FOOD SAFETY IN MILK MARKETS OF SMALLHOLDER FARMERS IN TANZANIA: A CASE OF PERI URBAN WARDS IN TEMEKE MUNICIPALITY

BY

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ABSTRACT

The present study was carried out to establish food safety status of milk marketed by smallholder farmers in peri-urban wards of Temeke Municipality, Dar es salaam Tanzania between January 2010 to March 2010. A total of 69, 7 and 44 milk samples respectively from farmers, milk vendors and milk kiosks were collected from four randomly selected wards to assess presence of toxin producing s*taphylococcus aureus*. At randomly selected milk selling shops, 120 consumers were interviewed on their perception regarding safety of milk. Standard methods were used to isolate *S. aureus* in milk samples. Data were analyzed using SPSS version 12.0. About 1792 litres (90%CI: 1337-2358) of milk are sold everyday in Temeke municipality peri-urban wards kiosks and out of this amount, 407 litres (90%CI: 119-799) was found to be contaminated with *S. aureus*. The probability of purchasing contaminated milk was therefore 0.227 (90%CI: 0.062-0.436). Every day, 953 (90%CI: 718-1,249) people purchase milk from kiosks in peri-urban Temeke, and among them, 217 (90%CI: 62-427) people were estimated to purchase contaminated milk. Milk quality as defined by Total Bacterial Count (TBC) along the chain was also determined and found to be an average of $2.8 \times 10^6 \pm 9.8 \times 10^5$ cfu at producer level, $3.4 \times 10^7 \pm 2.6 \times 10^7$ cfu at vendor's level and $4.8 \times 10^7 \pm 3.3 \times 10^7$ cfu at kiosk level. TBC values for kiosk milk served hot was also determined and found to be an average of $3.7 \times 10^5 \pm 2.3 \times 10^5$ cfu. Other organisms isolated in the milk samples include *Bacillus spp*, *Escherichia coli*, *Proteus spp*, *Enterobacteria spp*, *Corrynebacterium spp* and *Micrococcus* spp. Consumers knowledge on health risks associated with milk consumption was high (71.67%) and there was no significant difference on the level of awareness among consumers in the sample wards (P>0.05).

DECLARATION

I, Kaiza Kilango Gratian, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and has neither been submitted nor been concurrently submitted for degree award in any other Institution..

Kaiza Kilango Gratian Date

(MSc. Human Nutrition Candidate)

The above declaration is confirmed by

Prof. L.R. KURWIJILA Date

(Supervisor)

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DEDICATION

This work is dedicated to my mother Mrs Natujwa Kaiza, my best friend Violeth and my lovely uncle Dominic Leonard.

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SYMBOLS AND ABBREVIATIONS

CAST	Council for Agricultural Science and Technology
CCP	Critical Control Point
EAS	East African standard
FAO	Food and Agriculture Organization of the United Nations
FGDs	Focus Group Discussions
HACCP	Hazard Analysis Critical Control Point
HIV/AIDS	Acquired Immune Deficiency Syndrome
ILRI	International Livestock Research Institute
MoAC	Ministry of Agriculture and Co-operatives
NMC	National Mastitis Council
OIE	The World Organization for Animal Health.
PUI	Peri-urban Interface
SEs	*Staphylococcus aureus* enterotoxins
SPSS	Statistical Packages for Social Sciences
SUA	Sokoine University of Agriculture
UPA	Urban Peri-urban Agriculture

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

The World is becoming increasingly urban. In most developing countries, the rate at which cities grow is very high and it is expected that by 2025 more than 50 percent of the population in the developing world will be living in cities (FAO, 2000). The practice of producing crops and/or raising livestock within urban and peri-urban areas plays a big role in feeding these growing city populations (FAO, 2000) cited by (Makita *et al.,* 2009). It should be noted that urban and peri-urban agriculture also carries public health risks; examples of risks include transmission of zoonotic diseases (Makita *et al.,* 2009).

The peri-urban interface (PUI) is characterized by a co-existence of urban and rural activities (Douglas, 2008). The term PUI, while widely used lacks a single, universal definition and most of the time researchers define it depending on their circumstances and situations. In this study PUI is defined as the areas around cities and towns characterized by rapid demographic, economic, environmental, social and cultural interactions and changes (Makita *et al.,* 2009).

Food safety and trade issues related to farming, including urban and peri-urban agriculture (UPA), are becoming more pronounced. There has been an increased scientific awareness of the public health risks from unsafe food, including both acute and long-term health consequences (Lindsay, 1997).

Food safety programmes are increasingly focusing on a farm-to-table approach as an effective means of reducing foodborne hazards. This holistic approach to the control of food-related risks involves consideration of every step in the chain, from raw material to food consumption. Hazards can enter the food chain on the farm and can continue to be introduced or exacerbated at any point in the chain (Frost, 2005).

Collecting quantitative and qualitative information about milk-borne health risks under different production and marketing situations is an important step to address food safety concerns. The present study attempted to determine dairy marketing in peri-urban wards of Temeke Municipality, in Dar es Salaam city, so as to assess public health risks from the informally marketed milk. The study concentrated on informally marketed milk because in Tanzania, the informal market comprises over 90% of market share (Omore *et al*., 2001). Informal milk marketing is of public health concern in most developing countries including Tanzania, because it is facing hygiene and safety problems in all areas of food production and retailing (Solution Exchange, 2008). Potential health hazards transmissible through milk and milk products include the classical zoonoses i.e. bovine tuberculosis and brucellosis. Others include those associated with contamination by coliforms e.g. *E. coli*-O157:H7, *Listeria monocytogenes, Salmonelosis,* and toxin producing *Staphylococcus aureus* (Unger and Munstermann, 2004).

1.2 Problem Statement

Malnutrition affects one in three children worldwide. Animal source foods have a positive impact on the quality and micronutrient enhancement of the diet of children and women, and can prevent or ameliorate many micronutrient deficiencies (Neumann and Harris, 1999).

Although dairy products are deemed one of the first class protein and safest classes of food, there is considerable concern, because hazards originating from dairy products could affect a large number of consumers. Potential problems are associated with the presence of microbiological hazards (e.g, *Listeria monocytogens*, *Salmonella*, *Staph. aureus*, *E. coli*) and chemical hazards (e.g., natural toxins, drug residues, food additives) (Jones, 1999). Blowey and Edmondson (2000), reported that although milk is a very nutritious food that is rich in carbohydrates, protein, fats, vitamins and minerals, it can be associated with health risks to consumers, such as presence of zoonotic pathogens and antimicrobial drug residues, especially in informal markets. The quality of milk may be lowered by a number of factors such as milk adulteration, contamination during and after milking, and presence of udder infections.

1.3 Research Justification

Currently, most of the milk sold in Tanzania and the developing world in general is sold in informal markets where conventional regulation and inspection methods have failed and where private or civil sector alternatives have not emerged. According to European Academies Science Advisory Council it estimated that at least 60% of all human pathogens are zoonotic (European Academies Science Advisory Council, 2008). Risk based approaches for assessing and managing food safety offer a powerful new method for reducing the enormous health burden imposed by food borne disease, while taking into account other societal goals such as pro-poor economic growth. Initial studies by ILRI and partners (Grace *et al*., 2009), have shown the effectiveness and impact of risk-based approaches applied to informal markets; however, examples of their field use have not been introduced, the capacity to implement them has not been developed and the constraints to uptake of the concept have not been properly described yet in developing countries. This study attempted to fill this gap, developing tools and evidence that allow risk analysis to be applied in informal markets.

1.4 Objective of the Study

1.4.1 General objective

The main objective of this study was to assess safety of milk produced and marketed by smallholder farmers and their market intermediaries in informal channels.

1.4.2 Specific Objectives

The specific objectives of the study were:

1. To assess prevalence of potential milk borne hazards and likelihood of their occurrence along producer to consumer food chain.
2. To conduct risk assessment on specific milk food safety hazard.
3. To validate consumers perception of milk food safety from various informal outlets.

1.5 Hypotheses

Ho: Milk marketed in informal sector is free from coagulase positive *Staph. aureus.*

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Definition of Peri-urban

Peri-urban settlement can be defined as transition areas from rural to urban, the speed of population increase is high, migration is from city or town by house construction, and there is still space for crop cultivation (Makita *et al.,* 2009).

2.2 Importance of Food Safety

Food safety risks are defined here as they pertain to human health, covering well-established and perceived impacts from agents and sources including microbial pathogens i.e., illness-causing bacteria, viruses, parasites, fungi, and their toxins (Ahmed, 1991); residues from pesticides, food additives, livestock drugs, and growth hormone (Buzby *et al*., 2001); environmental toxins such as heavy metals (e.g., lead and mercury) (Buzby and Tanya, 1997) as well as zoonotic diseases that can be transmitted through food from animals to humans (e.g., tuberculosis); foods produced or processed with practices perceived to involve risks, such as irradiation (CAST, 1994) and food allergies (Van Putten *et al*., 2010). Milk is among foods which are highly associated with allergies (Kitagwa *et al.,* 2006).

As consumers become better informed, they are demanding better quality and safer food. Quality attributes such as appearance, shape, colour and absence from blemishes can easily be detected by consumers. However, food safety is a hidden quality attribute due to the fact that microbial contamination or chemical residues are not always obvious. This means that any food may present a threat to consumers and may result in illness and general poor health (Mangwayana *et al.*, 2000).

Most export markets now have very demanding quality requirements where specifications such as variety or size must be adhered to. Food health requirements are now very strict and any factors causing illness have to be tested and should not exceed prescribed limits (Nhachi and Kasilo, 1996).

Besides its beneficial effects on nutrition, milk can also act as a vehicle for the transmission of diseases (Hempen *et al.*, 2004). Potential health hazards transmissible through milk and milk products include the classical zoonoses i.e. Tuberculosis and brucellosis. Others are associated with contamination of Coliforms e.g. *E. coli*-O157:H7, *Listeria monocytogenes, Salmonellosis,* and toxin producing *Staphylococcus aureus,* the latter often associated with infectious mastitis. *S. aureus* was hazard of interest in this study based on the fact that, the most common mastitis pathogens previously reported in Tanzania are Gram-positive bacteria, with *Staphylococcus aureus* being the most prevalent (Kinabo and Assey, 1983; Mdegela *et al.,* 2004).

2.3 Health and Economic Impact of Unsafe Food

Food safety is an essential public health issue for all countries. Foodborne diseases due to microbial pathogens, biotoxins, allergens, and chemical contaminants in food represent serious threats to the health of thousands of millions of people. Serious outbreaks of foodborne disease have been documented on every continent in the past decades, illustrating both the public health and social significance of these diseases. Consumers everywhere view foodborne disease outbreaks with ever-increasing concern. Outbreaks are likely, however, to be only the most visible aspect of a much broader, more persistent problem. Foodborne diseases not only significantly affect people's health and well-being, but they also have economic consequences for individuals, families, communities, businesses and countries. These diseases impose a substantial burden on health-care systems and markedly reduce economic productivity. Poor people tend to live from day to day, and loss of income due to foodborne illness perpetuates the cycle of poverty (FAO, 2006).

Food safety issues are a sensitive area in terms of public health management especially from an economic point of view. The subject is made more confusing because the sources of contamination are variable and can take place at any point in the food production and marketing chain. Currently there is limited scientific data to quantify the magnitude of the problem and to provide baseline data from which informed decisions can be made. More information is needed that will help improved regulatory policy decisions to be made. Scientific data will also help ensure more effective control when outbreaks occur (Mangwayana *et al*., 2000).

Unnevehr and Hirschhorn (2000) reported that 70% of deaths among children under 5 are linked to biologically contaminated food and water. Impacts include fatalities in vulnerable groups (e.g. malnourished infants and people with HIV/AIDS) and in 2-3 cases, severe and disabling long-term effects such as joint disease, kidney failure, cardiac, retinal and neurological disorder. Evidence is growing that in developing countries, ill health can not only be a personal and household tragedy, but a major factor in causing and perpetuating poverty (Lawson, 2004).

The cost of food borne diseases is estimated to exceed $5 billion per year in the United States (Foegeding *et al*., 1994), and $1.3 billion annually in Canada (Todd, 1989). Economic burden on people in India affected by an outbreak of *Staphylococcus aureus* food poisoning was found to be higher than in case of a similar outbreak in the US (Sudhakar *et al.*, 1988).

Unsafe food and food borne illnesses also affect producers because they will earn a poor reputation which may take time to overcome. Those who are engaged in marketing unsafe food such as vendors or wholesalers also receive a tarnished reputation. This means that they will lose their market and therefore their incomes will be reduced (Nhachi and Kasilo, 1996).

2.4 Causes of Bacterial Contamination of Milk

2.4.1 Udder health and milking hygiene

The bacteria that cause udder infections in a herd mainly come from infected quarters or cows and the environment in which the animals are kept (Blood and Radostits, 1989). Spread of contagious bacteria to teats of uninfected quarters or cows, occurs primarily at milking time (NMC, 1987). The rate of new infections is however, greatly reduced if proper milking hygiene practices are followed at milking times. Pre-milking udder hygiene *e.g.* washing with clean water and drying using hand towels reduces milk contamination by transient bacteria located on the udder. Teats and the lower portion of the udder must be washed with a warm sanitizing solution, which should be changed periodically to prevent accumulation of pathogens in the solution (Robert, 1996). The use of post milking teat disinfectants has proved to be effective measure in reducing new infections because it reduces the resident teat skin bacterial population, which is the main source of infection for the mammary gland (Kurwijila, 1991).

2.4.2 Personal hygiene

All people involved in dairying should maintain cleanliness and must be in sound health. Organisms may drop from hands, clothing, nose, and mouth and from sneezing and coughing. It is important for milkmen to be in good health so that they not become a source of infectious diseases such as tuberculosis (Kurwijila, 1998).

2.5 Bacteriological Quality of Milk

Total bacteria counts in milk mainly reflect its storage temperature and time elapsed since milking. Coliforms counts indicate the level of hygiene, since coliforms are microorganisms of faecal origin. East African Countries have harmonized standard for some products including milk. The standard plate count per millilitre (or gram) for raw reconstituted (prepared) milk or pasteurized milk (at the plant in the final container) shall not exceed 30,000 (EAS, 2007). The classification for Standard Plate Count/ ml or g in raw milk is shown in Table 1.

Table 1: Microbial limits in raw milk

Grade	cfu/ml
I or A	<200,000
II or B	>200,000-1,000,000
III or C	>1,000,000-2,000,000

Source: EAS (2007)

Various bacteria are ordinarily found in milk, as shown in Table 2. These bacteria easily multiply under favorable temperatures to cause spoilage and/or pose health risks through bacterial infection or production of toxins. Some bacteria such as *Staphyloccus aureus,* if allowed to multiply (normally after milk becomes sour) may produce heat labile toxins that cause illness. Time elapsed since milking and temperature at which milk is stored are the main factors that influence bacterial counts in milk.

The major milk-borne pathogens of concern are zoonoses and environmental coliforms of fecal origin. The latter are commonly introduced in milk due to poor handling at farm and along the market pathway. Common sources of fecal bacteria are use of contaminated water and containers that have not been cleaned properly.

Table 2: Bacterial types commonly associated with bovine milk

Bacteria	Effect on milk/consumer
Lactococci:L.lactis-diacetylactis, L. lactis, L. Cremoris	Flavor production and fermentation
Lactobacillus: L. lactis, L. bulgaricua, L. acidophilus, Leuconostoc lactis, Propionibacterium	Acid production/fermentation
Pseudomonas, Bacillus cereus	Spoilage
Enterobacteriaceae	Pathogenic and Spoilage
Staphylococci: Staph. Aureus	Pathogenic
Streptococcus: Strep. Agalactiae	Pathogenic
Zoonotic Brucella abortus	Pathogenic
Zoonotic Mycobacterium bovis	Pathogenic
Coliforms (mostly introduced through poor hygiene)	Some are Zoonotic and pathogenic (e.g. *E. coli*-0157:H7)
Listeria: Listeria monocytogenes	Pathogenic; mainly in unpasteurised cheese

Source: Adapted from O'Connor (1995)

2.6 *Staphylococcus aureus* in Milk

2.6.1. Microbiology

S. aureus is a facultative anaerobic**,** Gram-positive coccus, which appears as grape-like clusters when viewed through a microscope and has large, round, golden-yellow colonies, often with haemolysis, when grown on blood agar plates (Ryan and Ray, 2004). The golden appearance is the etymological root of the bacteria's name; *aureus* means "golden" in Latin. *S. aureus* is catalase positive (meaning that it can produce the enzyme "catalase") and able to convert hydrogen peroxide (H_2O_2) to water and oxygen, which makes the catalase test useful to distinguish staphylococci from enterococci and streptococci. A small percentage of *S. aureus* can be differentiated from most other staphylococci by the coagulase test: *S. aureus* is primarily coagulase-positive (meaning that it can produce "coagulase", a protein product, which is an enzyme) that causes clot formation while most other *Staphylococcus* species are coagulase-negative (Ryan and Ray, 2004). However, while the majority of *S. aureus* are coagulase-positive, some may be atypical in that they do not produce coagulase (the most common organism in patients with nosocomial bacteremia is coagulase-negative staphylococcus (Matthews *et al.*, 1997). Incorrect identification of an isolate can impact implementation of effective treatment and/or control measures (Matthews *et al.*, 1997).

2.6.2 Mastitis in cows as a source of *S.aureus*

Mastitis is an inflammation of the milk-producing glands causes great pain to the dairy cows (Althaus, 2003). In dairy cows, mastitis is frequently caused by bacterial infections, and less frequently by agents such as yeasts, fungi and algae (Karimuribo *et al*., 2008). Bacterial pathogens that cause mastitis are generally classified as either contagious or environmental based upon their primary reservoir and mode of transmission. The primary reservoir of contagious mastitis pathogens is the udder of the cow, and they are commonly transmitted among cows by contact with infected milk. The most common mastitis pathogens previously reported in Tanzania are Gram-positive bacteria, with *Staphylococcus aureus* being the most prevalent (Kinabo andAssey, 1983; Mdegela *et al.*, 2004).

Mastitis can occur in either clinical or subclinical forms; clinical mastitis is characterised by changes in the udder and milk that are directly observable, whereas the subclinical disease is characterised by an increase in somatic cells in the milk, and the absence of clinical signs (Karimuribo *et al*., 2008). Although mastitis occurs sporadically, it assumes a major economic importance in dairy cattle. Losses attributed to mastitis include reduced milk yield, milk discard, premature culling, treatment costs, and increased labor (Fetrow, 2000). The use of dry cow therapy, post milking teat disinfectants, and effective pre-milking hygiene are effective control procedures for most contagious mastitis pathogens.

Exposure to environmental mastitis pathogens may occur continuously because the primary route of exposure is contact with moisture, mud, and manure. Unlike mastitis caused by contagious pathogens, mastitis caused by environmental pathogens cannot be eradicated from a dairy herd (Smith and Hogan, 1993). The most important environmental mastitis pathogens include gram-negative bacteria (such as *E. coli* and *Klebsiella* spp.) and *Streptococcus* spp. (such as *Strep. uberis* and *Strep. dysagalactia*). Mastitis caused by environmental pathogens can be controlled by reducing exposure and by increasing immune resistance of the cow.

2.6.3. Staphylococcal food poisoning

Staphylococcus aureus is an important food-borne pathogen. It is a versatile pathogen of humans and animals and causes a wide variety of diseases ranging in severity from slight skin infection to more severe diseases such as pneumonia and septicemia. Of particular relevance to the food processing industry is the ability of some *S. aureus* strains to produce heat stable enterotoxins that cause staphylococcal food poisoning (SFP), which ranks as one of the most prevalent causes of gastroenteritis worldwide (Dinges *et al*., 2000). The intoxication is characterized by enteric responses like diarrhea, abdominal cramps, and vomiting within 1-6 h of consumption of contaminated food (Leenalitha and Peter, 2007). The toxins are heat stable proteins (Leenalitha and Peter, 2007). The bacterium is heat labile and does not compete well with other microorganisms and therefore, contamination usually occurs after the food has been processed when there is little competition from other microorganisms.

The organism usually gains access to foods from food handlers or other surfaces like the processing equipment. Although Staphylococci are commonly found on animal skins, water, soil etc, bacteria from food handlers and other human sources are considered as the most important contributing factors to intoxications associated with food (Leenalitha and Peter, 2007). Food poisoning is of great concern to food industries and regulatory agencies as it represents massive health and economic losses. The foods that are commonly contaminated by staphylococcus entotoxins (SEs) are baked dessert items such as cream filled pastries, cream pies, chocolate éclairs, meat and meat products, potatoes, tuna, chicken, turkey, ready-to-eat salads, eggs, poultry, dairy and milk products (Leenalitha and Peter, 2007).

Staphylococcus aureus does not form spores. Thus, *S. aureus* contamination can be readily avoided by heat treatment of food. Nevertheless, it remains a major cause of food borne diseases because it can contaminate food products during preparation and processing. *Staphylococcus aureus* is indeed found in the nostrils, and on the skin and hair of warm-blooded animals. Up to 30-50% of the human populations are carriers (Le Loir *et al*., 2003).

Staphylococcus aureus is able to grow in a wide range of temperatures (7° to 48.5°C with an optimum of 30 to 37°C; Schmitt *et al*., 1990), pH (4.2 to 9.3, with an optimum of 7 to 7.5; Bergdoll, 1989) and Sodium chloride concentrations (up to 15% NaCl). These characteristics enable *S. aureus* to grow in a wide variety of foods. This, plus their ecological niche, can easily explain their incidence in foodstuffs that require manipulation during processing, including fermented food products, such as cheeses.

2.7. Microbiological Risk Assessment

Microbiological Risk assessment in foodstuffs relies on classical microbial detection and quantification of indicator micro-organism. The detection of coagulase positive staphylococci uses a selective Baird-Parker medium, whose composition is standardized (for France, norms AFNOR V08-057/1 and 2, ISO 6888/1 and 2). Sensitivity of these routine tests is around 10^2 cfu/g for solid foodstuffs and 10 cfu/g for liquid samples. The different media used for the detection and quantification of *S. aureus* have been reviewed by Baird and Lee (1995). In many countries, low degree of contaminations by *S. aureus* are tolerated in most foodstuffs (up to 10^3 cfu/g in raw milk cheeses, in France), as they are not considered a risk for public health (Le Loir *et al*., 2003).

2.8. Risk-based Approaches to Food Safety in the Informal Sector

There are three main frameworks for risk analysis relevant to veterinarians and public health experts. They include the OIE framework (Wright *et al*, 2007), Codex Alimentarius Commission framework (Codex, 2003) and HACCP (Mahnaz and Leila, 2009). OIE risk analysis consists of trade standards and biological standards. These standards are developed through elected Specialist Commissions and are adopted by OIE Members during the annual OIE General Session.

Codex Alimentarius Commission risk analysis consists of risk assessment, risk management and risk communication. The risk analyses applied in the food safety context are the Codex Alimentarius Commission risk analysis and HACCP frameworks. The present study used the Codex Alimentary Commission framework for microbiological risk analysis (MRA). Risk assessment consists of the following steps: i) hazard identification, ii) hazard characterization, iii) exposure assessment, and IV) risk characterization. The risk assessment definitions used in this study are similar to that of Potter (1996):

Hazard: A biological, chemical or physical agent in or property of food with the potential to cause an adverse effect.

Hazard identification: Identification of known or potential health effects associated with a particular agent in food

Exposure assessment: The evaluation of degree of intake likely to occur.

Dose-Response assessment: Determination of relationship between the magnitude of exposure and the magnitude and frequency of adverse effects.

Risk characterization: The estimation of the adverse effects likely to occur in a given population, and a summary of assumptions and sources of uncertainty.

2.9 Food Safety along Dairy Value Chains

There are different passages or outlets of dairy value chains through which milk products flow from the producer to the consumer. On the way to the consumer, the product change ownership from time to time among the milk-marketing participants (Kohls and Uhl, 1990).

This has implications on quality of milk and transaction costs as well as potential risk of contamination with pathogens. However, an understanding of functional market chains is an important first step towards understanding /dealing with food safety risks.

2.9.1 Marketing system for milk and milk products produced in Tanzania

Pastoralist and agro-pastoralist produce milk from the traditional sector adopting extensive to semi extensive mixed farming systems. It has been reported that about 95% of the produced milk is consumed at home and seasonal surplus are marketed in urban centres (Kurwijila, 1998). The milk marketing from this sub-sector is carried out by informal milk marketing agents (Sumberg, 1996) and usually is traded within the surrounding areas of production, but such milk is prone to adulteration by water and easily contaminated by pathogenic microorganisms (Minja, 1999). Where improved dairy cattle exist, farmers do so for commercial rather than subsistence reasons.

It is estimated that over 80 % of milk consumed in developing countries, an estimated 200 billion litres annually, is handled by informal market traders, with inadequate regulation

(FAO, 2004). A study conducted by MoAC/SUA/ILRI, (1998) in Dar es Salaam, Arusha, Kilimanjaro, Tanga, Mwanza, Mbeya and Iringa reported the dominance of an informal milk marketing chain, where by up to 98% of marketed milk was from producers directly to consumers.

The marketing business is achieved either directly from producers or via marketing agents, normally without any quality control measures only relying on mutual trust. In the absence of quality control measures in the current predominately informal milk marketing system, the quality of milk as received by the final consumer is not known. The peri-urban wards of Temeke Municipality being part of Tanzania involved in milk production are no exception and have adopted a similar marketing model. In these wards, farmers sell their milk directly to neighbours who collect from the farm, or are delivered to the consumer by the farmer. Some farmers sell milk in hotels, restaurants and kiosks. Milk kiosks have mushroomed in urban and peri-urban areas, especially in Dar es Salaam. In these places milk is boiled and cooled before sale, some milk sellers ferment part of the milk and sell it as sour milk locally known as ‘’*mgando*.’’ Kurwijila (1998) reported an observation that several milk kiosks were involved in selling a substantial proportional of un-boiled fermented milk. The limited information on the microbiological quality in animal products in the East African region Tanzania inclusive necessitated the study.

2.9.2 Dairy value chains in peri urban wards of Temeke Municipality

The most important participants identified in Temeke peri-urban wards were farmers, vendors, and retailers. These traders play the role of middlemen, linking producers to consumers.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of Study Area

Temeke District/Municipalities is one of the three Districts/Municipalities forming the City of Dar es Salaam. The other Districts/Municipalities are Ilala and Kinondoni. The study was conducted among milk producers (farmers), vendors, milk sellers in milk shops/bars and consumers who take milk in these milk shops in and around peri-urban areas of Temeke municipality. Fig. (1) shows the survey areas in peri-urban areas of Temeke municipality. The sites were randomly chosen to be able to give picture of safety of milk in all Peri-urban wards of Temeke Municipality. According to 2002 census population size of Temeke district was 768 451. It is estimated that, Temeke annual population growth is 4.6%, therefore in the year 2010 population size of Temeke Municipality is estimated to be 1 101 209 in which men are 555 102 and women are 546 107. The district has cattle population of 9850 where by beef cattle are 5706 and dairy cows are 4144 (Temeke Municipal, 2008).

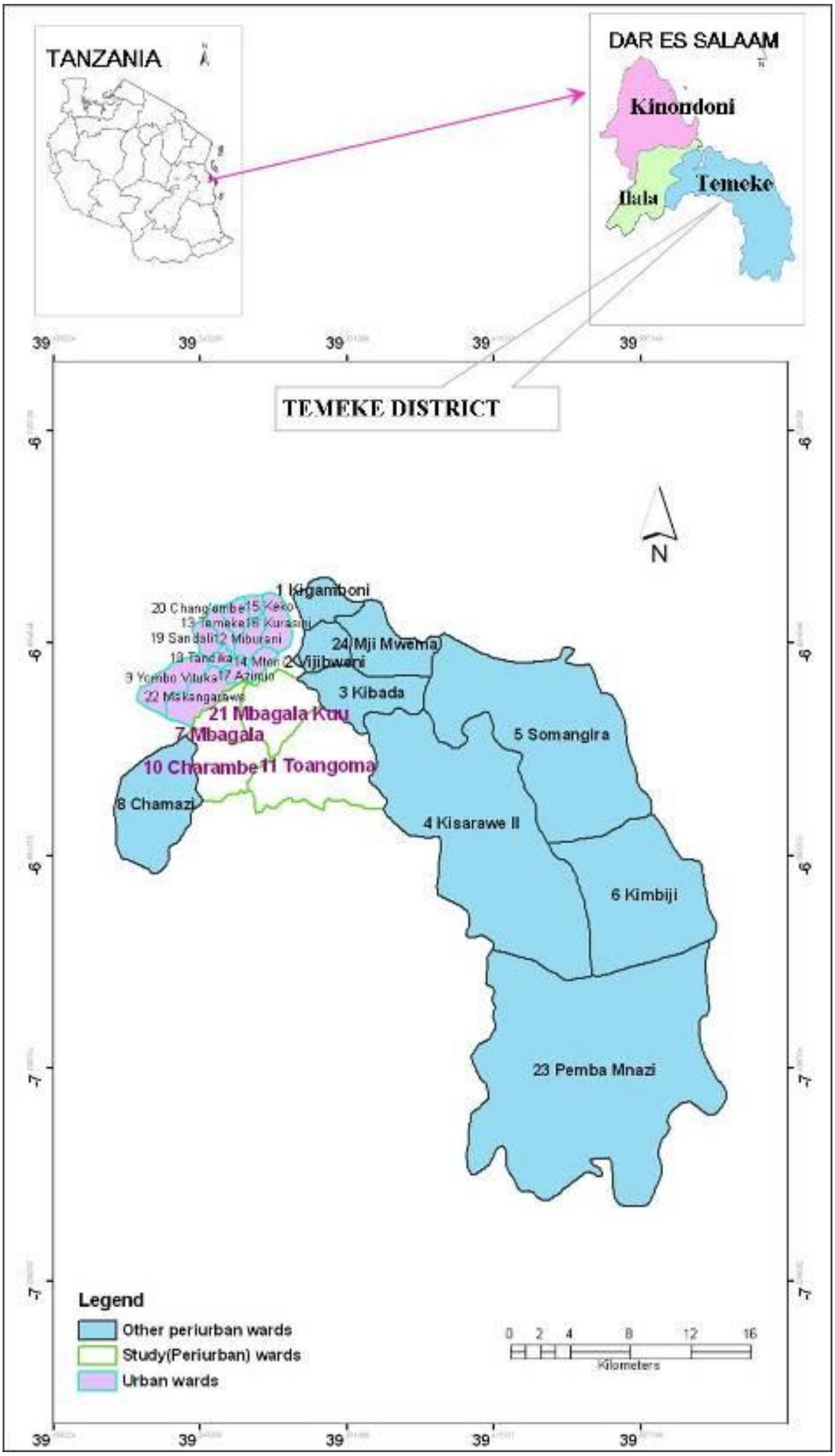

Figure 1: Peri-urban areas of Temeke municipality

3.2 Conceptual Framework

The concept of food safety in milk markets of small holder farmers under this study was focused on the microbiological food safety hazards. In particular hazards due to *staphylococcus aureus* was studied Fig. 2

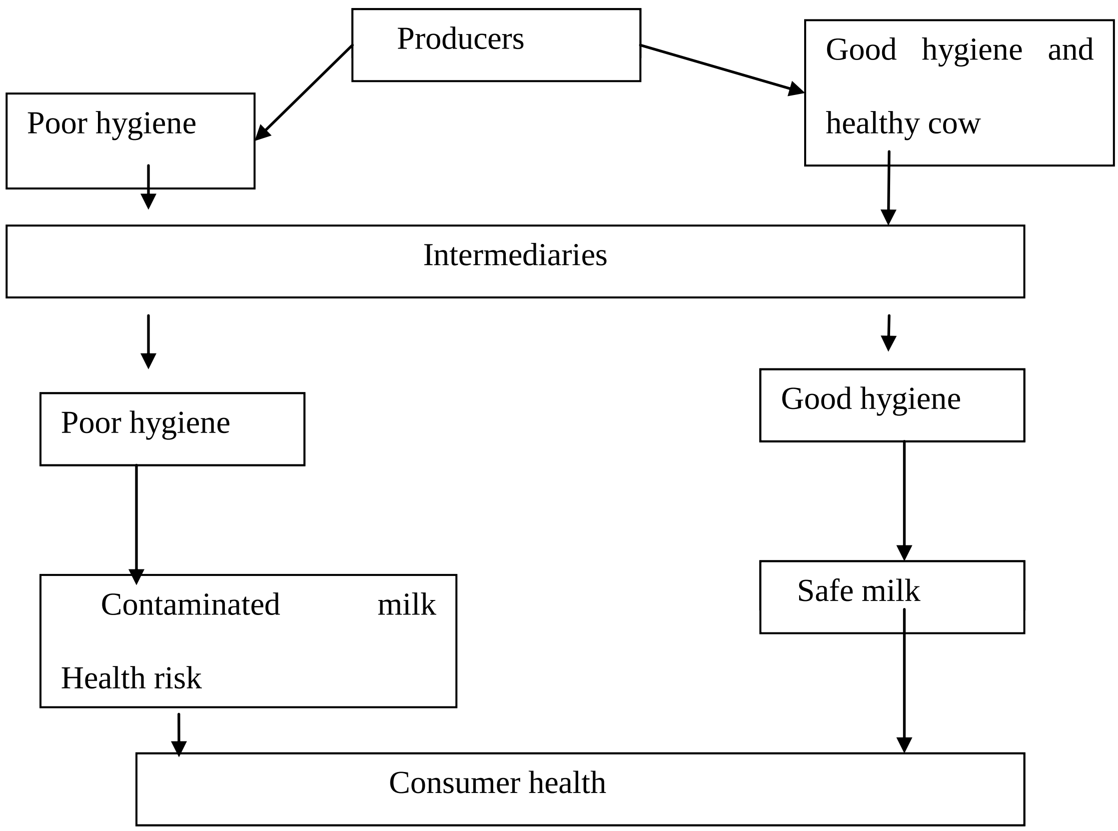

Figure 2: Conceptual Framework

3.3 Study Design

The study was cross sectional study applying the combination of Hazard Analysis and Critical Control Point (HACCP) framework and *Codex Alimentarius* Commission microbiological risk assessment. The study identified potential points where microbial hazard contamination may occur in the dairy value chain from farmers to milk shops.

A scenario tree was drawn to describe basic steps involved in the milking of cows, milk selling and transportation, preparation and serving practices. Market channels identified in the study area were analyzed by product pathways Fig. 3.

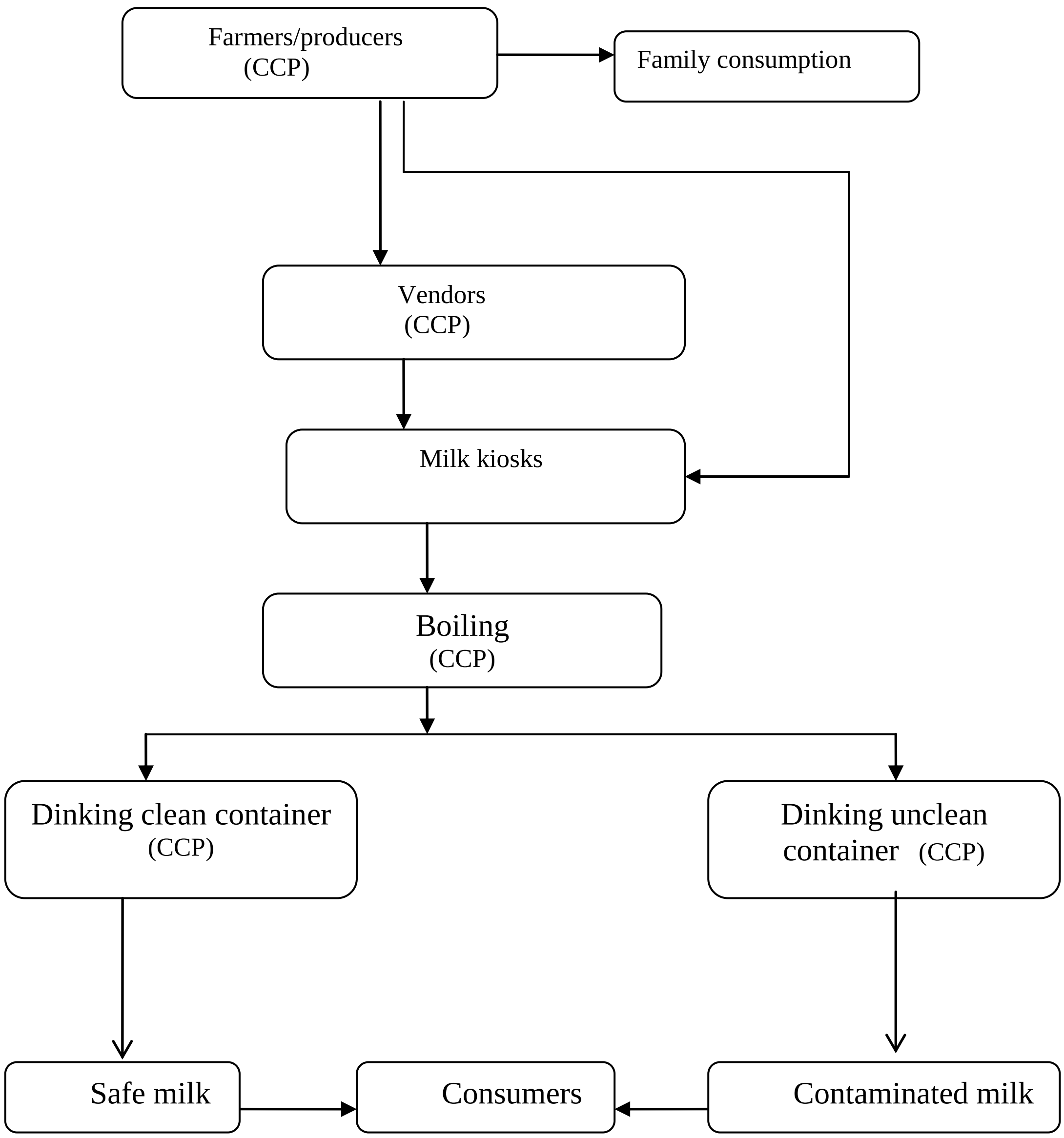

Figure 3: Milk marketing channels identified in Temeke peri-urban wards

3.4 Sampling Frame and Eligibility

The study was conducted by using two approaches; a participatory epidemiological approach was focused on three groups: producers, consumers and marketing agents.

Information was collected through a survey by means of face to face focus group discussions for milk consumers at kiosks using a checklist. At the producer level face to face interviews were conducted using a structured questionnaire. Smallholder farmers included in the study were those who have at least one milking cow and marketing agents were restaurants and other milk shops/kiosks, which sell fresh unpacked milk. Focus group discussions were used so as to obtain qualitative information from consumers on their perceptions regarding milk quality and safety. For assessment of milk quality a quantitative microbiological risk assessment was carried out through sampling and testing for presence of *S. aureus* in the milk samples along the dairy value chain.

3.5 Determination of Sample Size

The number of milk samples to be used in the study was determined by using the formula according to (Fisher *et al*., 1991). The sample size was estimated based on an estimated prevalence of 14% (prevalence of *S. aureus* from smallholder dairy and pastoral cattle herds in the urban and peri-urban areas of the Dodoma municipality in Central Tanzania and from pastoral herds in Dodoma and Morogoro regions, Tanzania) reported by Mdegela *et al*. (2005).

- Sample size for estimated prevalence is given by
- $N= Z^2 \times P (1-P)/d^2$ ....(i)

Where

- Z = confidence level/ confidence interval (CI)
- P= Estimated prevalence
- 1-P = the probability of having no hazards disease b;
- d= precision level
- N= sample size
- The level of confidence will be at 95%

- Precision = 0.05 (5%)

$$N = \frac{1.96^2 \times 0.14\ (1-0.14)}{0.05^2} = 185 \text{ ....(ii)}$$

From above, sample size was logically reduced to 120, based on the assumption that would still be able to give enough information on the study area (Temeke peri-urban wards).

3.6 Data Collection and Sampling Procedure

The study was conducted by following the reverse of the dairy value chain i.e. from consumption point (milk kiosks/restaurants) backward to milk producers (farmers).

3.6.1 Sampling procedure

Temeke municipality has got 13 peri-urban wards, which include Kimbiji, Kigamboni, Mbagala, Somangila, Vijibweni, Mjimwema, Pemba Mnazi, Kisarawe, Kibada, Charambe, Chamazi, Mbagala Kuu, and Toangoma.

Four wards namely Mbagala, Mbagala Kuu, Toangoma and Charambe were randomly selected from peri-urban wards and used in the study. A total of 120 milk samples were collected from milk shops (44), vendors (7) and smallholder farmers (69), (Table 3, 4 and 5). Sixty (60) milk consumers (15 from each sample ward) were interviewed through questionnaires on their perception regarding quality and safety of milk they buy from milk shops. Focus group discussions (FGDs) were also conducted to another 60 milk consumers so as to collect more information regarding consumer’s perception on quality and safety of milk they buy from milk shops. The FGDs involved four groups each consisting of fifteen people from each surveyed ward. The principle researcher (PR) and two research assistants participated in the discussions. The principal researcher was the moderator, while the research assistants took notes. During the discussion, the moderator introduced the topic and allowed the group members to discuss. The discussion in each session lasted about one hour.

3.6.1.1 Milk shops/kiosk

The selling point survey was conducted in milk shops (milk kiosks and restaurants), which sell unpacked milk. The health officers in their respective wards facilitated accessibility to the milk shops/kiosks. A list of streets from each selected ward was prepared and each street was assigned a number. The numbers to be selected were generated using a random number generator and milk shops were selected from the selected streets to satisfy the desired sample size. The owners of these milk shops were asked to participate in the study after they had been explained the study objectives. A total of 22 milk shops were included in the study (Table 3). These shops were used to get information on milk source i.e. farmers or vendors. The identified source farmer and/vendor were traced back and included in the study.

The questionnaire forms for gathering information regarding milk handling practices before selling was administered. This was a brief type of questionnaire/check list (Appendix 3). Two milk samples were collected from each surveyed shop. The first sample contained milk just received from the farmer and the second sample was boiled milk served hot.

Chilled milk, which sold in all sample shops was formally processed, pasteurized, homogenoused milk packed in pouches. The collected samples were placed in clean sterile vacutaner tubes labelled accordingly and immediately stored in a cool box with ice cubes, ready for shipment to the laboratory for use in the microbiological analysis. A total of 22 raw and 22 boiled milk samples respectively were collected from the sample shops (Table 3). Information on consumers visiting each of the 22 shops regarding their perception of milk food safety from various informal outlets, were collected through the focus group discussions.

Table 3: Number of milk shops/kiosks and milk samples collected from each ward

Ward	Number of shops	Raw milk sample	Boiled milk served hot sample
Mbagala	6	6	6
Mbagala Kuu	6	6	6
Charambe	5	5	5
Toangoma	5	5	5
Total	22	22	22

3.6.1.2 Vendors

Seven (7) vendors encountered during the field survey were sampled (Table 4). The numbers of vendors involved was few because most of farmers sell their milk at their farm gate either directly to milk shops/kiosks or to neighbours. The questionnaire forms (Appendix 2) for gathering some milk information regarding milk hygiene, milk quality and marketing were administered. Milk samples (about 2 ml) were collected from each surveyed respondent. The collected samples were placed in a clean sterile Vacutaner tube, labelled accordingly and immediately stored in a cool box with ice cubes ready for shipment to the laboratory for use in the microbiological risk assessment.

Table 4: Number of vendors and milk samples collected from each ward

Ward	Number of vendors	Number of milk sample (raw milk)
Mbagala	2	2
Mbagala kuu	2	2
Charambe	1	1
Toangoma	2	2
Total	7	7

3.6.1.3 Farmers

The farmers included in the study were those identified by milk kiosk as their milk suppliers. A total of 29 farmers were visited and 69 milk samples were collected from these farmers. The extension staff in their respective wards facilitated accessibility to the dairy farmers. Two visits were made to each of the selected farmer.

In the first visit, farmers were interviewed using a structured questionnaire (Appendix 1). The questionnaire was used to collect animal- and herd-level information on milking and milk handling practices, knowledge on mastitis; practices related to mastitis control, factors affecting milk quality and knowledge on health risks associated with consumption of milk. The second visit was for milk sample collection. One sample of about 2 ml was collected aseptically from the quarters of each milking cow using clean sterile Vacutainer tube. The collected samples on each day were then kept in a cool box with ice cubes and immediately transferred to the laboratory for analysis. Table 5 shows the number of farmer’s milk samples collected from each ward.

Table 5: Number of farmers and milk samples collected from each ward

Ward	Number of farmers		Number of milking cows	Number of milk samples
	Male	Female		
Mbagala	6	3	25	25
Mbagala Kuu	8	1	20	20
Charambe	2	2	10	10
Toangoma	4	3	14	14
Total	20	9	69	69

3.6.1.4 Control milk samples

Formal processed milk

One set of controls was formally processed, pasteurized, homogenoused milk packed in pouches. Milk shops which sell formal processed milk among selected milk shops included in the study were identified in each ward (Table 3). One shop was selected randomly in each ward and one packet of formal processed milk was bought. The collected sample was labelled accordingly and immediately stored in a cool box with ice cubes ready for shipment to the laboratory for use in the microbiological risk assessment.

Raw milk from farmers

The other set of controls was raw milk from farmers. One farmer was randomly selected from each ward among the farmers included in the study (Table 5). About one litre of milk was collected aseptically from the farmer's milk container and placed in a clean sterile bottle. The bottle was labelled accordingly and immediately stored in a cool box with ice cubes ready for shipment to the laboratory for use in the microbiological risk assessment. At the laboratory the milk was first tested for presence of *S. aureus* before boiling. Milk was then boiled in laboratory setting and left to cool before being tested again for presence of *S. aureus*.

3. 6.1.5 Direct observation

The information from direct observations was used to supplement the other information obtained by interviews and focus group discussions. The information was most useful with regard to aspect of hygiene of physical premises and personnel working on the dairy establishments.

3.7 Laboratory Microbial Tests

The laboratory tests were carried out at Central Veterinary laboratory (VIC) Temeke in Dar es Salaam as follows:

3.7.1 Microbial counts

3.7.1.1 Total plate count

Total plate count was done. The exercise followed the procedure outlined by FAO (1987) and Lampert (1975). The diluent used was peptone water, which was prepared by dissolving an equivalent weight of peptone pellets in distilled water. Then 9ml were pipetted into first tubes for sterilization. Sterilization was done in an autoclave at 121°C for 15minutes.The whole procedure was done aseptically. The autoclaved agar was melted in a boiling water bath and then was cooled at 45°C. Milk samples were shaken to ensure even distribution of bacteria then it was transferred with sterile pipette to 9ml diluent. One (1ml) of this was thoroughly mixed, dilution was added to 9 ml of another sterile peptone water solution which gave a dilution of 1:100 and this procedure was repeated up to 1:1000 dilution. Plating was done on the Petri dish and the dishes were labelled accordingly.

The agar was then poured onto the Petri dish quickly and mixed thoroughly with milk by gently rotating the dish. This was left for few minutes in order to solidify before incubation at 32^{o}C for 48 h. Counting of the colonies which had grown from the milk samples was carried by visual observation. Duplicate plates showing 30 to 300 colony forming units (cfu) were counted and the means determined. The number of colonies was multiplied by the dilution factor which was $x\ 10^3$

3.7.2 Media and test used for isolation of *Staphylococcus aureus*

Blood media

The media was used for checking the level of bacterial contamination in milk samples and subculture for the purpose of purification of colonies. Blood agar is often used to isolate *S. aureus* and many strains will lyse red blood cells producing a clear zone around the colony. This lysis is not diagnostic for *S. aureus* as not all strains produce hemolysins.

MacConkey Agar without Crystal Violet

MacConkey agars are slightly selective and differential plating media mainly used for the detection and isolation of gram-negative organisms from clinical, dairy, food, water, pharmaceutical and industrial sources. MacConkey Agar without Crystal Violet is a differential medium that is less selective than MacConkey Agar. The lack of crystal violet permits the growth of *Staphylococcus* and *Enterococcus.* Staphylococci produce pale pink to red colonies and enterococci produce compact tiny red colonies either on or beneath the surface of the medium.

Mannitol Salt Agar (MSA)

Mannitol salt agar is a selective medium used for the isolation of pathogenic staphylococci. The medium contains mannitol, a phenol red indicator, and 7.5% sodium chloride. The high salt concentration inhibits the growth of most bacteria other than staphylococci. On MSA, pathogenic *Staphylococcus aureus* produces small colonies surrounded by yellow zones. The reason for this change in color is that *S. aureus* ferments the mannitol, producing an acid, which, in turn, changes the indicator from red to yellow. The growth of other types of bacteria is generally inhibited.

Catalase taste

This test is used for gram positive cocci. Catalase tests is used distinguish catalase-negative *Streptococcus* spp. from catalase-positive *Staphylococcus* spp.

Coagulase taste

The single`1 most significant characteristic which identifies *S. aureus* is its ability to coagulate (clot) plasma. This is accomplished by the release of the enzyme coagulase

3.7.2.2 Laboratory procedure for isolation of *S. aureus*

Milk samples submitted to the laboratory were cultured using standard microbiological methods. Briefly, 0.01 ml of milk was streaked on a portion of a Blood Agar plate, Mac Conkey Agar and Mannitol Salt Agar (Becton-Dickson Microbiology).The plates were incubated at 37°C overnight in a CO_2 incubator.

Plates were examined for growth at 24 and 48 h. Bacteria were identified by colony morphology and Gram stain. For gram-positive cocci, catalase tests were performed to distinguish catalase-negative *Streptococcus* spp. from catalase-positive *Staphylococcus* spp. Catalase-positive gram-positive cocci were further identified using a coagulase test as summarized in Fig. 4.

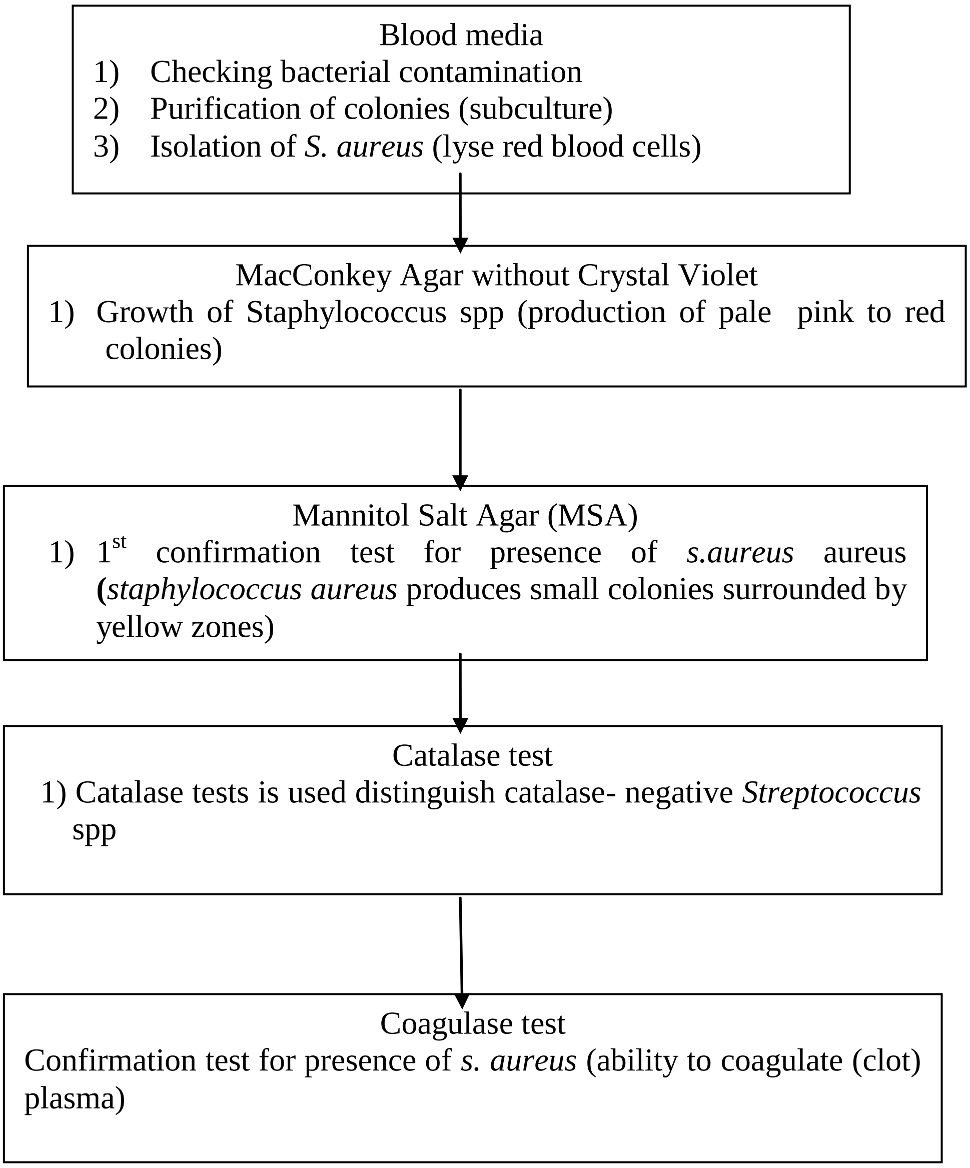

Figure 4: Flow chart for isolation of *S. aureus*

3.7.3 Data analysis

Laboratory hazard analysis results and data collected by questionnaire were entered into MS-ACCESS and MS-EXCEL and then analysed using SPSS. Analysis were conducted to describe sources and pathways of milk; assess milk bacteriological quality; quantify the prevalence of the pathogen (*Staphylococcus aureus*); assess milk handling practices by market agents; and, conduct a quantitative risk assessment of milk-borne public health hazards. For the hazard response (presence of *Staphylococcus aureus*); test of significance (significant p-values) was used to identify significant associations with kiosk unboiled raw milk and kiosk boiled milk served hot. There was no milk served chilled from farmers, Milk served chilled which is sold in most milk shops is formal processed (pasteurized, homogenized and packed in pouches).

3.7.3.3 Exposure assessment of milk contaminated with *Staphylococcus aureus*

Poisoning from *S. aureus* through milk consumption occurs when humans consume enterotoxin produced by the pathogens. Kitagwa *et al*. (2006) reported that presence of *Staphylococcus aureus* in boiled milk could be due to insufficient boiling, people with poor personal hygiene handling the food or serving the food using dirty utensils. In the present study, storage time and temperature are not known. Therefore only exposure to milk contaminated with the pathogen was assessed. Also, number of consumers consuming milk sold at kiosks in peri-urban areas of Temeke municipality was estimated.

The exposure to milk contaminated with *S. aureus* purchased in kiosks in peri-urban Temeke Municipality was stochastically modelled following the methodology below.

To calculate the total quantity of milk sold in kiosks in the areas per day, total quantity of milk sold by 22 interviewed kiosks was estimated stochastically by summing randomly sampled quantity data in each kiosk under the same probability (from uniform distribution) using the bootstrap technique. Then, average quantity of milk sold in each kiosk was estimated by taking the summation of litres solid in all kiosks and divide it by 22 (number of kiosks). Secondly, the number of kiosks in peri-urban areas of Temeke Municipality was estimated by estimating the numbers of kiosks in Mbagala, Mbagala Kuu, Charambe and Toangoma Wards (surveyed peri-urban Wards in the Municipality) by sampling integer values between 50 to 70 (these numbers were estimated by Ward officials from the four surveyed wards as expert opinions) in uniform probability distribution and summing up these numbers. Finally, the quantity of milk sold per day in kiosks in peri-urban Temeke (Q) was estimated using formula below.

Q = Y/22 * Number of milk kiosks/ward *N ....(iii)

Where

- Q = Quantity of milk sold per day in kiosks in per-urban wards of Temeke Municipality
- Y= Estimated total quantity of milk sold by 22 interviewed kiosks
- N = Total number of peri-urban wards in Temeke municipality

The quantity of milk contaminated sold in these kiosks in peri-urban Temeke was estimated as follows. Firstly, the model showing a single purchase of milk contaminated or not was constructed using binomial distribution. The contamination rate fed into the model was estimated from the microbacterial tests (5/22= 22.7%- boiled and sold milk samples in kiosks were contaminated). Secondly, quantity data from each of 22 kiosks were sampled randomly in uniform probability distribution and each sample was multiplied with a sample taken from above mentioned binomial distribution (contaminated or not, 1 or 0) to obtain total amount of milk contaminated among milk sold in 22 kiosks.

Thirdly, the total quantity of milk contaminated among milk sold in kiosks in peri-urban Temeke, was calculated using the estimated number of kiosks in the areas as the same manner used for total quantity of milk sold in kiosks in the areas. Finally, the probability of purchasing contaminated milk from a kiosk in the peri-urban areas of Temeke Municipality was estimated by dividing the quantity of milk contaminated with *S. aureus* by the total quantity of milk sold in kiosks the peri-urban areas of Temeke Municipality.

The number of consumers purchasing contaminated milk per day through kiosks in peri-urban Temeke was estimated taking steps explained as follows. At first the average quantity of milk consumption per person was estimated by using answers from 60 consumers in the interviews, taking average of daily milk consumption (a point estimate). Then the total quantity of milk sold in kiosks in peri-urban Temeke was divided by this average quantity of milk consumption per person to calculate the number of people purchasing milk from kiosks in peri-urban Temeke. Finally, this number of people purchasing milk was multiplied with the probability of purchasing contaminated milk obtained above to calculate the number of people purchasing contaminated milk per day. The Monte Carlo simulation was performed for these all stochastic outputs by running 5000 iterations using @Risk (Palisade).

3.8 Ethical Consideration

Permission to conduct the study was sought from the district and municipal authorities before starting the study. The aim and purpose of the study was explained to all study participants.

CHAPTER FOUR

4.0 RESULT AND DISCUSSION

4.1 Milking Practice by Farmers

Table 6 shows results of milking practice. It was found that milking in all surveyed wards was performed by owner, employee or other family member. About 58.6% (n=29) of visited farmers reported that milking was conducted by employee. All the farmers reported to milk their cows twice a day and they wash cow's udder before milking. It was observed that majority of the farmers i.e. 79 %(n=29), did not use post milking teat disinfectants as preventive measure against new infections. Most of the milkers used water only in washing their hands. It was noted that only 17.2 %(n=29) used water and soap for washing hands and only one farmer wore an over coat when milking his cows.

The use of one piece of cloth for drying all cows and washing hands alone without drying them with a clean separate cloth before milking, allows drops of water to remain behind which may contain micro-organisms that act as a source of contamination leading to mastitis. Effective hygienic practice during milking is an important element of the system controls, necessary to produce safe and suitable milk and milk products. It is important that measures are taken to educate farmers on the importance of improving animal husbandry practices and adopting better milking hygiene measures along with the use of CMT in disease monitoring (Karimuribo *et al*., 2005).

Failure to maintain adequate sanitation and employee practices has been shown to contribute to the contamination of milk with undesirable or pathogenic microorganisms or chemical or physical hazards. Karimuribo *et al*. (2005) reported that poor house hygiene and unhygienic milking practices are among the factors which can result in high udder infections; zoonotic infections and poor quality of the milk.

Table 6: Milking practice by farmers in Temeke peri-urban wards

Factor	Farmers in Temeke peri-urban wards (N=29) (%)
Who milks the cow	
Owner	4(13.8)
Employee	17(58.6)
Family member	8(27.6)
Total	29(100)
Use of udder wash	
Yes	29(100)
No	0(0)
Total	29(100)
Washing technique used	
Cold water	5(17.2)
Warm water	24(82.8)
Total	29(100)
Use of post milking teat disinfectants	
Yes	7(24.1)
No	75(9)
Total	29(100)
Udder drying	
Yes	25(86.2)
No	4(13.8)
Total	29(100)
Drying technique used	
Individual cloth/towel	18(62)
A cloth/towel for all cows	7(24.1)
Not applicable	4(13.8)
Total	29(100)
Washing of milkers hands	
Washing with water only	24(82.8)
Washing with water and soap	5(17.2)
Total	29(100)
Wearing overcoat	
Yes	1(3.4)
No	28(96.6)
Total	29(100)

Note: Figures in brackets are percentages of the total sample (N=29)

4.2 Awareness About cow Mastitis Among Farmers

Table 7 shows that all farmers surveyed were aware of mastitis problems in cows. 89.7% of farmers reported that they had encountered mastitis problem to their cows. The awareness about mastitis by most of the farmers could be a result of long experience in the business (mean 10) years, and from neighbors keeping cows. The information obtained from farmers about the awareness of mastitis compares well with that reported by (Moshi, 1998) in Tanzania when he studied mastitis in goats, also by Mdegela *et al.* (2005).

Table 7: Awareness on cow's mastitis among farmers

Ward	N	YES (%)	NO (%)
Mbagala	9	8(27.6)	1(3.4)
Mbagala Kuu	9	8(27.6)	1(3.4)
Charambe	4	3(10.3)	1(3.4)
Toangoma	7	7(24.1)	0(0)
Total	**29**	**26(89.7)**	**3(10.3)**

Note: Figures in brackets are percentages of the total sample (N=29)

4.3 Types of Milk Marketed in Milk Shops

Most of the milk shops sell boiled milk served hot 95.5% (Table 8). This is because most consumers prefer boiled milk as they believe it is free from microbial contamination. This is in agreement with reports by other researchers, for example Omore *et al*. (2003) reported that 57% of the retailers who cited various product types indicated either fresh boiled or warm milk as their main product they sell.

Table 8: Types of milk marketed in milk shops

		Milk varieties which are solid	
Ward	n	Raw milk (%)	Boiled milk served hot (%)
Mbagala	6	0(0)	6(27.3)
Mbagala Kuu	6	0(0)	6(27.3)
Charambe	5	0(0)	5(22.7)
Toangoma	5	1(4.5)	4(18.2)
Total	22	1(4.5)	21(95.5)

Note: Figures in brackets are percentages of the total sample (N=22)

4.4 Source of Milk and its Transportation

About 86.4% (n=22) of milk kiosk owners obtain their milk directly from farmer's while 13.6% buy from vendors. It was found that only half of the milk received by kiosk from farmers/vendors was chilled. Major transport means of milk in the study area was foot and bicycle/P. transport. This finding is consistent with the finding by Omore *et al.* (2003), who reported that procurement of milk from producers in Dar es Salaam takes place at homesteads and transportation of milk is mainly done using bicycle or public transport and in some cases by head carrying.

It was noted that all milk agents i.e. vendors and milk kiosks (Table 9 and 10) used plastic buckets and gallons for milk handling during procurement. This finding is in line with that reported by Omore *et al*. (2003), who found that in Tanzania 41%, 12% and 8% of the respondents who cited various handling materials used plastics buckets, plastic gallon and plastic jerry cans respectively. Plastic containers are not recommended for handling milk as they are known to be vulnerable to bacterial contamination. Milk handling problems coupled with lack of quality assurance of milk delivered to most of the retailers and household consumers pose potential sources of public health risks to consumers. Omore *et al*. (2005) reported that the use of plastic containers was associated with high coliform counts in raw milk. This is likely due to the fact that plastic containers are difficult to clean and sterilize.

Table 9: Source of milk and transportation for kiosk

Ward	n	Kiosk milk source(type)	
		Farmer (%)	Vendor (%)
Mbagala	6	5(22.7)	1(4.5)
Mbagala Kuu	6	5(22.7)	1(4.5)
Charambe	5	5(22.7)	0(0)
Toangoma	5	4(18.2)	1(4.5)
Total	22	19(86.4)	3(13.6)
		Condition of milk when received at kiosk	
		Chilled (%)	Warm (%)
Mbagala	6	2(9.1)	4(18.2)
Mbagala Kuu	6	2(9.1)	4(18.2)
Charambe	5	3(13.6)	2(9.1)
Toangoma	5	4(18.2)	1(4.5)
Total	22	11(50)	11(50)
		Type of container used in carrying milk	
		Plastic (%)	Aluminium (%)
Mbagala	6	6(27.3)	0(0)
Mbagala Kuu	6	6(27.3)	0(0)
Charambe	5	5(22.7)	0(0)
Toangoma	5	5(22.7)	0(0)
Total	22	22(100)	0(0)
		Means of transport	
		Foot (%)	Bicycle
Mbagala	6	2(9.1)	4(18.2)
Mbagala Kuu	6	4(18.2)	2(9.1)
Charambe	5	2(9.1)	3(13.6)
Toangoma	5	3(13.6)	2(9.1)
Total	22	11(50)	11(50)

Note: Figures in brackets are percentages of the total sample (N=22)

Table 10: Source of milk and transportation for vendors

Ward	n	Milk source for vendors	
		Farmer (%)	Other source (%)
Mbagala	2	2(28.6)	0(0)
Mbagala Kuu	2	2(28.6)	0(0)
Charambe	1	1(14.3)	0(0)
Toangoma	2	2(28.6)	0(0)
Total	7	7(100)	0(0)
		Condition of milk when received by vendors	
		Chilled (%)	Warm (%)
Mbagala	2	1(14.1)	1(14.3)
Mbagala Kuu	2	1(14.1)	1(14.3)
Charambe	1	0(0)	1(14.3)
Toangoma	2	1(14.1)	1(14.3)
Total	7	3(42.9)	4(57.1)
		Type of container used in carrying milk	
		Plastic (%)	Aluminium (%)
Mbagala	2	2(28.6)	0(0)
Mbagala Kuu	2	2(28.6)	0(0)
Charambe	1	1(14.3)	0(0)
Toangoma	2	2(28.6)	0(0)
Total	7	7(100)	0(0)
		Means of transport	
		Foot (%)	Bicycle
Mbagala	2	1(14.3)	1(18.2)
Mbagala Kuu	2	1(14.3)	1(9.1)
Charambe	1	0(0)	1(13.6)
Toangoma	2	0(0)	2(9.1)
Total	7	2(28.6)	5(71.4)

Note: Figures in brackets are percentages of the total sample (N=7)

4.5 Quality Checking Techniques

Overall 45.5% (n=22) and 28.6 %(n=7) of the milk kiosk owners and vendors respectively in the study area did not use any form of quality control checks prior to milk procurement. The most commonly used method by kiosk owners in quality control checking was boiling (Table 11). About 57.1% (n=7) of vendors used viscosity and colour as main technique for assessing quality of milk before buying. This finding is in line with the findings reported by Omore *et al.* (2003), who found that 58% of milk traders in Tanzania did not do any quality control before procurement of milk.

Table 11: Quality control technique used by milk kiosk owners and vendors when buying milk.

Marketing agent	Technique used	Percentage (%)
Kiosk	Clot on boiling test	9(40.9)
	Lactometer	1(4.5)
	Organoleptic	1(4.5)
	Viscosity and colour	1(4.5)
	None	10(45.5)
	Total	22(100)
Vendor	Clot on boiling test	0(0)
	Lactometer	1(14.3)
	Organoleptic	0(0)
	Viscosity and colour	4(57.1)
	None	2(28.6)
	Total	7(100)

4.6 Bulking Milk from Different Farmers

No respondents (vendors) bulked milk from different farmers. A majority of the vendors 85.7% (n=7) reported that bulking milk from different farmers can result to low quality milk/increase health risks due to an increased chance of contamination (Table 12). It was observed that kiosk owners bulk milk from different farmers/vendors especially when demand is high.

Bulking of milk from many sources increases the risk of infection with milk-borne zoonoses. This is especially so among people who drink milk without boiling it. Kleeberg (1984), reported that the milk from an affected cow could contaminate milk from all the remaining healthy animals in the herd, or even milk from several other farms provided that the whole is mixed together. The risk from bacterial contamination has been reported to originate at farm level (Mathias, 1998) and increases with bulking and number of agents handling milk before it reaches the consumer (Omore *et al*., 2003).

Table 12: Perception of milk vendors on effect of milk bulking on contamination of milk with health hazards in peri-urban wards of Temeke Municipality

Practice	Vendors in Temeke peri-urban wards (N=7) (%)
Milk bulking undertaken	
Yes	0(0)
No	7(100)
Total	7(100)
Awareness of health risk on bulking Milk	
Yes	6(85.7)
No	1(14.3)
Total	7(100)
Reasons for health risk	
Through mixing contaminated milk	6(85.7)
None	1(14.3)
Total	7(100)

Note: Figures in brackets are percentages of the total sample (N=7)

4.7 Hygiene, Milk Handling Practices by Market Agents and Training for Workers in Milk shops

Table 13 summarizes general observation on overall hygiene, milk handling practices and general respondent’s information regarding training on catering/food hygiene. A majority of workers (59.09%) clothes was clean. 95.5% of kiosks reported that they have toilet facilities for themselves and their customers. It was observed that only 31.81% (n=22) had hand basins with running hot water. Overall 36.36% (n=22) of milk kiosks sterilize the equipment used in serving milk with hot water, after washing them with clean tap water. All milk shops had cold facilities for storage of foods and most of them (77.3 % n=22) store the raw food separately from ready to eat foods. Only one kiosk 4.54 % (n=22) had one personnel who had undergone a formal training on food hygiene.

Food handlers can be a source of the spread of food-borne disease caused by poor personal hygiene or cross-contamination (Lues and van Tonder, 2007) as cited by Guven *et al*. (2008). The study found that 95.5% (n = 22) of food handlers did not receive any formal food hygiene training and therefore do not have a high level of general food hygiene. The lack of training in milk hygiene may be a contributing factor to unhygienic milk handling by the informal sector traders. Holmberg and Blake (2009) reported that out of 131 staphylococcal foodborne diseases involving 7126 cases, poor personal hygiene of the food handler was noted in 43 outbreak report forms (33%).

Table 14 shows that small traders had been in business for short period of only 3 years (SD=3), much shorter periods than farmer groups (mean= 10). This may indicate a high turnover in milk market business or an expanding market with several recent entrants. These findings however, compare well with those reported by Omore *et al*. (2001), who studied indigenous markets for dairy products in Africa.

Table 13: Hygiene, milk handling practices and training for workers in milk shops of Temeke peri-urban wards.

Hygiene factor considered	Proportion of workers in milk shops of Temeke peri-urban wards (N=22) (%)
Workers clothes	
Clean	13(59.1)
Dirty	9(40.9)
Total	22(100)
Toilet availability	
Yes	21(95.4%)
No	1(4.5)
Total	22(100)
Hand basin with running hot water	
Yes	8(36.4)
No	14(63.6)
Total	22(100)
Hygenic hand drier	
Yes	1(4.5)
No	21(95.5)
Total	22(100)
Soap for washing hands	
Yes	18(81.8)
No	4(18.2)
Total	22(100)
Utensils sterilised	
Yes	8(36.4)
No	14(63.6)
Total	22(100)
Cold storage available	
Yes	22(100)
No	0(0)
Total	22(100)
Ready Vs raw food storage	
Together	5(22.7)
Separately	17(77.3)
Total	22(100)
Food hygiene training	
Yes	1(4.5)
No	21(95.5)
Total	22(100)

Note: Figures in brackets are percentages of the total sample (N=22)

Table 14: Experience on milk business among farmers and kiosk owners in Temeke peri-urban wards

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Value chain actor	n	Minimum(years)	Maximum(years)	Mean	SD
Kiosk operators	22	1	12	3.18	3.03
Farmers	29	2	26	10.31	6

4.8 Microbiological Risk Factors

4.8.1 Prevalence of *Staphylococcus aureus* in raw milk from farmers and milk vendors

Among the sixty nine (69) farmer's milk sample submitted for laboratory analysis 16 samples (23.19%) were found to contain *Staphylococcus aureus*. No *Staphylococcus aureus* was isolated from vendor's milk samples (Table 15).

Table 15: Prevalence of *Staphylococcus aureus* in raw milk from farmers and milk vendors

Source	Ward	n	Staphylococcus aureus positive samples(%)
Farmers	Mbagala	25	8(11.6)
	Mbagala Kuu	20	0(0)
	Charambe	10	2(2.9)
	Toangoma	14	6(8.7)
	Total	69	16(23.2)
Vendors	Mbagala	2	0(0)
	Mbagala Kuu	2	0(0)
	Charambe	1	0(0)
	Toangoma	2	0(0)
	Total	7	0(0)

The principle microbial hazard in the present study was *Staphylococcus aureus.* This is in agreement with reports by other researchers. Studies by Akaro and Minga (1994) on bovine mastitis in Tanzania, showed high prevalence of *Staphylococcus aureus*. The overall prevalence of 23.19% from farmers found in this study is lower when compared with results of Karimuribo *et al*. (2005), who found a prevalence of 35.3% in milk from pastoral herds in Dodoma and Morogoro regions, Tanzania. These results were also lower than the prevalence of 56% reported by Anyam and Adekeye (1995), for caprine mastitis and prevalence range of 40-67% reported by Akaro and Minga (1994), for bovine subclinical mastitis in the southern highland of Tanzania. The figure in this study were however, higher than the results reported by Makovec and Ruegg (2003), who found prevalence of 9.7% in milk samples submitted for microbiological examination in Wisconsin from 1994 to 2001.

4.8.2 Prevalence of *Staphylococcus aureus* in raw milk and ready to eat milk at milk shops in Temeke peri-urban wards.

Table 16 summarizes the study findings on the prevalence of *Staphylococcus aureus* in raw milk and ready to drink milk at milk shops in Temeke peri-urban wards. *Staphylococcus aureus* was isolated in 11 out of 22 kiosk milk samples, of which 6(27.27%) was from raw milk and 5(22.72%) was from boiled served hot milk. Good hygiene practice in food preparation and service plays an important role in ensuring food safety. The study found that the majority of food handlers did not receive any formal food hygiene training and therefore do not have a high level of general food hygiene knowledge. Kitagwa *et al*. (2006) reported that inadequate hygiene training and/or instruction and supervision of all people involved in food related activities pose a potential threat to the safety of food and its suitability for consumption. It is therefore important that all personnel will be aware of their role and responsibility in protecting food from contamination or deterioration.

Table 16: Prevalence of *Staphylococcus aureus* in raw milk and ready to eat milk at milk shops in Temeke peri-urban wards.

Source	Ward	Type of milk	n	*Staphylococcus aureus* positive (%)
	Mbagala	Raw milk	6	2(9.1)
		Boiled milk served hot	6	2(9.1)
	Mbagala Kuu	Raw milk	6	1(4.5)
		Boiled milk served hot	6	1(4.5)
	Charambe	Raw milk	5	2(9.1)
		Boiled milk served hot	5	2(9.1)
	Toangoma	Raw milk	5	1(5.5)
		Boiled milkl served hot	5	0(0)
	Total	Raw milk	22	6(27.3)
		Boiled milk served hot	22	5(22.7)

Note: Figures in brackets are percentages of the total sample (N=22)

4.8.3 Prevalence of *Staphylococcus aureus* in pasteurized packed milk and laboratory boiled milk collected from farmers in Temeke peri-urban wards.

There were no bacterial isolates found in laboratory boiled milk (Table 17). This is in agreement with reports by other researchers. Omore *et al*. (2005) reported that boiling of milk effectively destroys all milk-borne pathogens in raw milk. This suggest that sufficient cooking, storage and serving of food using clean utensils/equipment can reduce food safety risks associated with microbial contamination.

Pasteurized packed milk samples had no *Staphylococcus aureus* but it was found to contain *Bacillus spp*. Schraft *et al*. (1996), reported that *Bacillus spp* are frequently found in pasteurized milk. They are a health risk to the consumer since they produce enterotoxins (Champagne, 1994).

Table 17: Prevalence of *Staphylococcus aureus* in pasteurized packed milk and laboratory boiled milk collected from farmers in Temeke peri-urban wards.

	Raw milk (%)	Laboratory boiled milk (%)	Pasteurised packed milk (%)
Negative	2(50)	4(100)	4(100)
Positive	2(50)	0(0)	0(0)
Total	4(100)	4(100)	4(100)

Note: Figures in brackets are percentages of the total sample (N=4)

4. 8. 4 *Staphylococcus aureus* in unboiled and boiled milk kiosk samples

Table 18 shows that there is no significant difference in the level of *Staphylococcus aureus* between (kiosk) unboiled raw milk and (kiosk) boiled milk ($P>0.05$). Laboratory results indicate that 5(22.72%) of boiled milk collected as hot milk samples from milk kiosks contains *Staphylococcus aureus* (Table 18). The bacterium is heat labile and does not compete well with other microorganisms and therefore, contamination usually occurs after the food has been processed, when there is little competition from other microorganisms. The organism usually gains access to foods from food handlers or other surfaces like the processing equipment (Leenalitha and Peter, 2007). Kitagwa *et al.* (2006) reported that presence of *Staphylococcus aureus* in boiled milk could be due to insufficient boiling, people with poor personal hygiene handling the food or serving the food using dirty utensils.

Table 18: *Staphylococcus aureus* in raw and boiled kiosk milk

Type of milk	n	staphylococcus aureus	
		Positive	Negative
Raw milk	22	6(27.27%)	16 (72.73%)
Boiled milk served hot	22	5(22.72%)	17(77.27%)
Boiled milk served chilled	0		
Total	44		

X^2=0.12 df =1 P= 0.728

4.8.5 Microorganisms isolated in the milk samples

Other organisms isolated in this study based on colony morphology and gram stain include *Staphylococcus spp* other than *S. aureus*, *Bacillus spp*, *Escherichia coli*, *Proteus spp*, *Enterobacteria spp*, *Corrynebacterium spp* and *Micrococci* spp. *Staphylococcus spp* and *E. coli* were the most common organisms found in majority of milk samples (Fig. 6, 7, 8 and 9). These organisms have been also reported by other authors. Aziz *et al*. (1986) cited by Contreras *et al*. (1995) and Kinabo and Assey (1983) from caprine mastitis in Nigeria and bovine mastitis in Tanzania, respectively. *Coliforms*, *Staphlylococcus spp*, *Micrococcus spp*, *Streptococcus spp* have been also reported by Karimuribo *et al*. (2005).

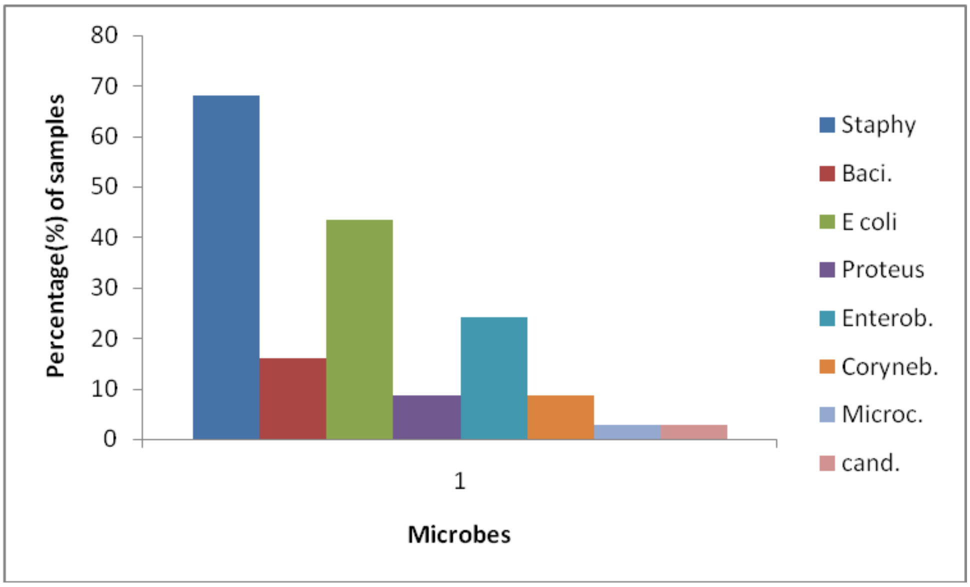

Figure 5: Microorganism's isolated from farmer's milk samples

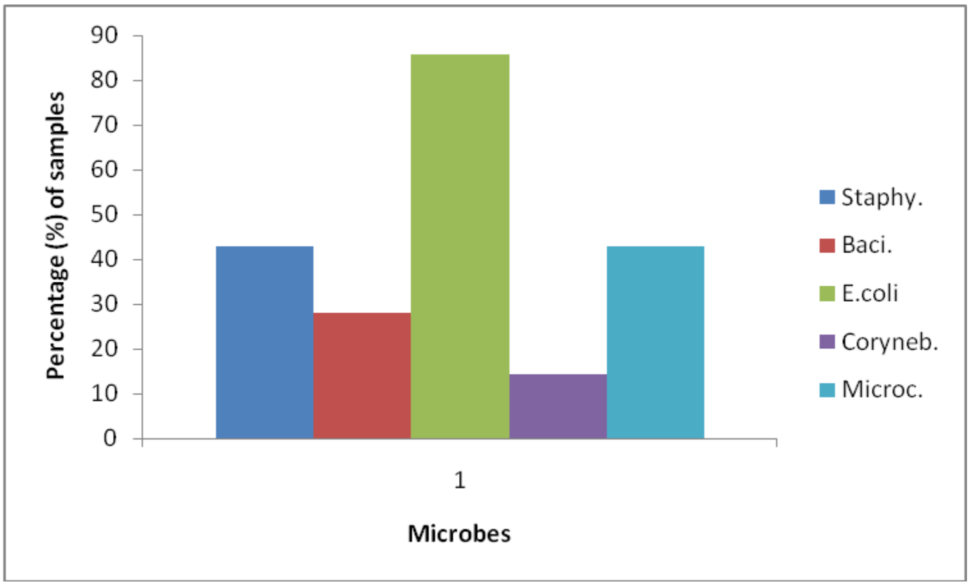

Figure 6: Microorganisms isolated in vendor's milk samples

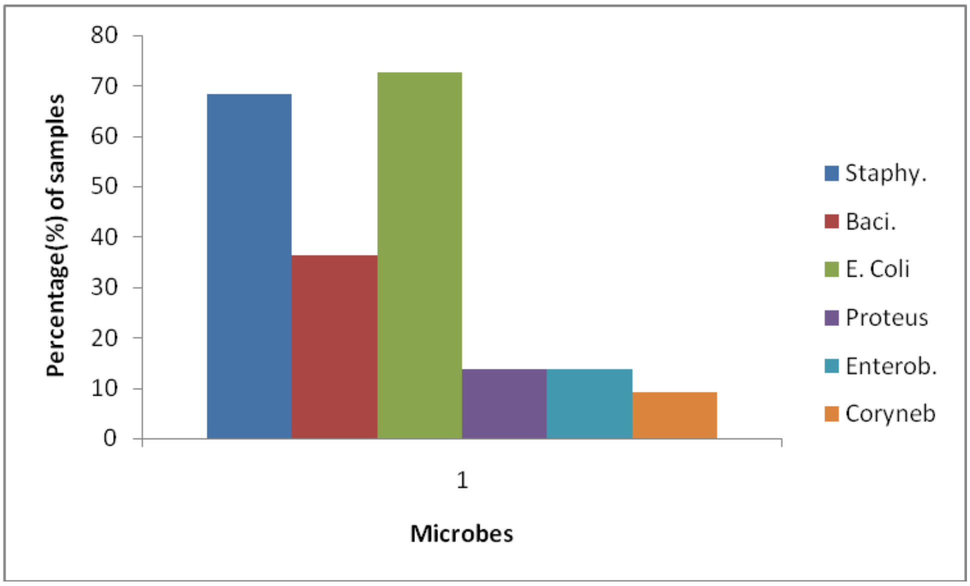

Figure 7: Microorganisms isolated in kiosk raw milk samples

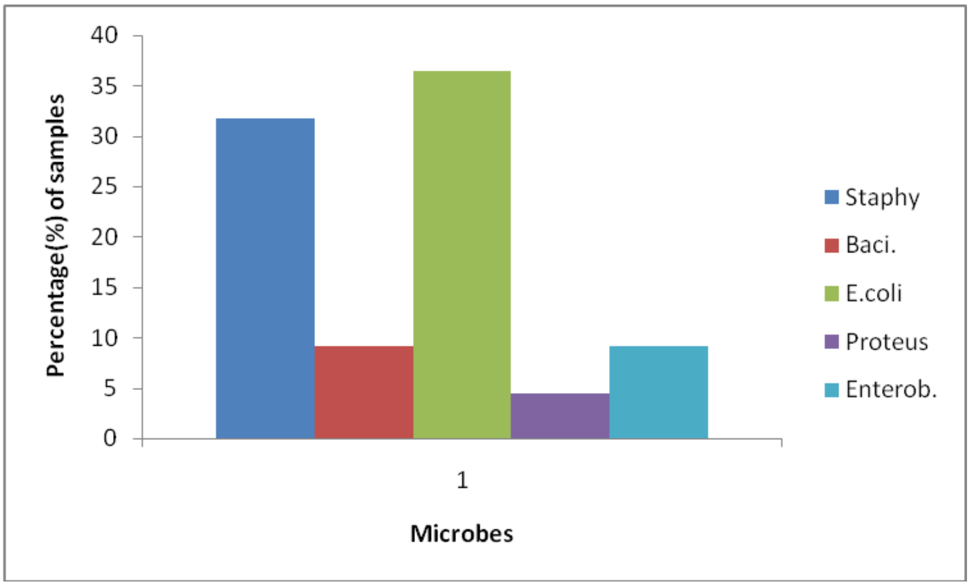

Figure 8: Microorganisms isolated in kiosk boiled milk (served hot) samples

4.8.5.1 Microorganisms in laboratory boiled and packaged processed milk

There were no microorganism isolated in laboratory boiled milk but unboiled milk was found to contain *Bacillus spp* (25%) and *Corrynebacterium spp* (25%). All packaged processed milk was found to contain *Bacillus spp* but no *S. aureus.*

4.8.6 Bacteriological quality of milk

Total Bacterial counts

According to EAS, the standard plate count per millilitre (or gram) for raw reconstituted (prepared) milk shall not exceed 30 000. Out of 22 kiosk heated milk (served hot) samples 27.3% had TBC above 30 000. Raw milk intended for further processing is considered good when it contains less than 2 000 000 colony plate count per millilitre (EAS, 2007). The proportions of raw milk samples with TBC above the EAS specification for farmers, vendors and kiosk raw milk (received unchilled) are 29%, 57% and 27.3% respectively (Figure 10). TBC values for vendor's milk received chilled (42.86%) and kiosk unboiled milk received chilled (50%) were less than 30 cfu per millilitre.

TBC values for kiosk served hot (3.7 x 10^5 ± 2.3 x 10^5) was the lowest among all TBC value computed. This could be due to the fact that the boiling practices kill most of the bacteria; the bacteria that were found in boiled milk could be associated with contamination from handling equipment and the hygienic of milk handler (Kitagwa *et al*., 2006). The TBC values of farmers milk samples (2.8 x 10^6 ± 9.8 x 10^5) in the present study is higher than those reported by Karimuribo *et al*. (2005) who found 8.9 x 10^5 ± 3.5 x 10^7 in Mvomero district. TBC values for kiosk raw milk samples received unchilled (4.8 x 10^7 ± 3.3 x 10^7) and vendors raw milk samples received unchilled (3.4 x 10^7 ± 2.6 x 10^7) were higher than TBC value for farmers' milk. This is in line with findings by Omore *et al*. (2005) who reported that bacterial counts increase (and subsequently, milk quality decreases) as milk passes through increasing numbers of intermediaries.

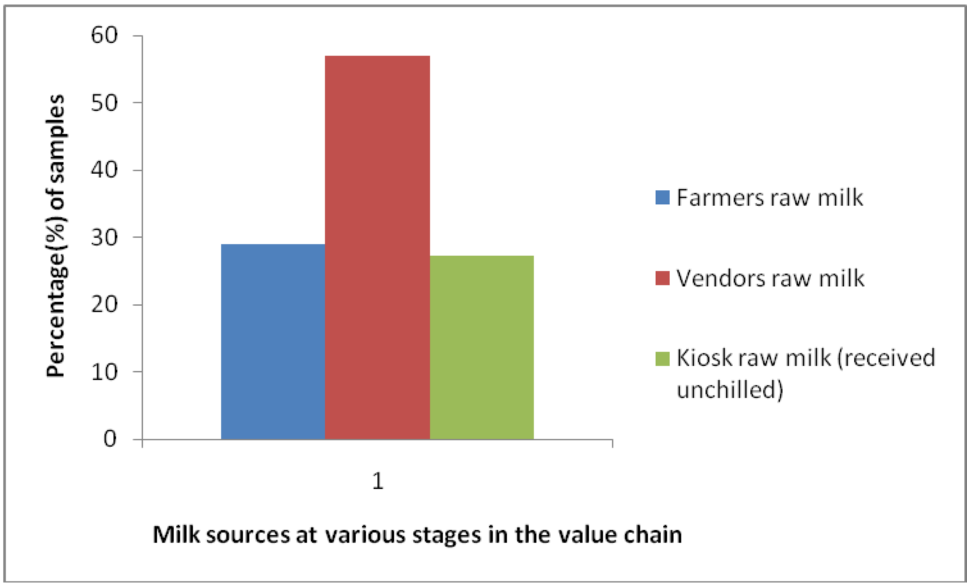

Figure 9: Percentage of raw milk samples with total counts above 2000000 cfu/ml

4.8.7 Exposure assessment of milk contaminated with *Staphylococcus aureus*

The total amount of milk sold in kiosks in peri-urban areas of Temeke Municipality a day was 1792L (90%CI: 1337-2358). Among this amount, 407L (90%CI: 119-799) was contaminated with *S. aureus* and the probability of purchasing contaminated milk was 0.227

(90%CI: 0.062-0.436) as shown in Figure 10. Every day, 953 (90%CI: 718-1,249) people purchase milk from kiosks in peri-urban Temeke, and among them, 217 (90%CI: 62-427) people were estimated to purchase contaminated milk (Fig. 11).

The result of the assessment indicated that a large fraction of the milk sold in milk kiosks of Temeke peri-urban wards could be contaminated by *S. aureus* at the time of consumption. The amount of milk contaminated found in this study 407L (22.71%) is however low when compared to amount reported by Syven, 1998 cited by Lindqvist *et al*. (2002) who indicated that about 30% of the samples contained *S. aueus* above theoretical detection limit of the analytical method, 100cfu/g when doing a similar study.

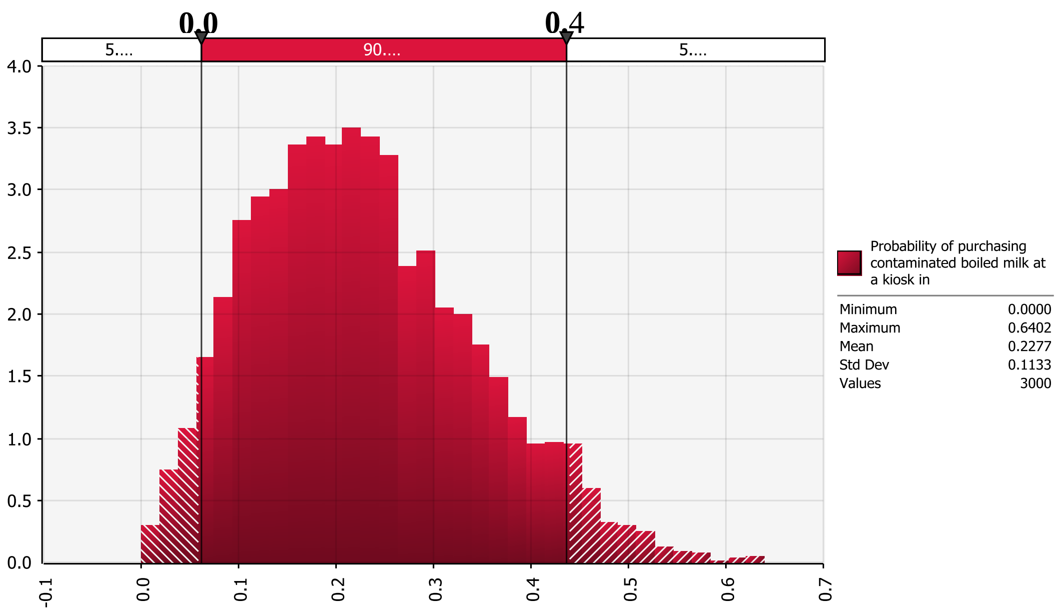

Figure 10: Monte Carlo simulation of probability of purchasing milk contaminated with *S. aureus* from a kiosk in peri-urban Temeke

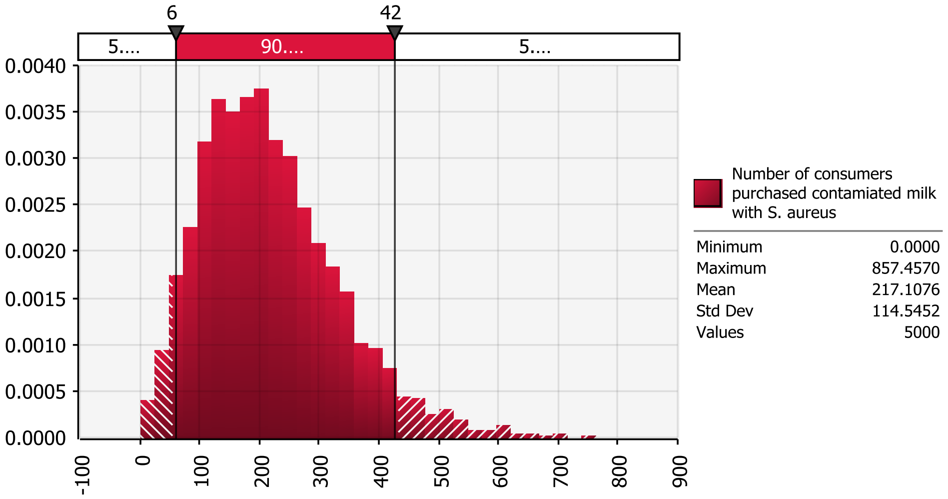

Figure 11: Probability of number of consumers purchased milk contaminated with S.aureus

4.9 Consumer's Perception of Milk Food Safety from Various Informal Outlets.

Consumers form the last group of the food chain i.e. farm to fork and therefore they are at risk of any malpractice occurring in the chain. The following paragraphs explain the consumer's perception of milk food safety from various informal outlets.

4.9.1 Consumers perception of milk quality attributes

Table 19 shows that most consumers cited milk viscosity 46.67 %(n=60), colour taste and smell 30 %(n=60) and cream at the top11.67% (n=60) as indicators of good quality milk and there was no significant difference on choice of milk shop based on milk quality attribute in the four wards (P>0.05%). These findings however, compare well with those reported by Makokha and Fadiga, (unpublished) who studied consumer perception of dairy and meat quality and safety, Kenya.

Table 19: Consumers perception of milk quality attributes

Ward	n	Milk quality attributes: Milk Viscosity (%)	Cream at the top (%)	Environmental Hygiene (%)	Colour, taste and smell(%)	P
Mbagala	15	53.33	13.33	6.67	26.67	0.4
Mbagala Kuu	15	46.67	20	6.67	26.67	
Charambe	15	60	6.67	20	13.33	
Toangoma	15	26.67	6.67	13.33	53.33	
Total	60					

X^2=9.365 Df=9 P=0.404

4.9.2 Consumer perceptions of health risks from milk

Out of 60 respondents interviewed 71.67% were aware that consumption of milk could be associated with health risks (Table 20). It was found that there was no significant difference on the level of awareness in all four sample wards (P>5%). The result of consumer's awareness on health risk from milk consumption in this study is high when compared with results reported by Karimuribo *et al*. (2005) who found 20.6% out 96 people when doing a similar study.

Table 20: Consumer perceptions of health risks from milk

Ward	n	Health risk from milk: Yes (%)	No (%)	Not sure (%)	P
Mbagala	15	66.67	33.33	0	0.504
Mbagala Kuu	15	60	33.33	6.67	
Charambe	15	73.33	26.67	0	
Toangoma	15	86.67	13.33	0	
Total	60				

X^2=5.314 df=6 P= 0.504

4.9.3 Consumer awareness of diseases associated with milk consumption

Table 21 shows that most consumers cited stomach problems 50% (n=60) and T.B 20 % (n=60) as major health problems which can be encountered when consume milk and there was no significant difference among diseases reported in the four wards (P>0.05%).

Findings of this study showed that the level of knowledge and awareness of health risks associated with drinking milk was high when compared with 21% reported by Karimuribo *et al*. (2005). The citation of stomach problems including diarrhoea by respondents in this study may be through experience of diarrheic cases associated with milk consumption attributed to lactose intolerance syndrome, which is considered to be high amongst black populations (Scrimshaw and Murray, 1998) cited by Karimuribo *et al*. (2005). The high level of awareness of tuberculosis as a zoonotic condition amongst milk customers in Tanzania may be related to the numerous reports of the link between tuberculosis and HIV/ AIDS problem in the country (Karimuribo *et al*., 2005).

Table 21: Consumers reporting incidences of diseases associated with milk consumption

		Diseases/health risk from milk consumption				
Ward	n	T.B (%)	Stomach problems (%)	Allergies (%)	None (%)	P
Mbagala	15	33.33	33.33	0	33.33	0.219
Mbagala Kuu	15	0	53.33	6.67	40	
Charambe	15	20	46.67	6.67	26.67	
Toangoma	15	26.67	66.67	0	6.67	
Total	60					

X^2=11.9 df=9 P= 0.219

4.9.4 History of foodborne diseases

About 12.0%(n=60) of the respondents reported to have encountered foodborne problems in last year which they associate it with milk consumption (Table 22) There was no significant difference in the level of history of foodborne diseases reported in the four wards (P>0.05%). Omore *et al.* (2005), reported that two consumers household (out of 420) in Nakuru reported having a member diagnosed with brucellosis in the previous one year.

Table 22: Consumers reporting history of foodborne diseases

		Foodborne history in last year			
		None	Once	More than once	
Ward	n	(%)	(%)	%	P
Mbagala	15	80	13.33	6.67	0.704
Mbagala Kuu	15	73.33	6.67	20	
Charambe	15	86.67	6.67	6.67	
Toangoma	15	86.67	0	13.33	
Total	60				

X^2=3.80 Df=6 P= 0.704

Furthermore, during FGDs it was observed that in general many milk consumers/customers were aware of the public health risks associated with milk consumption. Most of them reported stomach problems/diarrhoea as major health risk one can encounter from drinking milk.

This could be the reason why most of them prefer boiled milk served hot, as they believe boiling of milk kills most of pathogenic bacteria. A majority of respondents reported they normally drink milk from a kiosk which has a good environment and its workers are generally clean. Milk viscosity and cream at the top on boiling reported to be major sign used by most customers as symbol of good quality milk. Most of the respondents during FGDs commented that milk kiosks should be located in dust free areas and health officials should provide health education to milk kiosks owners and farmers so as to ensure good hygienic practice on handling of milk in order to ensure safety of milk to the customers. Members from FGDs also advice that there should be known milk collecting centres where by milk will be checked by health officials for its wholesomeness for human consumption. Milk kiosks owners should be promoted to buy milk from these established centres so as to ensure safety of milk (Omore *et al*., 2005).

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATION

5.1 CONCLUSIONS

The present study showed that the quality of milk in the study areas was poor. This was based on high values of TBC in milk samples. The proportions of raw milk samples with TBC above EAS specification for vendors, was high than other milk agents. This could be associated with poor hygiene of containers used to carry milk and time elapsed when moving in streets looking for customers. TBC in milk mainly reflect its storage temperature and time elapsed since milking. Findings of this study showed that 22.7% of the milk sold in Temeke peri-urban kiosk was contaminated with *S.aureus.* This suggests that the person who purchase milk from kiosks in peri-urban Temeke is at risk of consuming milk that is contaminated by *S.aureus.* The hypothesis of milk marketed in informal sector is free from coagulase + *Staph. aureus* is rejected since *S. aureus* was isolated from kiosk heated milk. It could have been due to exogenous contamination (poor hygiene after boiling) as *S.aureus* is generally heat labile.

Microbial contamination in milk marketed in Temeke peri-urban wards and Tanzania at large could be associated with unhygienic milking and handling practices that do not promote good milk. Lack of training for milk handlers could be another factor for milk contamination. There is therefore the need to plan and offer simple and practical training courses on hygienic handling of milk for milk handlers.

Findings of this study showed that the level of knowledge and awareness of health risks associated with drinking milk among consumers was high (71.67%). T.B and stomach problems including diarrhoea cases were the major health problems cited by majority of the respondents. The high level of awareness of tuberculosis as a zoonotic condition amongst milk customers in Tanzania may be related to the numerous reports of the link between tuberculosis and HIV/ AIDS problem in the country.

5.2 RECOMMENDATIONS

It is recommended that:

Extension workers to be motivated to educate farmers on the importance of milk born diseases as a disease of public health concern. Furthermore extension workers should be more close to farmers and train them on good animal husbandry including hygienic milking and handling of milk.

Training in food hygiene is essential for food handlers because food safety is a major problem and of increasing concern in developing countries including Tanzania. Adequate training strategies should be established, implemented and maintained to improve the knowledge and resulting attitude and practices of food handlers and food consumers.

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APPENDICES

Appendix 1: QUESTIONNAIRE SURVEY FOR LIVESTOCK KEEPERS IN THE STUDY AREA.

NAME OF ENUMERATOR: FILLED IN BY ________________________

Date:dd/mm/yy {______/____/_______} 1)__________________________________

Time started:____________________ Time ended:________________________

District: ______________________ Ward :_________________________________

Questionnaire No. _____________________

SECTION A: BACKGROUND INFORMATION

1. Respondent's name ___________________________

2. GPS coordinates _____ Altitude____ m.a.s.1; Average ambient temperature: _________ {_______} ^{0}C

3. Background

Sex of respondent	Age of respondent (yy)	Position in the house hold	Education level	Housing structure	Period in Dairy farming started (yy:mm)	Distance to milk market (km)
(____)	(______) Yrs	(____)	(____)	(____)	(____)	(____)

Codes

Sex of Respondent	Age of Respondent	Position in the household	Distance to milk market
1. =Male 2. =Female	1. = <20 years 2. =20 – 30 yrs 3. =30-50 4. => 50	1. = Household head 2. =Spouse 3. =Employee 4. =Others (specify)	1. = 1-5km 2. = 5-10 3. = 10-50km 4. = > 50km

Education level:	Housing structure	Period in Dairy Farming
1. =Primary school	1. = Earth floor and wall	1. = 1-5 years
2. =Secondary school	2. = Concrete Floor and wall	2. = 5-10years
3. =Certificate	3. =Others (specify)	3. = > 10years
4. =Diploma		
5. =University degree		

SECTION B: MILKING PRACTICE AND HYGIENE

4. How many cows do you have? ____________

5. How many cows are you milking? ____________

Who milks the cows?	Do you wash the udder before milking?	If YES what do you use?	Do you use a disinfectant for udder wash?	If YES what type of disinfectant	How often do you use the disinfectant?	If never, why?
{_____}	{_____}	{_____}	{_____}	{_____}	{_____}	{_____}

6. HYGIENE

Codes

Who milks the cows
1. = Owner
2. = Employee
3. = family member

Udder wash before milking
1. = YES
2. = NO

If YES what do you use?
1. = Cold water
2. = warm water
3. = Cold water with soap
4. = warm water with soap

Uses of disinfectant for udder wash
1. = YES
2. = NO

If YES what type of disinfectant?
1=. Soap
2. = Household Detergent
3. =Commercial Dairy Detergent

How often do you use the disinfectant?
1. = Everyday
2. = At all milking
3. =When available
4. =never

If never, why?
1. = Expensive
2. = Not available
3. = Not aware

6. HYGIENE CONT.

Do you dry the udder after washing?	If yes what do you use?	Do you disinfect the teat after milking?	Does the milker wash and disinfect the hands?	Does the milker maintain a special overall/overcoat for milking?	If yes how often is the overcoat used?	If the above are not done why?
{____}	{____}	{____}	{____}	{____}	{____}	{____}

Codes

Do you dry the udder after washing?
1. = YES
2. = NO

If yes what do you use?
1. = Individual paper towels
2. = Individual piece of cloth
3. = A cloth for all cows
4. = Any other

Do you disinfect the teat after milking?
1. = YES
2. = NO

.

Does the milker wash and disinfect the hands?
1. = YES
2. = NO

Does the milker maintain a special overall/overcoat for milking?
1. = YES
2. = NO

If yes how often is the overcoat used?
1. = Always
2. = Rarely
3. = When the owner is around

If the above are not done why?
1. = Not aware
2. = Expensive
3. = Not available

SECTION C: DISEASES PROBLEMS (MASTITIS) AND THEIR TREATMENT

7. What problem(s) do you face in the course of production?

___

___

___

8. TREATMENT

In situation where you have a disease problem in your herd who provides you with veterinary services?	If treatment is performed by yourself/attendant, where do you buy the drugs?	Do you get instructions/advice on how to administer the drug?	Have you ever been advised to withhold animal products intended for human consumption during and after treatment?
{____}	{____}	{____}	{____}

Who treat sick cows
1. = Private veterinarian
2. = Government veterinarian
3. =Community animal health worker
4. =Myself
5. =Other specify

____

If treatment is performed by yourself/attendant, where do you buy the drugs?
1. = Pharmacy/Veterinary
2. = Livestock and Agriculture input shop
3. = veterinary centre

____

Do you get instructions/advice on how to administer the drug?

1. = YES
2. = NO

Have you ever been advised to withhold animal products intended for human consumption during and after treatment?

1. = YES
2. = NO

If YES what was the reason(s) given for the withholding of the product?

____

____

____

Have you ever implemented the above advice?	DO you experience mastitis in your heard?	If YES, which season is mastitis mostly encountered?	What type of drug formulation do you use in treating mastitis?	Do you keep treatment records?
{____}	{____}	{____}	{____}	{____}

8. TREATMENT CONT.

Codes

Do you implement the advice 1. = YES 2. = NO	DO you experience mastitis in your heard? 1. = YES 2. = NO	If YES, which season is mastitis mostly encountered? 1. = Dry season 2. = Rain Season
What type of drug formulation do you use in treating mastitis? 1=. Intramammary tubes 2. = Injectable solutions.		Do you keep treatment records? 1. = YES 2. = NO

If yes what are the key information /components of record keeping do you have

___

___

___

SECTION E: INFORMATION ON MARKETING OF MILK

9. Marketing

Where do you sell the milk obtained?	Do you get any problem in marketing your products?
{____}	{____}

Codes

Where do you sell the milk?	Do you get any problem in marketing your products?
1. Milk shop	1. = YES
2. Vendor	2. = NO
3. Retail customers	

If YES, what are the major problems encountered?

____

____

____

… Thank you for your assistance and co-operation

Appendix 2: QUESTIONNAIRE SURVEY FOR VENDORS OF MILK IN THE STUDY AREA.

NAME OF ENUMERATOR:	FILLED IN BY ________________________
Date:dd/mm/yy {______/____/_______}	1)__________________________________
Time started:____________________	Time ended:________________________
District: ______________________	Ward :__________________________________
Questionnaire No. _____________________	

SECTION A: BACKGROUND INFORMATION

1. Respondent's name __________________

2. GPS coordinates _____ Altitude____ m.a.s.1; Average ambient temperature: _________ {_______} ^{0}C

3. Background

Sex of respondent	Age of respondent (yy)	Education level
(____)	(______) Yrs	(____)

Codes

Sex of Respondent	Age of Respondent	Education level
1. =Male 2. =Female	1. = <20 years 2. =20 – 30 yrs 3. =30-50 4. => 50	1. =Primary school 2. =Secondary school 3. =Certificate 4. =Diploma 5. =University degree

SECTION B: MILK QUALITY, MARKET, TRANSPORTATION AND HYGIENE

4. How do you assess the quality of milk before receiving it?

____
____
____

5. Milk quality, market, transportation and hygiene

Do you bulk milk from different farmers?	Do you clean the container with portable water?	What equipment you normally use for carrying the milk?	What is the means for transport?	Distance to milk market (km)	Where do you sell the milk obtained?
(____)	(____)	(____)	(____)	(____)	(____)

Codes

Do you bulk milk from different farmers?
1. = YES
2. = NO

Do you clean the container with portable water?
1. = YES
2. = NO

What equipment you normally use for carrying the milk?
1. = Plastic container
2. = Aluminum container

What is the means for transport?
1. By foot
2. Bicycle
3. Motorcycle/car

Distance to milk market (km)
1. =1-5km
2. = 5-10
3. = 10-50km
4. = > 50km

Where do you sell the milk obtained?
1. = Milk shop
2. = Retail customers

Thank you for your assistance and co-operation

Appendix 3: QUESTIONNAIRE SURVEY FOR SELLERS OF MILK IN MILK SHOPS IN THE STUDY AREA.

NAME OF ENUMERATOR: FILLED IN BY ________________________

Date:dd/mm/yy {______/____/_______} 1)__________________________________

Time started:____________________ Time ended:________________________

District: ______________________ Ward :__________________________________

Questionnaire No. _____________________

SECTION A: BACKGROUND INFORMATION

1. Respondent's name __________________ Business Name (where applicable) ____

2. GPS coordinates _____ Altitude____ m.a.s.1; Average ambient temperature: _________ {_______} ^{0}C

3. Background

Sex of respondent	Age of respondent (yy)	Position in the shop/kiosk	Education level
(____)	(_______) yrs	(____)	(____)

Codes

Sex of Respondent	Age of Respondent	Position in the household	Education level
1 =Male	1. = <20 years	1. = Owner	1. =Primary school
2 =Female	2. = 20 – 30 yrs	2. = Employee	2. =Secondary school
	3 = 30-50		3. =Certificate
	4. = > 50		4. =Diploma
			5. =University degree

SECTION B: MARKETING INFORMATION AND HYGIENE

4. MARKETING INFORMATION

When did you start milk business? (__________) year(s)

Where do you get milk for your shop?	At what time you have many customers?	Are you selling fresh milk?	Are you making soured milk?	Are you pasteurizing the milk before fermenting it?
(_____)	(_____)	(_____)	(_____)	(_____)

How do you assess the quality of milk before receiving it?

____

____

____

Codes

Where do you get milk for your shop? 1. = Farmer 2. = Vendor	Business peak time 1. = Morning 2. = Afternoon 3. = Evening	Are you selling fresh milk? 1. = YES 2. = NO
Are you making soured milk? 1. = YES 2. = NO	Are you pasteurizing the milk before fermenting it? 1. = YES 2. = NO	

5. HYGIENE INFORMATION

Are the walls, floor and ceiling in good condition and enable you to clean and disinfect them where necessary?	Do you have a cleaning schedule?	How often do you use the disinfectant?	If never, why?	Do you have a toilet on the premises?	Do you have a wash hand basin with a supply of running hot water, soap, and hygienic hand drying facilities?
(____)	(____)	(____)	(____)	(____)	(____)

If you have cleaning schedule how often does the premises receive a

(a) Deep cleaning ____________________

(b)General Cleaning_______________________

Codes

Walls, floor and ceiling able to be cleaned Easily? 1. = YES 2. = NO	cleaning schedule 1. = YES 2. = NO	Use of disinfectant 1. = Everyday 2. = When available 3. = where necessary 4. = never
If never, why? 1. = Expensive 2. = Not available 3. = Not aware	Toilet availability 1. = YES 2. = NO	Water basin, running water and soap 1. = YES 2. = NO

SECTION C: INFORMATION ON STORAGE

6. Storage

. Are all food always covered or wrapped at the premises?	Are raw and ready to eat foods stored separately?	Do you use any of the following in your premises:-
(____)	(____)	(____)

Codes

Are all food always covered in or wrapped at the premises? 1. = YES 2. = NO	Are raw and ready to eat foods stored separately? 1. = YES 2. = NO	Do you use any of the following your premise 1. = Fridges 2. = Freezers 3. = Chilled display cabnets

SECTION D: TRAINING ON HYGIENE

7. How many employees do you have that handle food? ___________________

8. How many of these handle unwrapped foods? _______________________

9. How many have received

(a) Basic or foundation in hygiene training (6 hour course) ___________________

(b) Intermediate food hygiene training (2-3 day training course ___________________

(c) Other similar food hygiene training (specify) ___________________________

10. If no Food Handlers have been formally trained please state how you ensure they handle food hygienically?____

Thank you for your assistance and co-operation

Appendix 4: QUESTIONNAIRE SURVEY FOR CUSTOMERS/CONSUMERS OF MILK IN THE STUDY AREA.

NAME OF ENUMERATOR:	FILLED IN BY ______________________
Date:dd/mm/yy {______/____/_______}	1)______________________________
Time started:__________________	Time ended:______________________
District: ____________________	Ward :______________________________
Questionnaire No. ___________________	

SECTION A: BACKGROUND INFORMATION

1. Respondent's name ________________

2. GPS coordinates _____ Altitude____ m.a.s.1; Average ambient temperature:

_________ {_______} ^{0}

3. Background

Sex of respondent	Age of respondent (yy)	Education level
(____)	(______) Yrs	(____)

Sex of Respondent	Age of Respondent	Education level
1. =Male	1. = <20 years	1. =Primary school
2. =Female	2. =20 – 30 yrs	2. =Secondary school
	3. =30-50	3. =Certificate
	4. => 50	4. =Diploma
		5. =University degree

Codes

SECTION B: CONSUMER PERCEPTION ON MILK QUALITY

4. Why do you prefer milk instead of other drinks such as soda?

____

____

How many times you take milk in a week?	Why do you prefer this place among many other milk shops around this place?
(_____)	(_______)

Codes

How many times you take milk in a week?	Why do you prefer this place among many other milk shops around this place?
1. = All the days	1. = low price
2. = 2 – 3 days	2. = good customer care
3. = When I have money	3. = quality of milk
	4. = Clean environment

Thank you for your assistance and co-operation

Appendix 5: Consent form

Thank you for agreeing to participate. We are very interested to hear your valuable opinion on how the milk stakeholders i.e. Government, farmers (livestock keepers) and business men can play their role so as ensure safety of milk and milk products from farm to fork.

- The purpose of this study is to learn what milk stakeholders can do so as to ensure consumers are getting safe product all the time. We hope to learn things that the Ministry of livestock and fisheries development together with other stakeholders can use to improve informal milk business.
- The information you give us is completely confidential, and we will not associate your name with anything you say in the focus group.
- We would like to tape the focus groups so that we can make sure to capture the thoughts, opinions, and ideas we hear from the group. No names will attach to the focus groups and the tapes will be destroyed as soon as they are transcribed.
- You may refuse to answer any question or withdraw from the study at anytime.
- We understand how important it is that this information is kept private and confidential. We will ask participants to respect each other's confidentiality.
- If you have any questions now or after you have completed the questionnaire, you can always contact a study team member like me, or my colleague.

Signature...

Name...

Checklist for focus group discussion

1. Why do you prefer this place among many other milk shops around this place?
2. How do you assess the quality of milk before receiving it?
3. Is there any health effect(s) which can be encountered by drinking milk?
4. What is your advice to the milk kiosk owners and all milk stakeholders so as to ensure that the consumers are getting safe milk all the time?