Tarag, another variant of fermented milk popular in China, contains (/100 g) 4.6 g of fat, 5.6 g of protein, and 2.0 g of lactose in 100 g of fermented milk (Zhang et al. 2009).

The section below gives a summarized overview of the availability of fermented milk in select locations globally.

i. Kephir (Argentina, France, Portugal, Taiwan, and Turkey)

Kephir is a thick fermented milk beverage created from bovine, goat, sheep, or horse milk, which can contain different measures of alcohol and carbon dioxide. Kephir is produced using crude, purified, or UHT treated milk (Lopitz-Otsoa et al. 2006). While kephir is created commercially in numerous nations, especially in Eastern Europe, it is also made in homes in Argentina, France, Portugal, Taiwan, and Turkey.

ii. Tarag (China)

Matured goats are usually used in the production of Tarag, which is a staple food among the Mongolian people in China, who allegedly can consume one to two liters of tarag per individual every day (Zhang et al. 2009). Tarag is produced using raw, whole milk from the Zang and Chaidamu breeds of goats.

iii. Rob, Zabadi, and Gariss (Sudan**)**

The Sudanese history of utilizing milk dates to 5000 years ago. Sudanese of the Meroe Kingdom (690 BC-AD 323) may have known how to ferment dairy animals' milk (Abdelgadir et al. 1998). Dirar (1993) classified the Sudanese fermented dairy products into two noteworthy categories: the really indigenous, which includes Ransack, Gariss, Biruni, and Mish; and the semi-indigenous, which includes Zabadi and Gibna beida (Dirar 1993; Abdelgadir et al. 1998).

iv. Kadam (Mali)

Kadam is a conventional refreshment in Mali, especially in the hot season. Leftover milk is collected and left to sour. Contingent upon the season, the souring may take a couple of hours or a few days.

v. Ikivuguto (Rwanda)

Milk represents an important food, and its nutritional value, as well as its many health benefits, has been well-known to the Rwandese society since ancient times. Milk and its products, including the ikivuguto, assume a key part in the economic and social life of Rwandans. The conventional method for creating Ikivuguto is that once the cow has been milked, the milk is put in a container called an "*inkongoro*." After this, the milk is transferred to a big, wooden container called "*icyansi*," and is left at room temperature in a warm and clean place called "*uruhimbi*." To keep the product safe, the container is normally secured either with a straw-woven cover, known as "*umutemeri*," or with a top produced using a calabash. An aging time of no less than two to three days is required.

3.0 Milk Production and Fermentation in Rwanda

Milk production in Rwanda has steadily grown over the years due to an increase in the number of cows and improved cow breeds. Gradual increase in milk production in Rwanda was observed since the beginning of the last decade; from 50,000 Mt (million tons) in 2000 to about 731,000 Mt in 2015 (IFAD 2016). The increase in milk production is associated with the increase in the total number of cows, improved breeds, and animal health care. Before 1994, Rwanda had around 600,000 head of cattle, which increased to 1,349,792 in 2016. Of that cattle population in Rwanda, 615,631 (45 percent) were local breeds, 439,414 (33 percent) were dairy crossbreeds, and 294,747 (22 percent) were pure dairy breeds (IFAD 2016). The dairy sector was found to be the fastest growing agricultural sector in Rwanda, accounting for 10.5 percent of agricultural GDP (IFAD 2016); agriculture accounts for over 33 percent of Rwanda's GDP (Daly et al. 2016). The increase in cattle and milk production in Rwanda is linked to programs initiated by the government of Rwanda such as Girinka, which is a poverty reduction program that gives one cow, free of charge, to a poor family, artificial insemination, animal health, and animal husbandry (IFAD2016).

However, milk consumption in Rwanda is still low compared to the recommendation of 220 liters per capita by WHO (Heifer International 2008). In the 1990s, milk consumption was less than 20 liters per person per year, and 64 liters in 2015 (IFAD 2016). In the National Dairy Strategy of 2013-2017, MINAGRI (2013) revealed that milk consumption in Rwanda was 40 liters per person per year, with the target of 80 liters per year in 2020. Around 75 percent of milk is consumed in rural areas (Karenzi et al. 2013). Ikivuguto is one of most liked milk products and is widely consumed in many areas of the country in addition to being interconnected with Rwandan culture. Since the majority of milk sold informally is used for ikivuguto, the government seeks to improve the way milk is collected by ensuring that milk is tested at the points of sale (IFAD 2016). Further, the government is in the process of formalizing milk collection and increasing the consumption of processed milk rather than raw milk (IFAD 2016). Article 5 of the Ministerial Order for selling milk states that milk must be tested for quality (MINAGRI 2016). Article 14 specifies that the person selling fermented milk must apply in writing for a license at the sector level where the kiosk is located (MINAGRI 2016). Article 15 states that for fermented milk and ghee to be sold at the kiosk, they must comply with standards established by the Rwanda Standard Board

(MINAGRI 2016). The Rwanda government supports the marketing and consumption of all types of milk and milk products after testing the quality.

3.1 Milk Collection, Transport, and Quality Control in Rwanda

Milk collection in Rwanda is of two types: formal and informal. It is reported that the formal collection count is between 10 and 15 percent, while the informal collection count is between 85 and 90 percent (Daly et al. 2016). Karenzi et al. (2013) report that 96 percent of milk is sold informally. Most of the formally collected milk goes to industrial processing before marketing, while the milk collected informally is subjected to traditional processing or is marketed raw. Informal milk collection can be suspicious due to some instances of adulteration and poor hygiene. Transporting milk in plastic jerry cans, which is not uncommon in Rwanda, increases the total bacteria count and shortens the stability of the product. The government is proposing to collect all milk through collection centers before marketing to ensure its quality. One hundred milk collection centers were built in Rwanda, out of the 177 needed to collect all the milk. However, only 28 milk centers are fully functional (IFAD 2016).

Milk is an unstable product that must be handled with care, and it must be checked for quality before processing or consumption. Hand milking is commonly practiced in Rwanda (around 98.6 percent); the remaining 1.4 percent is milked mechanically. Mechanized milking is mainly done in Kigali (Land O'Lakes, Inc. 2012). It was reported that the majority (98.5 percent) of people wash their hands before milking, and 80 percent of udders are washed prior to milking (Land O'Lakes, Inc. 2012). In rural areas, wooden equipment is used for milking and storing milk (*inkongoro* is used for milking, and *icyansi* is for storing). Some use plastic equipment for storage; however, wooden and plastic equipment are not easy to clean, and they can harbor microorganisms, which can compromise the quality of milk. It is advised that milk should reach its cooling center within two hours of milking (DMS 2009; Land O'Lakes, Inc. 2012). Milk testing is also at a low level, and it was reported that 47 percent of milk sold by farmers is not tested at the point of sale (Land O'Lakes, Inc. 2012).

The principal tests for milk are acidity and density (Majyambere 2012). Other tests conducted include visual observation and taste. The lack of cooling systems in rural areas leads to the waste of a lot of milk. Some milk is adulterated, leading to the rejection or production of products with poor quality (Land O'Lakes, Inc. 2012). It was reported that 62.5 percent of milk processors encounter adulterated milk less than 3 times a week, while 12.5 percent encounter adulterated milk more than 3 times a week. It was also reported that milk leaves collection centers having an average of 500,000 to 700,000 total bacteria count per ml (TBC/ml), and by the time milk reaches the processing plant, it grows from 800,000 to 1,300,000 TBC/ml, and the Rwanda Standard Board (RSB) recommendation is less than 1,000,000 TBC/ml (Land O'Lakes, Inc. 2012). If the milk clots when boiled, it cannot be processed due to a high acidity related to a high number of bacteria (Majyambere 2012). Milk should be handled with care and quickly chilled in order to prevent microbial proliferation, which can compromise its quality.

3.2 Processing Traditional Fermented Milk, 'Ikivuguto,' in Rwanda

Ikivuguto is a fermented milk product consumed in many parts of Rwanda. Fermentation is done by environmental microorganisms emanating from milking equipment or from the air. This causes ikivuguto's quality to vary from one batch to another or from one place to another. In some areas, milk is allowed to stand in a container after milking, and microorganisms present in the containers intervene in fermentation (Karenzi et al. 2013). In many rural areas, wooden equipment is used, such as an *inkongoro* for milking, and an *icyansi* (*igicuba*) for fermentation. Either wooden or another type of lid can be used. After fermentation stirring is done, the product obtained is called ikivuguto, which is consumed directly (Karenzi et al. 2013).

In some areas, ikivuguto is churned by women; the process takes around two hours, using an *igisabo* (a big calabash). Butter (*ikimuri*) is separated, and the remaining milk product is called *amacunda*. Amacunda is used for drinking, while *ikimuri* is subjected to an aging process and used either as frying oil in food preparation, or as a cosmetic product. Another method of preparing ikivuguto is to add pre-fermented ikivuguto (starter culture) to heated and cooled milk, then allowing it to stand at room temperature to ferment. Fermentation is more controlled in the second type than in the first. Once a good ikivuguto is used, the end product will also be good; however, there is a fear of disseminating pathogens once the milk used as starter culture is contaminated since quality control is rarely done. In some areas, after fermentation is complete, products are refrigerated so that they can last longer. In both types of fermentation, microorganisms that intervene in fermentation are responsible for the taste, flavor, and texture of the final product (Karenzi et al. 2013).

3.3 Microorganisms Involved in Ikivuguto Fermentation

There are different microorganisms that intervene in ikivuguto fermentation, and they are known as LAB (Lactic Acid Bacteria). There are different types of LAB for milk fermentation, including *Lactobacillus, Lactococcus, Streptococcus*, and *Leuconostoc sp.* (Gehemu 2015). LAB involved in ikivuguto fermentation are *Lactococcus lactis* and *Leuconostoc pseudomesenteroide*, as well as *Leuconostoc mesenteroides* subsp. *mesenteroides* to a lesser extent since it does not grow alone in milk (Karenzi et al. 2013). *Lactococcus lactis* takes 8 hours to complete fermentation at pH 4.6, and *Leuconostoc pseudomesenteroides* takes 14 hours with a titratable acidity of 80^{o}D (Karenzi et al. 2013). When ikivuguto is kept at 4^{o}C, it can last for 36 days without deterioration (Karenzi et al. 2013). Ikivugoto was reported to have more resemblance in both consistency and flavor to a Sweden product called "*Filmjölk*," which is fermented by *Lactococcus lactis* and *Leuconostoc mesenteroides*, mesophilic lactic acid bacteria. The consistency of ikivuguto also resembles that of yogurt, which is fermented by thermophilic LAB *Lactobacillus bulgaricus* and *Streptococcus thermophilus* (Karenzi et al. 2013). LAB contribute to the preservation of milk due to the acid production and increase in flavor, and LAB fermented products were found to be beneficial to health due to different bioactive compounds they produce (Gehemu 2015).

3.4 Use of Synthetic Starter Culture in Milk Fermentation in Rwanda

Fermented milk is obtained by adding starter culture to raw milk to obtain sour milk. During fermentation, lactic acid bacteria convert lactose into lactic acid, which is responsible for the sourness of milk. In this process, the pH drops below 4.6, which contributes to the preservation of milk by preventing pathogens to grow (DMS 2009; Gehemu 2015). During fermentation, other byproducts develop and are responsible for the pleasant flavor and aroma of the product (Gehemu 2015). During the manufacturing of ikivuguto, whole or skimmed milk can be used. Starter culture used is made of a mixture of *Streptococcus cremoris, Streptococcus diacetylactis,* and *Leuconostoc citrovorum* (DMS 2009). Starter culture is added at the rate of 2 to 3 percent to milk, which is pasteurized and cooled at room temperature (DMS 2009).

3.5 Consumer Behavior Regarding Ikivuguto Consumption in Rwanda

Milk is consumed in both processed and unprocessed forms. A high amount of milk is sold to the informal sector where it is either processed or consumed raw. A majority of ikivuguto consumers are in the informal sector because their products are affordable for consumers of middle and low purchasing power. The price of formally processed milk doubles after processing due to the processing cost and packaging material. For example, the cost of packaging material for yogurt is estimated to range between 15 and 20 percent of total production (Daly et al. 2016). The high cost of industrially processed milk leads to the consumption of ikivuguto by a high number of people from different economic statuses (Majyambere 2012). A survey conducted in the Nyanza district revealed that ikivuguto is preferred by adults, and they do not feed it to children because it is sour. They fear that it is not nutritious, and spontaneous fermentation can introduce pathogens that can cause the product to be unsafe (Kazaroho et al. 2016). Fermented milk is consumed alone or with meals (Kamanzi and Mapiye 2012). A high consumption rate of ikivuguto was also reported by other authors (Majyambere 2012; Karenzi et al. 2013). Milk sold informally is over 70 percent of the total production, and retailers sell it in the forms of raw milk, curd milk, or ikivuguto, and UHT milk (DMS 2009). Table 1 shows that fermented or curdled milk is the second highest consumed variety, after boiled milk.

Milk Product	Raw Milk	Boiled Milk	Pasteurized Milk	Curdled Milk (Ikivuguto)	Cheese
Percentage	1	43	13	38	5

***Source**: Land O'Lakes, Inc. 2012*

Table 1: Form of Milk Consumption in Rwanda

4.0 Material and Methods

4.1 Socio-economic Characteristics of Respondents

In this survey, mostly females of different ages, matrimonial status, and levels of education, were interviewed. The processor/seller respondents were composed of 87 percent females and 13 percent males. Regarding the age, the highest proportion of respondents (80 percent) was between 19 and 45 years old, and 20 percent were above 45 years old. No person below 18 years old was encountered during the survey of ikivuguto producers and sellers, which can mean that people under 18 are too young to enter the business. It was also observed that 71 percent of respondents were married, 27 percent were single, and 2 percent were widowers. Regarding the education level of processor respondents, the study showed that 82 percent attended at least secondary school, and 28 percent attended primary school, whereas 7 percent had no formal education. On the other hand, interviewed consumers were composed of 42 percent males and 52 percent females, and the majority (90 percent) ranged from 19 to 45 years old. Ikivuguto processing and commercialization is mainly a business for women, and its processors can be found at all levels of education and people, with secondary education occupying more than half of processors. Due to the short shelf life of ikivuguto, all processors/producers we talked to also retail directly to consumers. A breakdown of ikivuguto producers and consumers we interviewed can be found below (Table 2).

District	Processors/Sellers	Consumers
(Eastern Province)		
Gatsibo	28	9
Nyagatare	26	5
Kayonza	1	4
Ngoma	13	3
Kirehere	1	1
(Western Province)		
Nyabuhu	6	6
(Northern Province)		
Musanze	13	5
Burera	2	1
Gicumbi	3	-
(Southern Province)		
Huye	4	-
Nyanza	3	1

Table 2: Ikivuguto Producers and Consumers' Locations

Government organizations were interviewed about the promotion of ikivuguto. From the Rwanda Standard Board (RSB), a top standard development officer was interviewed. From the Ministry of Agriculture and Animal Resources (MINAGRI), the Director of Agriculture and Livestock Inspection and Certification Services was interviewed. From the Ministry of Health (MINISANTE), a health sector policy specialist was interviewed, and from Nyanza Dairy, which is a government owned milk processing plant that processes ikivuguto, a production manager was interviewed.

5.0 Discussion

5.1 Availability and Quality

Ikivuguto is produced by fermenting cow milk. Milk production varies from cow to cow, and local breeds produce less milk compared to exotic breeds (MINAGRI 2013). Seasons also influence the availability of

milk. Milk is abundant in the rainy season when feeds are plentiful, while during the hot season, production is significantly less. The study shows that milk is available all the time in all parts of Rwanda, but with fluctuations. Approximately 63 percent of processors get enough milk all the time; 15 percent get enough during the rainy season and see a shortage in the hot season; and 22 percent never get enough milk. Hot seasons normally occur in June, July, August, and September. Processors get their milk from different sources, and the majority (above 86 percent) obtain raw milk directly from farmers or middlemen.

5.2 Quality Control

Quality control is important for ikivuguto processing since low quality can compromise the health of consumers and the quality of the end-product. Before processing, modern and traditional methods can be used to assess the quality of raw milk. Approximately 48 percent of respondents use modern methods for quality control, 20 percent use traditional methods, and 32 percent never test raw milk due to the trust they have in their suppliers. The quality control of milk was also reported by Land O'Lakes, Inc. (2012) where 47 percent of milk is not tested at the point of sale. However, the use of the traditional method was not reported. Testers conduct small tests, such as density, using a lactodensimeter or the clot-on-boiling method (Land O'Lakes, Inc. 2012). Others buy raw milk from milk collection centers where they are sure that milk has been tested during purchase. Some testers use smell, while others taste the product. For experienced buyers, visual observation is enough to know when milk has been adulterated with water. Good quality milk is thick with a good-looking cream. Milk can be poured on the ground, and when it spreads and dries quickly, it is an indicator that it is adulterated with water. Good quality milk does not spread and dry. To further test whether milk is adulterated with water, it is allowed to stand for some time. During this time, water will separate from other components of milk if the milk is adulterated with water. Moreover, boiling good quality milk brings up the foam while poor quality milk doesn’t bring foam to the top. Those who rely on trust always buy from suppliers they know very well, who practice hygienic conditions, and who do not dare to adulterate their milk. Feedback from consumers is also mainly used by those who trust their suppliers.

5.3 Ikivuguto Processing

Approximately 75 percent of respondents use traditional fermentation which in this case is simply raw milk, left to ferment without the use of starter culture or additives, while the remaining 25 percent either use traditional or modern starter culture. During ikivuguto processing, raw milk is boiled in a pan after a quality check. Fire wood or charcoals are used as a heat source. Once boiled, milk is cooled at room temperature while using a mixer to prevent creaming. After cooling, milk is filtered into a well cleaned saucepan or bucket, and a small quantity of previously fermented milk, known as *imvuzo*, is added to initiate fermentation. Others may add industrially made imvuzo; however, some do not add anything. In these three cases, milk stands overnight in a fermenter (bucket, saucepan, or can) for fermentation; this takes 12 hours or longer. Fermentation is slow at a low temperature, and quicker at a high temperature.

Natural fermentation is responsible for the variation in ikivuguto from one batch to another (Karenzi et al. 2013). After fermentation, ikivuguto is obtained, and after stirring, it can be consumed directly (Karenzi et al. 2013). The final product can be kept in a fridge to stop fermentation for later consumption. However, those who do not have a fridge transfer ikivuguto into jerry cans for storage. The product is served to customers in glass cups.

5.4 Consumer Perception

The ideal ikivuguto is firm and homogenous in texture, not too sour, and white in color. It does not have other scents apart from the natural milk. Consumers prefer non-industrially produced ikivuguto to the industrially produced variety because of its natural taste. Additives in commercially produced ikivuguto can alter its taste, texture, and flavor. Microorganisms, which intervene in fermentation, were reported to be responsible for the taste, flavor, and texture of the final product (Gehemu 2015; Karenzi et al. 2013). Consumers are also concerned with the effects of the additives on their health and testified that traditionally processed ikivuguto is thicker than its industrial-made counterpart. Table 3 shows consumer perception concerning the different quality parameters of ikivuguto where safety was classified as the most important. Failure to meet product safety can endanger the lives of consumers by exposing them to diseases.

Intrinsic Quality	Very Important	Important	Neutral	Somewhat Important	Not Important
Sensory	51.72	24.14	17.24	6.9	0
Safety	89.66	10.34	0	0	0
Shelf life	75.86	24.14	0	0	0
Convenience	31.03	55.17	6.9	6.9	0
Health	55.17	44.83	0	0	0

Table 3: Characteristics of Ikivuguto

5.5 Shelf Life

Ikivuguto is a product with short shelf life. Shelf life depends on the storage conditions. The shelf life of ikivuguto tends to increase when stored in the fridge and shortens at room temperature. The study revealed that the shelf life of ikivuguto, for more than 80 percent of processors, is 2 to 3 days. During fermentation, the pH drops below 4.6, contributing to the preservation of milk by preventing pathogens' growth (DMS 2009; Gehemu 2015). This shelf life is short for a commercial product. The main reason for this short shelf life may be linked to a lack of facilities like refrigeration. The fridge's temperature hinders

lactic acid bacteria (LAB) from continuing fermentation by stabilizing the quality of the product. On the other hand, milk kept at room temperature continues to undergo fermentation, and when the increase of acidity is too high, the product becomes sour and less palatable. On the other hand, the short shelf life of ikivuguto may be linked to a lack of packaging materials. It was found that 80 percent of ikivuguto is not packaged, and the remaining 20 percent is packaged in plastic jerry cans. This implies that environmental microorganisms can enter the product during serving, thereby contributing to the deterioration of the product. Packaging in plastic jerry cans is also suspicious because these materials are obtained after exhausting edible oil, and they are not easy to clean.

5.6 Health and Nutritional Benefits of Ikivuguto

Milk is a product with a high amount of nutrients. It contains protein, carbohydrates, lipids, vitamins, and is a good source of minerals. In combination with bread, milk can be a complete diet. During fermentation, health promoting agents are produced by LAB. LAB fermented products were found to be beneficial to health due to different bioactive compounds they produce (Gehemu 2015). Consuming ikivuguto helps body protection against different types of diseases. Interviewed consumers were all aware of the health benefits associated with milk; while 55 percent classified milk as very important, 45 percent classified it as important. Ikivuguto is used to test and detoxify intoxicated people. Once an intoxicated person drinks ikivuguto, he may vomit, which can help to alleviate toxicity.

5.7 Ikivuguto and Economic Empowerment in Rwanda

Ikivuguto is known everywhere in the country and is an integral part of the local culture. It is a product that is locally made, affordable, and consumed by people of different categories. A majority of interviewed consumers (85 percent) reported that they have been consuming ikivuguto for over a decade, and, among them, some have been consuming it since they were infants. Land O'Lakes, Inc. (2012) reported that ikivuguto is consumed at the rate of 38 percent compared to other types of milk. Kazaroho et al. (2016) reported that ikivuguto is preferred by adults and is consumed alone or with meals (Kamanzi and Mapiye 2012). Regarding ikivuguto consumption (Figure 1), more than 1/3 of consumers spend between 2,000 RWF and 5,000 RWF on ikivuguto per month, and slightly less than 1/3 spent between 10,000 RWF to 20,000 RWF per month. Consumers who spend more than 20,000 RWF per month total 14 percent. Ikivuguto is consumed by people from different backgrounds, with rural areas dominating the market.

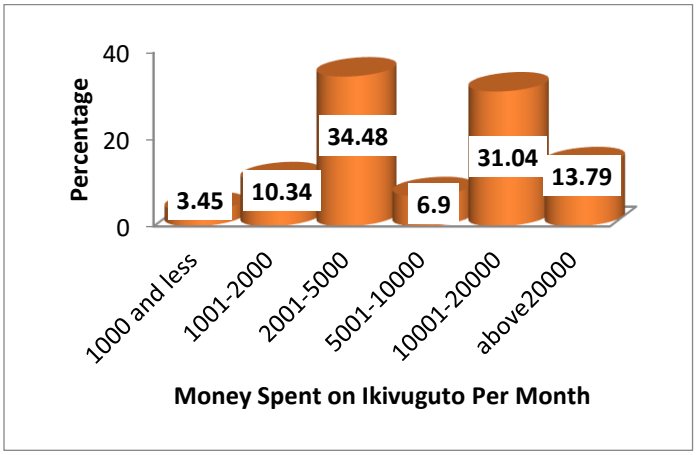

Figure 1: Money Spent on Ikivuguto per Month by Consumers

5.8 Ikivuguto and Women Producers

Ikivuguto has been used for ages and it does not need to be advertised for consumers to purchase it. It is produced using cheap, raw materials, and its price is affordable. The price of milk depends on the area of the country. Areas with a high quantity of milk tend to have a lower price, while areas with low quantity tend to have higher prices. In areas with an abundant milk supply, the price ranges between 150 and 250 RWF per liter, as shown in Figure 2. The majority of ikivuguto processors earn 100 RWF or less per liter. The profitability of small-scale dairy sectors was also reported by IFAD (2016). Those who process more are likely to earn more. However, the processing capacity of ikivuguto producers is still low since the processing capacity of 62 percent of producers is still less or equal to 20 liters per day.

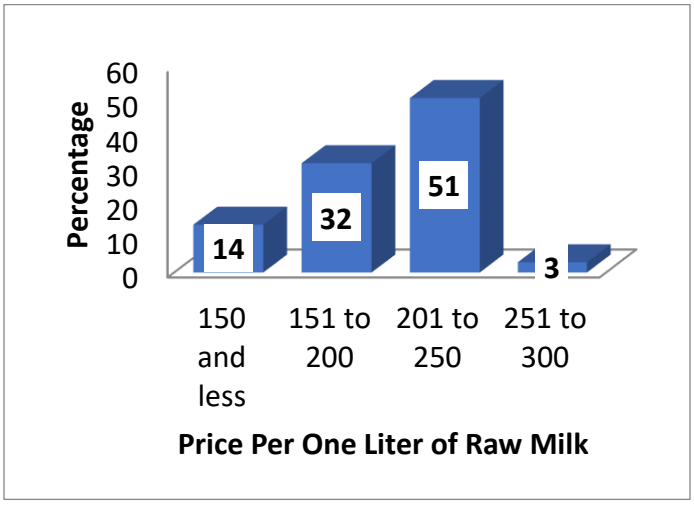

Figure 2: Price of Raw Milk

Consumers are willing to accept increasing prices if the quality of ikivuguto improves. All interviewed consumers (100 percent) reported that ikivuguto should not be banned for any reason. However, they are

willing to pay additional costs for improved ikivuguto. The promotion of ikivuguto through certification is another option that the government is considering for traditionally processed and sold ikivuguto, although this will come at a considerable cost to the government (MINAGRI 2013). Ikivuguto was reported to be a profitable product, and its competitiveness is confirmed by more than 93 percent of respondents. About 70 percent of processors reported that they sell all their products. Most people involved in processing and selling ikivuguto are female, while males outnumber females in supply and consumption (Table 4).

Activity	Gender	Percentage
Raw Material Suppliers	Male	62.86
	Female	37.14
Processors	Male	3
	Female	97
Sellers	Male	10
	Female	90
Middlemen	Male	94
	Female	6
Consumers	Male	62.86
	Female	37.14

Table 4: Gender Distribution in the Value Chain of Ikivuguto

5.9 Government Support

In Rwanda, the government supports small scale enterprises through various means, including the facilitation to conduct business and the provision of finances and trainings. Although the government of Rwanda facilitates businesses, however, a majority of people (95 percent) revealed that they have not received any support from the government, and 5 percent received support in terms of training. The government is seeking to improve the way milk is collected by making sure that milk is tested at the point of sale (IFAD 2016). This will help in processing safe products and reduce spoilage during production. Moreover, fermented milk sold at kiosks must comply with standards established by the Rwanda Standard Board (MINAGRI 2016). Similarly, the Rwanda Standard Board (RSB) is in the process of providing training and issuing safety certificates to small scale processing plants; the ikivuguto sector is no

exception. This will help consumers trust the quality of processed ikivuguto, and the product will be able to be sold far from areas of production, which will increase the income of the processors.

5.10 Challenges for Rural Women Ikivuguto Producers

Milk production is not constant throughout the year, and it is a very sensitive product that requires careful handling. Milk production is high during the wet season when feed is abundant and decreases in the dry season due to the reduction of feed. Approximately 28 percent of processors did not experience price fluctuation in processing, 33 percent experienced wide fluctuation, and 39 percent reported slight fluctuation. The variation in prices affects 43 percent of business people involved in the ikivuguto market. Effects on businesses are mainly related to the shortage of milk for processing, increase in price of both raw and processed milk, and reduction of consumers due to the increase in price. Milk production can be increased through animal health and animal husbandry (IFAD 2016). To maintain uniformity in milk supply, it is better to make sure that feed is available throughout the year. The availability of feed may be achieved by storing grasses, like silage or hay, during the abundant production time, so that they can be used during dry season. To satisfy those who never get enough milk and increase milk production, a possible solution could be the addition to herds of some animals of exotic breeds that have high milk production, but also high maintenance requirements (MINAGRI 2013).

Milk is a very sensitive product, and it is affected by inadequate infrastructures, knowledge, and the capital of processors. This study revealed that in the business of ikivuguto, 25 percent of processors have encountered spoilage of ikivuguto during processing, and they are unaware of the causes of spoilage. Training can help processors know and test quality parameters of good raw material (DMS 2009). Many processors do not know how to measure the quality of raw milk, which leads to buying low quality milk that cannot be processed or to the selling of low quality product. There is no doubt that those who depend on trust (approximately 32 percent) are unaware of the quality parameters of milk. Moreover, the lack of a cooling system is responsible for wasting a lot of milk, which can lead to rejection or poor quality products (Land O'Lakes, Inc. 2012). Electricity cuts lead to the rapid growth of microorganisms, thereby spoiling both raw and processed milk. The quality of milk can also be compromised during handling by using plastic or non-stainless-steel equipment. Poor roads, transporting milk at high temperatures, and using bicycles for transportation contribute to milk loss before reaching the market or processing area (DMS 2009; ADF 2011). Some consumers wish to take ikivuguto to their homes; however, that is not possible due to lack of packaging materials. It was also revealed that 93 percent of ikivuguto producers do not involve middlemen in selling their products. This means that ikivuguto is consumed in the area of production. Ikivuguto producers should be trained on how to expand their businesses by reaching different areas of the country, and even on exporting it. Most processors produce low quantity ikivuguto, and this is linked to insufficient capital, requiring a link between the processors and the banks so that processors can increase their production.

6.0 Conclusion

Ikivuguto is a traditionally fermented milk product and is fermented by environmental microorganisms. Most people involved in the ikivuguto business are females. The product is consumed by both men and women and is consumed and commercialized by people of different ages and levels of education. It is a competitive product and predominates in rural areas. Compared to other milk products, ikivuguto ranks first for being consumed by a high number of people. The reduced milk supply and its increased price in the dry season affect the ikivuguto business. Ikivuguto has a shelf life of two to three days; however, it can be prolonged when it is kept in a refrigerator. Some people involved in the ikivuguto business are not aware of the quality parameters of milk, and they experience spoilage during processing. Insufficiency of infrastructure and low capital are also constraints in the milk sector.

According to the findings, traditionally fermented ikivuguto holds the potential to improve the economic situation of many rural women in Rwanda. The majority of ikivuguto processors earn 100 RWF or less per liter. The more ikivuguto is processed, the more likely it is to earn more money per liter. Ikivuguto was reported to be a profitable product, and its competitiveness is confirmed by more than 93 percent of respondents. About 70 percent of processors reported that they sell all their products; however, the processing capacity of rural women producing ikivuguto is still low since the processing capacity of 62 percent of producers interviewed is still less or equal to 20 liters per day.

There have been concerns regarding hygiene in the production of ikiguvuto that may lead to the government banning the product; however, consumers are willing to accept increased prices if the quality of ikivuguto improves. All interviewed consumers (100 percent) reported that traditionally fermented ikivuguto should not be banned for any reason, such as poor hygiene in the production, opting instead to pay additional costs for improved ikivuguto. Rather than placing a ban on the traditional production of ikivuguto, the proposed certification of producers by the Ministry of Agriculture is likely to increase the number of its consumers.

Further, there are certain constraints that impede the extent to which rural women can benefit from the production and marketing of ikivuguto. These impediments relate to poor roads, milk transportation at high temperatures, and bicycle transportation. The amount of milk lost due to these constraints is estimated to be 35 percent. Roads, water, electricity, and training are needed and will provide huge benefits to rural women producing ikivuguto. The provision of cooling facilities will help increase quality and quantity. Training ikivuguto producers on hygiene and quality to produce reliable products is also necessary. During training, an emphasis should be placed on the prevention of adulteration and on the microbiological quality of milk. Packaging materials increase the price of the product and are out of reach of rural women who sell their products unpackaged, thereby shortening its shelf life. Promoting rural tourism in relation to indigenous beverages, such as fresh, unpackaged ikivuguto, can improve rural women's income without the financial burden of packaging. Most female producers of ikivuguto are interested in expanding their business, but they are not able to do so due to lack of capital. Forming cooperatives can help address this issue. On the whole, ikivuguto is a viable product that can greatly

empower rural women economically, especially when the noted challenges and constraints in this paper are addressed appropriately.

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