THE QUALITY OF BULK TANK MILK AND ASSOCIATED MANAGEMENT PRACTICES IN THE MANGAUNG METROPOLITAN MUNICIPALITY, SOUTH AFRICA

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DECLARATION OF INDEPENDENT WORK

I, Gaboinewe Tshegofatso Setlhare the undersigned, do hereby declare that this research project submitted to the **Central University of Technology, Free State**, for the degree **MAGISTER TECHNOLOGIAE: ENVIRONMENTAL HEALTH: FOOD SAFETY** is my own original and independent research work that is true and authentic. This research work has not been submitted before to any institution by myself or any other person in fulfilment of requirements for the attainment of any degree or qualification.

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SUMMARY

Milk has played a huge role in human diet across the world and has been the most accessible food product over the years. Necessarily, moves have arisen with the intention to improve its quality. Some factors that are necessary in improving the quality of milk are, amongst others; the hygiene of food handlers, transportation of milk, storage of milk and the possible diseases that can be transmitted. In farms and commercial outlets, food handlers, transportation, storage and the possible disease that can be transmitted through milk at a low temperature until it can be transported to outlets, for further processing or markets; however, at times bulk tanks are used as a point of sale. In, South Africa, a considerable number of people tend to consume raw milk originating from cow, sheep and goat that is not pasteurised. Moreover, there have been reports that some people alter milk by combining pasteurised milk with raw milk or by adding water to increase the quantity of milk thereby increasing their profit whilst decreasing the quality of milk. This milk is also consumed mostly by farm families as it is the only source of calcium that is affordably accessible to them.

The current study was conducted over a period of a year, where fifty four (54) milk outlets where identified by authorities (Environmental Health Practitioners) from the Mangaung Metropolitan Municipality for microbial and physicochemical analysis. However, only 28 outlets were operating during the study when questionnaires were administered. A case study of five (5) different dairy farms was also conducted to follow

up milk quality from the production point to the point of final sale to the public (farm to fork). All samples were obtained from bulk tank milk by pouring milk directly into the sterile glass bottles, transported to the laboratory on cold ice to maintain the cold chain and analysed for both microbiological (indicator microbes) and physicochemical parameters. These bottles were marked according to the shop names and transported to the laboratory immediately for analyses. Questionnaires were also distributed and administered at outlets selling milk to assess food handlers' attitude, knowledge and practices, questionnaires were explained to the respondents and responses kept anonymous for openness of respondents who may be uneasy about the process and outcomes. The latter was crucial as most outlets were owned or co-owned by foreign nationals and most felt uncomfortable with the study thinking that the intent was to close them down and/or report them to the authorities.

The results showed that out of 28 outlets were questionnaire was administered, 63% of outlets had lack of knowledge about the required cooling temperature of milk, more especially when milk arrived at the outlets. The survey further indicated that *Escherichia coli* were present in 54% of outlets and this was found in all the outlets in Thaba-Nchu and this area represented 32% of the entire study. Thirteen percent (13%) of outlets showed adulteration of milk whilst 94% showed non-compliance of coliform counts in the areas of the study. Total Viable Counts were high in 76% of outlets and these shops were not complying with the regulation, and this was followed by 41% non-compliance when focusing on somatic cell count (SCC). These results indicate poor personal hygiene and lack of proper production practices. The identified levels of indicator microorganisms have a potential to cause quick deterioration of milk which will affect human health, causing possible diseases such as severe infections and gastrointestinal infections.

The study further revealed that bulk tank milk fat content was high in 6% of outlets and ethanol content was also found in 17% of outlets. This indicated non-compliance, possibly from poor hygiene practices and possible milk adulteration. Although inhibitory substance and protein content complied in all studied areas, only 26% outlets showed that pasteurisation was not done and this is known to limit the shelf life of milk. The study further showed that in five dairy farms where the case study was performed, temperature of the tankers used to transport milk was high and not complying with the standard (not above 5°C) at two farms (farm 1 and 3). Moreover, it was found that in one farm (farm 4), the temperature of the milk was not at the correct temperature level and thus not complying with the standard. Furthermore, the study showed that milk in one of the farms (farm 1) was not pasteurised. SCC were above the acceptable levels (500 000cfm^{-1}) at the farm and during transportation in farm 2. This suggested that farm management practices were neglected and economic loss will be experienced by these farmers or bulk tank owners if they cannot trace back the source of contamination.

On the other hand, the study found out that 64% of food handlers in these outlets were females and 79% were black workers who mostly did not receive proper training on food safety issues. Forty six percent (46%) of food handlers had working experience of 5-10 years, with 57% having an education level that ranges between grades 7-12. The study further showed that 93% of food handlers reflected a lack of knowledge and poor handling of milk on aspects such as the impact of hands on contaminating the milk. The importance of cleaning bulk tanks properly and the use of effective disinfectant are crucial in order to have milk that is less contaminated. The study revealed that 80% of food handlers ignored general hygiene practices. Although 100% reported that they used hot water to wash the equipment, only 32% used the required sanitizers to wash the milking equipment. Ninety three percent (93%) of the outlets have never replaced the bulk tank and this may also contribute to milk not complying with minimum standards according to Regulation relating to dairy milk and milk products (R1555 of 1997), especially in the light of possible formation of biofilms.

Factors such as ignorance, low morale and attitude of food handlers can greatly affect and compromise food safety aspects and thus affect the quality of milk. Therefore, it can be recommended that Environmental Health Practitioners (EHPs) should visit commercial outlets on a monthly basis to evaluate the hygiene practices and the conditions of the outlets as well as provide training to all people handling milk a practice not fully followed. Finally, an awareness programme must be provided to all food handlers on a quarterly basis; and this must be for the farmers, owners of outlets and food handlers. It will further be of great interest to investigate other microbial and physical components of milk to identify possible pathogenic strains concomitant to analysis done quarterly.

CHAPTER 1

Introduction and literature review

THE MANAGEMENT AND HANDLING PRACTICES OF BULK TANK MILK: A REVIEW

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1.1 GENERAL INTRODUCTION

The Codex Alimentarius Commission (CAC) defines milk as “the normal mammary secretion of milking animals obtained from one or more milkings without addition to it or extraction from it, intended for consumption as liquid milk or for further processing” (CAC, 1999). There are several definitions by other authorities, such as the United States of America (USA), which further defines milk as “being free from colostrum” (Motarjemi and Lelieveld, 2014). Approximately 85% of milk is obtained from cows, 11% from water buffaloes, 2% from sheep, and 2% from goats. Milk from camel, yak, reindeer, horse, and donkey is also important in certain regions, but is insignificant in global trade (Fox, 2011).

Milk is known to be highly perishable, and has traditionally been processed into a broad range of more stable dairy products. Dairy products with a long shelf-life, such as cheese, also serve as sources of food over many months. Because of the need for milk and related products, the dairy industry is one of the most important food sectors and it has been very successful in providing safe dairy products over the years. Nevertheless, concern for the safety of these products remains high on the agenda of public health authorities (Valentine *et al*., 2013). Such concerns result from knowledge about the rich nutrients that make available an ideal environment for growth of many microorganisms, which can lead to contamination. Unfortunately, contamination of dairy products can occur at different points in the food chain, through complex pathways. Regrettably, some dairy products have been reported as the sources of foodborne disease outbreaks caused by any of a broad range of microbial and chemical hazards (Hassanain *et al*., 2013; Nyenje and Ndip, 2013).

The control of milk hygiene is an important component of food control and environmental health practitioners (EHP) play a role in the enforcement of compliance from the production stage of milk until it reaches the consumer. Regulation 1256 of 27 June 1986 promulgated by the Health Act, 1977 (Act 63 of 1977) (RSA, Department of Health, 1977) stipulates regulations pertaining to milking sheds and the transport of milk which determine the procedures and registration requirements of a milking parlour regarding the structural, cold-chain and transportation requirements with which milking parlours must comply for the production and sale of milk and dairy products to the public. Regulation 1555 of 21 November 1997 promulgated by the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act 54 of 1972) (RSA, Department of Health, 1972) further highlights regulations relating to and determining the quality of milk and dairy products: this regulation focusses more on the hygiene and safety requirements for milk.

The production of dairy products has increased in South Africa over the past years due to demand and to the large numbers of small dairy farms growing in rural areas (Katsande *et al*., 2013; Mwanza *et al*., 2013). Already, the dairy industry is the fourth largest agricultural industry in South Africa (Meissner *et al*., 2013). During 2012, for example, it was reported that 4.5% more milk was produced than in 2011 (Statistics, 2012), and the demand keeps on growing in both rural and urban areas, where industrialisation is becoming more widespread. Moreover, increasing demand for unpasteurized milk has brought the safety and quality of raw milk into the focus of research and general debate (Cupakova *et al*., 2012; Ruusunen *et al*., 2015). With the demand for milk and milk consumption growing rapidly, unhygienic practices by food handlers have resulted in contaminated products in some instances (Afzal *et al*., 2011; Mukhopadhyay *et al*., 2012; Bali *et al*., 2013; Khan *et al*., 2013; Mwanza *et al*., 2013).

In rural areas milk is often introduced by hand into the storage containers which are then transported to commercial outlets and stored in bulk tanks. Several countries have introduced a system of bulk tanks, which are large stainless steel storage tanks used to cool and keep milk at a low temperature until it can be picked up by a milk hauler for distribution to processing plants or points for selling to the public (Elmoslemany *et al*., 2009; Luengo *et al*., 2009; Lues *et al*., 2010; Bashir *et al*., 2013). The bulk tanks are important pieces of dairy farm equipment used daily to store raw milk and regulate its temperature (Figure 1.1 shows a typical bulk milk tank). The milk is collected from farms in thermo-regulated tankers every other day and delivered to a processing facility. At these facilities, the milk is stored and processed to make specific dairy products and in some instances sold to the public directly (Hossain and Dev, 2013), with the latter being the most common practice since the early 1990's.

Figure 1.1: Bulk tank used in most commercial outlets: an example in a shop

The majority of populations in rural areas still use raw milk, possibly containing numerous pathogens. Lack of refrigeration plays a key role in the proliferation of spoilage microbes, and this situation has the potential of leading to foodborne disease outbreaks (Davis *et al*., 2014). Although the probability of foodborne diseases can be mitigated by avoiding the drinking of raw milk, this is difficult in rural areas as raw milk is often the only affordable and easily accessible source of nourishment (Ademola and Effiong, 2013; Oyakale *et al*., 2013). 70% of diarrhoeal diseases observed in developing countries are linked to foodborne pathogens which are ingested through the consumption of contaminated dairy products amongst other things (Perko, 2011; Das *et al*., 2013; Matofari *et al*., 2013).

1.2 FACTORS INFLUENCING MILK QUALITY

High quality raw milk is imperative for the production of high quality pasteurised milk and dairy products. The production of milk with low bacterial counts starts at the farm and is influenced by many procedures related to on-farm management practices (Elmonslemany *et al*., 2010). Moreover, hazards associated with milk and dairy products are numerous and these hazards are usually grouped under three categories, namely: biological, microbiological and physicochemical. These hazards may contaminate milk and dairy products at various points in the food chain. Regulation R1555 of 1997 of Foodstuffs, Cosmetics and Disinfectants Act (54 of 1972) amended, relating to milk and dairy products, mentions that "no person shall use or sell milk that contains extraneous matters such as antibiotics, residues and pathogenic organisms as this may render milk unfit for human consumption" (RSA, National Department of Health, 1997).

1.2.1 Animal feed at the farm

Animal feed plays an important role in the health of food-producing animals and the safety of products derived from them, namely milk and dairy products. Animal feed can be a source of infections in food animals, with various pathogens, e.g. viruses, bacteria and parasites that may subsequently lead to the contamination of milk (Modi *et al*., 2013). Infected or healthy asymptomatic carriers can excrete high numbers of *L. monocytogenes* in their faeces, contaminating the environment and ultimately the milk (Marnissi *et al*., 2013).

1.2.2 Mycotoxins in animal feed

Animal feed is a potential source of exposure of farm animals to environmental contaminants such radionuclides, polychlorinated biphenyls (PCBs) and dioxins (the latter is not a concern in South Africa as it has been banned, but it may still be present in some instances) (Motarjemi and Lelieveld, 2014). Mycotoxins in feed are also a problem, in particular Aflatoxin B which is a known human carcinogen present in maize, peanuts and other crops. This mycotoxin is metabolised and transferred to milk in the form of aflatoxin M1 (Kamkar *et al*., 2011). Proper drying and storage of the feed is an important measure for preventing growth of *Aspergillus flavus* mainly known for aflatoxin formation. Other mycotoxins such as ochratoxin, T-2 toxins, deoxynivalenol and zearalenone may also be carried over into milk.

1.3 MICROORGANISMS ASSOCIATED WITH BULK TANK MILK

The past few years have seen an increase in the bulk tank milk outlets in South Africa, especially in the peri-urban areas (Lues *et al*., 2010). Although bulk tanks are a useful tool for storing and controlling the temperature of milk, they have been reported to result in poor milk quality due to poor handling practices of milk at the farm level and possible contamination during transportation, before the milk reaches the consumer (Minj and Behera, 2012; Molineri *et al*. 2012; Garedew *et al*., 2012; Uzunoz and Akcay, 2012). In addition, farmers in rural areas produce small quantities of milk and the implementation of the HACCP system and quality assurance is costly and difficult to achieve in such settings (Sozen and Hecer, 2013).

In most cases, the cold chain is breached either before or after processing, than at the point of sale. It is crucial for farmers to distribute milk that is safe for human consumption, and this can be achieved by applying basic Good Manufacturing Practices (GMP) and Hazard Analysis Critical Control Point (HACCP) principles (Papademas and Bintsis, 2010; Tasci, 2011). HACCP is an important tool used in the dairy industry and at dairy farms. It assists in reducing opportunistic diseases and minimising possible contamination. This system (HACCP) improves the production process and the quality of the products and ensures the safety of food intended for human consumption (Ayalew *et al*., 2013). Quality control of food products is imperative as it allows for the early detection and localisation of microbes (Falasconi *et al*., 2012).

Recent studies have shown that pathogens commonly found in bulk tank milk include *Staphylococcus aureus, Escherichia coli, Citrobacter spp, Aeromonas hydrophila, Bacillus cereus,* spoilage bacteria of the genera *Enterobacter, Enterococcus, Campylobacter* and certain yeast and fungi, amongst others (Lingathurai *et al*., 2009 ; Vairamuthu *et al*., 2010; Wubet *et al*., 2013). Some of these microbes cause illnesses such as salmonellosis, mastitis, tuberculosis, brucellosis and listeriosis to mention but a few.

1.3.1 Total coliform count

Total coliform counts are used to assess milk production practices such as the hygiene of machines, sanitation and milk refrigeration. It indicates hygiene levels and the sanitary quality of production conditions (Salman and Hammad, 2011). Even though the coliforms come from the digestive tracts of animals, they can survive on the hands and clothes of humans, on milking equipment, in mud and even in the air. However, in order to avoid milk spoilage, they can be killed by pasteurisation. High counts are often observed due to the presence of cold-resistant bacteria (Pantoja *et al*., 2011). Salman and Hagar (2013) found that it is not only faecal contamination that can affect the quality of the milk: wet udders, inadequate cooling of milk and udder infection are also sources of contamination. Coliform counts higher than the acceptable amount indicate poor hygiene either during the cleaning of equipment or as a reslts unhygienic handling processes (Nkambule and Dlamini, 2012; Yeun *et al*., 2012).

1.3.2 *Escherichia coli*

In most countries the distribution of *Escherichia coli* in food has been reported to cause food poisoning outbreaks (Hadrya *et al*., 2012). Its presence in milk and milk products indicates faecal contamination due to poor hygienic and milking practices. When found in milk, it is a crucial indicator of faecal contamination because in most rural areas milk is sold directly from the farm to the consumers (LeJeune and Rajala-Schultz, 2009; Bagre *et al*., 2014). In developing countries, poor dairy practices have been found to be a major cause of contamination as there are no refrigeration facilities available, not enough water for washing of hands and equipment and lack of education for food handlers (Mhone *et al*., 2012).

1.3.3 *Staphylococcus aureus*

Contamination of milk with *Staphylocccus aureus* is common and is also associated with bulk tank milk. *Staphylococcus aureus* may access bulk tank milk either by direct excretion from the udder with clinical and subclinical staphylococcal mastitis, or by faecal contamination (Fagundes *et al*, 2010; Thaker *et al*., 2013). The pathogen spreads from cow to cow through milking machines and this, together with processing conditions, may also influence the presence of *S. aureus* in the milk. Even though many disease outbreaks have been associated with consumption of unpasteurised milk, the presence of pathogens has been observed in one of the studies to be higher at collection centres than it is at farms (Valentine *et al*., 2013) As a result, proper milk handling plays a crucial role in preventing milk contamination by staphylococcal microbes (Desissa *et al*., 2012).

The most common habitat for *Staphylococcus aureus* is on the human skin or hair, in nostrils, and in gastrointestinal and urogenital areas, suggesting that the hands are the primary mode of transmission from humans to milk (Al-Saimary, 2011). Unsanitary conditions and poor hygiene, such as not washing hands when handling milk , as well as coughing and sneezing without covering of the mouth can lead to *S. aureus* contaminating milk, and also raw, cooked and canned food products (Fagundes *et al*., 2010; De Oliveira *et al*., 2011). The education of food handlers is essential in order to produce good quality milk that is safe for human consumption.

1.3.4 *Bacillus cereus*

Bacillus cereus is a gram positive rod bacterium, which is facultative, anaerobic and can form endospores. It can grow at temperatures ranging from 10°C to 48°C, and spores are formed when growth conditions are unfavourable. Due to its ability to form spores, this pathogen is resistant to pasteurisation. In milk, contamination is associated with spores found in soil, on teats, on dirty milking equipment and on dirty paper towels used to dry the teats (Ksontini *et al*., 2011). Cleaning the teats before milking using clean washable towels is considered to be the most effective method for reducing spore counts and thus ultimately reducing milk contamination (Yobouet *et al*., 2014). The presence of this organism reduces the shelf life of milk even when the milk is stored at refrigeration temperatures.

1.3.5 *Listeria monocytogenes*

The presence of *L. monocytogenes* in milk is due to contamination from water, soil, dust, animal feed, faeces and sewage. It is a common bacterium in the dairy environment both on the farm and in the processing plant (Hunt *et al*., 2012; Konosonoka *et al*., 2012). This bacterium is capable of growing at refrigeration temperatures and it can also multiply to dangerous levels, irrespective of whether refrigeration is done properly or not. Even though pasteurisation of milk kills the organism, post-pasteurisation contamination may occur within the processing plant during food handling, storage and/or processing (Anderson *et al*., 2011). It is important that examinations of bulk tank milk be done to detect abnormalities in the milk. *Listeria* species can cause abortions in pregnant women and infections in the elderly when contaminated milk is consumed. Monitoring the presence of *L. monocytogenes* is an important control measure and a good farming management practices (Mugampoza *et al*., 2011).

1.3.6 Somatic cell count

Mastitis is a food safety problem and also the biggest economic problem facing farmers due to production loss. Milk contaminated with mastitis is not fit for human consumption hence, it is important that farmers take good care of their herds. Good udder health is important for good quality milk production and is the best tool for curbing mastitis (Katsande *et al*., 2013; Ruegg and Pantoja, 2013; Sinha *et al*., 2014). There are different factors affecting somatic cell count (SCC) such as age, stress, stage of lactation and season (Sharma *et al*., 2011). The somatic cell count in humans is caused by consumption of improperly pasteurised milk. Once such milk is ingested, the pathogens can pass directly from milk to human. Several studies have indicated that SCC is observed in bulk tanks where there is evidence of inadequate hygiene practices during milking and lack of knowledge especially amongst small scale farmers (Fagundes *et al*., 2011; Norman *et al*., 2011).

In milk, SCC is used as an indicator of milk quality and sanitation (Khalil *et al*., 2013). Low numbers indicate a healthy, well-managed dairy herd, and high numbers indicate possible mastitis infection or udder damage. It is usually caused by faulty milking practices or improper use of milking equipment. High SCC reduces the yield quality, flavour and shelf life of milk (Bytyqi *et al*., 2011), and this can results in huge financial loss.

1.4 FOODBORNE DISEASE OUTBREAKS

Up until the mid-20th century, consumption of raw milk was common and, not surprisingly, so were milk-borne diseases. This is unfortunately still the case in some developing areas of the world and among certain groups of people who consume raw milk. Improvements in sanitary practices, milk pasteurization, and animal health have all had a significant impact on the reduction and prevention of milk-borne illnesses. Today, such diseases remain a problem only in those places where raw milk and products made from it are still consumed, either legally or through ignorance of the health consequences. From 1998 to 2005, data in the USA indicated 39 illness outbreaks causing 831 cases with 66 hospitalisations and 1 death, all of which were related to the consumption of raw milk. Related sources of illness were homemade ice cream, soft unripened cheese made from raw milk, and rarely, butter and milk powder (Motarjemi and Lelieveld, 2014).

In Europe and the USA, milk and milk products are implicated in 2–6% of all bacterial foodborne disease outbreaks (Quinlan, 2013). In industrialised countries, most outbreaks are related to fresh, soft or semi-soft cheese made from raw ewes' or goats' milk, often produced using artisanal methods. Another example is reconstitution of dried milk powder r infant formula that can be a frequent cause of contamination and infections. Although little data is available, the prevalence of milkborne diseases may be higher in the developing countries, where sanitary infrastructure and refrigeration are less available (Quinlan, 2013). Official reports on the cause of outbreaks and factors leading to contamination of products are scarce or anecdotal: most available reports are from countries that have well-developed surveillance and outbreak investigation systems. Even then, many reports fail to provide an in-depth explanation of the errors or shortcomings that have led to the primary contamination of the product. Consequently, the examples cited above, amongst others, have shed light on the root cause of incidents and that have provided lessons for risk management (Motarjemi and Lelieveld, 2014).

1.5 OTHER POSSIBLE CONTAMINANTS OF BULK TANK MILK

Several studies report that microbial contamination occurs in raw milk during milking time, especially when done by hand process and accompanied by poor storage conditions at household level mainly in the rural areas (Lues *et al*., 2010; Molineri *et al*., 2012; Lingathurai and Vellathurai, 2013). Difficulties associated with cooling systems, storage and transportation of raw milk are more apparent in rural areas, where the shortage of proper equipment and lack of education is common. Managing the safety of milk involves controlling the various sources of contamination and the microbial load of raw milk (Welearegay *et al*., 2012). High standards of milk quality can be achieved when personal hygiene and cleanliness measures are put in place and production staff or rural families take into consideration food hygiene and safety measures (Mukhopadhyay *et al*., 2012) regardless of whether it is at household level or not. Apart from food handlers, external factors such as milking equipment, handling practices during milking, contaminated water, conditions of storage, transportation practices and the cleanliness of the udders may also contribute to contamination of milk at the farms and utimately at the point of sale (Ghazi *et al*., 2011).

One of the frequent problems associated with food processing and manufacturing is the presence of foreign objects, some of which are health hazards and may pose risks of injury or choking. Examples are glass, stones, wood, plastic fragments and metal (or metal particles resulting from friction between metal parts). Preventive measures should be put in place to protect the final food products. These include: hygienic design of equipment and preventive maintenance to prevent friction between metal parts and/or loose parts falling into the food products using shatterproof light covers to prevent glass contamination from taking place; and prohibiting jewellery, glass (have a glass-free policy) and wooden pallets in the processing area (Motarjemi and Lelieveld, 2014).

During the processing of milk, it is invariably subjected to procedures that will remove any physical contaminant. Centrifugal clarifiers are standard equipment in any commercial milk processing operation and filters are employed in many places. However, this is not the case in rural areas where such high class expensive equipment may be out of reach. To further reduce risk, sieving milk powder or using magnets for incidental presence can be used. As a final verification measure, products can be passed through metal detectors or X-ray equipment (important if glass jars or bottles are used) to confirm that preventive measures are effective or as a corrective measure in case of failure (Motarjemi and Lelieveld, 2014; Ghazi *et al*., 2011).

1.5.1 Water

The quality of drinking water is essential for people in rural areas and improving water supply can reduce the occurrence of foodborne diseases (Anyanwu and Okoli, 2012). Water used for cleaning the milking equipment may contribute to contamination when the water is not hygienic. It is important that the water used for cleaning and drinking should be free from *Escherichia coli* and total coliforms should be less than 10/100ml (SANS 241 of 2005). Cleaning equipment with cold water and without detergents is an insufficient cleaning method as the pathogens remain on the equipment. Hot water does not only kill the pathogens but may provide many minerals needed for hydrating the growth (Welearegay *et al*., 2012). Many studies emphasise the need for the training and education of food handlers regarding the importance of washing equipment correctly (Park *et al*., 2010; Annor and Baiden, 2011; Setlhare *et al.,* 2013). Attitude and behaviour are the most important aspects to be tackled as many food handlers continue their habit of washing milking equipment with cold water (Nee and Sani, 2011). Regular monitoring of microbiological and chemical properties of water will make it easy to establish water quality.

1.5.2 Air

Contamination of milk via air is normally caused by airborne pathogens like fungi, bacterial spores, toxins, antigens and unclean water droplets (Pathak and Verma, 2013). When these substances are distributed in the air, they easily contaminate milk, causing a health hazard to the consumer. Open buckets, bowls used to store milk, and dirty protective clothing of milk handlers at the point of sale are all unhygienic practices that lead to microbial contamination due to deposits of bio-aerosols which are simply airborne microbial contaminants (Ogugbue *et al*., 2011). Droplets from coughing and sneezing of handlers remain in the air and in this way pathogens are easily transferred from humans to the milk. It is therefore important that milk handlers be taught to cover their mouths while coughing or sneezing to avoid contamination of milk through the air in the form of bioaerosols.

1.5.3 Working utensils

Raw milk is a good culture medium for microbial growth and microbes can easily gain access to raw milk via working and processing contact surfaces in milk production areas (Schlegelova *et al*., 2010; Zagare *et al*., 2012). Microbes adhere to food contact surfaces and once the attachment becomes permanent, biofilms start to form, subsequently causing food contamination (Cleto *et al*., 2012). Contamination depends on the characteristics of the working surface, i.e. whether it is smooth, rough, old, new, dry or wet. Recovering microorganisms from different working surfaces is an important task for protecting consumers' health; methods of recovery include swabbing of the working surface to detect microorganisms that may contaminate milk (Ismail *et al*., 2013). Some disease outbreaks that have occurred have been caused by surface contamination and inadequately cleaned equipment and working surfaces (Gill and McGinnis, 2000; Moshoeshoe and Olivier, 2012; Kadariya *et al*., 2014). Therefore, microbiological analysis of working and processing surfaces is one of the methods that can be used to check good hygienic practices (Sudheesh *et al*., 2013).

It is important to identify potential sources of food contamination in order to develop effective sanitation methods. Even though some microorganisms are resistant to disinfectants used to clean and sanitise the food contact surface areas, an effective cleaning method may lead to a significant reduction in microorganisms (Bae *et al.,* 2012; Schlegelova *et al*., 2010; Ismail *et al*., 2013). In addition, Jaglic *et al.* (2010) mention that some areas remain contaminated even after cleaning. This is an indication of improper cleaning and sanitation as well as lack of knowledge by personnel of how to use the disinfectant to clean the areas (Jaglic *et al*). Food contact surfaces that remain contaminated and equipment used during processing milk and storage that is not properly sanitised to avoid any possible growth of microorganisms which can indicate negligence and lack of training of food handlers. Damp surfaces and areas where hygiene is poor can cause microbes to aggregate easily thus affecting milk quality (Jaglic *et al.,* 2010; Schlegelova *et al*., 2010).

1.5.3.1 Knowledge and attitude of food handlers

Over the years foodborne disease outbreaks have been linked to poor handling practices, poor food hygiene and negative attitudes by food handlers (Annor and Baiden, 2011). Such human and behavioural factors may enable pathogenic bacteria to come into contact with food and in some cases this causes illness to the consumers. Several studies have found that food handlers are untrained on how to handle perishable food, and more especially milk (Gadi *et al*., 2013; Sharif *et al*., 2013; Tan *et al*., 2013; Makwanda and Woyo, 2014). Poor personal hygiene, habits and attitude have been identified as some of the main components leading to contamination of food by food handlers and they may well be the source of transmission of microbes that affect the quality of milk.

Sharif *et al*. (2013) report that food handlers fail to wash their hands properly and some do not even see or understand the need for washing hands. In some instances the food handlers do not wash their hands at all. Incorrect practices such as not washing the equipment properly or washing it the following day may have a negative impact on milk. Habits such as picking one's nose, wiping faces with hands, wearing unclean protective clothing, using unclean containers as well as sneezing and coughing without covering the mouth can cause contamination of milk (Tan *et al.,* 2013). Sometimes food handlers may have basic knowledge regarding personal hygiene but they do not understand the essential aspects of hygiene when it comes to food. Therefore, attention needs to be paid to basic hygiene practices, knowledge of the Hazard Critical Control Points (HACCP) system that requires to be introduced in food industries, and education of food handlers about the importance of food safety, improvement in these areas will improve the quality of food (Gadi *et al*., 2013).

The other factor that food handlers lack knowledge on is that of keeping the milk at the required temperature level. An insufficiently low cooling temperature for storing milk may also contribute to the contamination of milk as many food handlers do not know that milk should be at or below 5°C to maintain the cold chain as stipulated by government regulations (R1555 of 1997). Effective food training should be provided to handlers to ensure that they have proper knowledge and implement proper practices. Such training will lead to an improvement and positive change in behaviour especially during milk storage (Nyamari, 2013).

1.5.3.2 Storage, handling and transportation of milk

Milk is a food of good nutritional value and rich in calcium, the consumption of which benefits the human body. Since milk can easily be contaminated, it is important that it is stored in clean containers at refrigerated temperatures immediately after processing to eliminate cross-contamination. Most of the commercial outlets in rural areas still demonstrate poor hygiene practices by using unclean and poorly sanitised containers, and such activity degrades the quality of milk. Common poor hygiene practices such as no usage of soap, lack of hot water and lack of sanitiser to wash milk storage containers may also affect the quality of milk (Yuen *et al*., 2012). The improper transportation of raw milk from the dairy farms to commercial outlets is also a problem (Salman and Hagar, 2013) because certain requirements to produce safe and clean milk are not followed. Transportation of milk by vehicles that do not have cooling equipment also increases the probability of microbes being introduced to the milk.

1.5.3.3 Cleaning and sanitation of equipments

Proper cleaning and sanitation of milking equipment is an important factor in producing good quality raw milk (Welearegay *et al*., 2012; Worku *et al*., 2014). Cleaning of milking equipment could be considered a critical aspect in milk producing outlets, because poor cleaning could influence the level of bacterial contamination of bulk tank milk (Bava *et al.,* 2009; Bliska, 2014). The hygiene of dairy farm milking equipment surfaces is one of the factors that influence the bacterial counts of the bulk tank milk, hence effective systems for ensuring the cleanliness of milking equipment are essential. Milk residues left on equipment surfaces support the growth of various microorganisms (Moshoeshoe and Olivier, 2012). Residues that build up on milking equipment provide the nutrients for growth and multiplication of the bacteria. Old containers, if not washed properly, can also harbour and support the growth and survival of the bacteria. Insufficient cleaning, poor temperature control and absence of sanitisers also tend to be other mechanisms that fuel the growth of microorganisms. It is thus important to ensure that the milk is stored at the correct use temperature and that the correct sanitisers are used (Nadia *et al*., 2012). Adesina *et al*. (2011) also states that it is important to clean equipment between and after every milking process, using the correct sanitiser. The effective cleaning of bulk tank requires the use of approved bulk tank detergents at the concentration recommended by the manufacturer (Garedew *et al*., 2012; Malek *et al*., 2012).

1.6 IDENTIFICATION OF CONTAMINATION POINTS

A farm that is managed properly plays an important role in producing good quality milk (Fagundes *et al*., 2011). It is important that once the milk leaves the udder, cleanliness, sanitation and cooling are maintained until the product reaches the consumer (Minj and Behera, 2012). Figure 1.2 below shows the typical process of milk production from farm to the consumer. Milking cows by hand is still a common method on small farms and in most rural areas, but whether the milking is done by hand or by machine, cleanliness is crucial (Lues *et al*., 2010; Uddin *et al*., 2011). The usage of glvers could also reduce the level of contamination, and exposed wounds should be hygienically covered at all times. Hands are the most common source of transmission (Fagundes *et al*., 2011) and many people handling milk tend not to employ good hygiene practices such as washing hands before handling milk. Omission of the use of hot water and disinfectants to wash hands before and between milking cows contributes significantly to milk contamination (Fawzi *et al*., 2009).

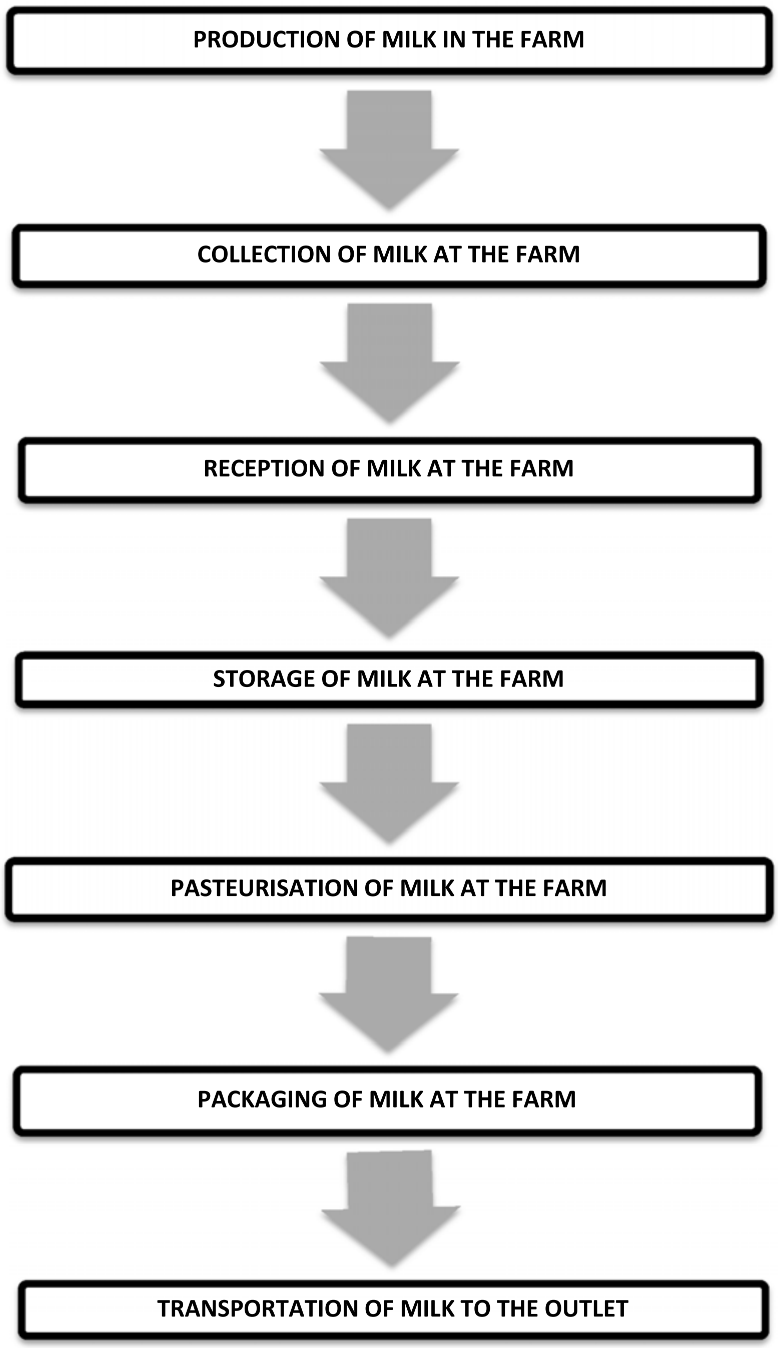

Figure 1.2: Typical process of milk production from the farm to the consumer

1.7 RATIONALE

1.7.1 Problem statement

Microbial pathogens and contamination play an important role in the food industry since milk is a major component of the human diet all over the world. Milk serves as a good growth medium for many organisms more especially pathogenic bacteria (Ali and Abdelgadir, 2011). Foodborne pathogens found in raw milk may cause various illnesses and related symptoms such as nausea, vomiting, fever, loose stools and, in severe cases, death (Agarwal *et al*., 2012). This is worrying because in rural areas milk is found to be more adulterated. Limited information is available regarding the quality of bulk tank milk, and also regarding management practices that can help in reducing the number of instances of milk contamination in South Africa. Poor storage methods and lack of refrigeration affect the quality of milk (Mwanza *et al*., 2013). Furthermore, improper cleaning facilitates contamination and affected milk may not be suitable for human consumption. Some outlets combine raw milk with pasteurised milk or alter the milk by adding water to increase their profit. All these challenges are of great concern in developing metropolitan cities due to urbanisation.

1.7.2 Limitations of the study

The initial plan was to conduct this study in 53 registered commercial outlets in the Mangaung Metropolitan Municipality, in the Free State Province. Samples for indicator organisms and physicochemical compositions were taken from all outlets. However the questionnaire surveys were performed at a later stage and it turned out that only 28 commercial outlets were selling milk, whilst the remaining outlets no longer sell milk or were not operating during the time of the survey.

1.7.3 Study aim

The overall aim was to assess management practices and to quantify the status of bulk tank milk in commercial outlets in and around the Mangaung Metropolitan Municipality area through the use of regulation R1555 of 1997 (RSA. National Department of Health, 1997).

1.7.4 The objectives of the study

To achieve the overall aim, the objectives of this study were:

- to assess the management and handling practices of milk in commercial outlets in the Mangaung Metropolitan Municipality area;
- to assess and/or observe the knowledge, attitude, practices and behaviour (KABP's) of food handlers;
- to quantify indicator microbes and selected physicochemical aspects as stipulated in R1555;
- to conduct a case study in dairy farms in relation to farm to fork principle using the R1555 guideline.

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CHAPTER 2

THE MANAGEMENT AND HANDLING PRACTICES OF BULK TANK MILK IN MANGAUNG, FREE STATE

THE MANAGEMENT AND HANDLING PRACTICES OF HANDLERS OF BULK TANK MILK IN MANGAUNG, FREE STATE

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2.1 ABSTRACT

The purpose of this study was to assess the effect of management and handling practices by food handlers in accordance with R1555 of 1997 (RSA. Department of Health, 1997) on bulk tank milk in commercial outlets. The knowledge, attitude, behaviour and practices of foodhandlers were also assessed. Questionnaires for the evaluation of food handlers concerning food safety in and around the Mangaung Metropolitan Municipality were developed and data were collected from outlets selling milk. The study revealed that 18% of food handlers did not have any form of education (although they had more than one year experience). 46% of food handlers had 5-10 years' experience working with milk: however the majority of the respondents (93%) did not have any kind of training about food hygiene and safety practices. 71% of the respondents did not know the required temperatures for storing and cooling milk. 93% of the respondents agreed that they had never replaced the bulk tank and 7% did not wash the mouth of the bulk tank often. Even though all the respondents (100%) mentioned that they knew the risks that fingernails posed to food, it was discovered that some of them had long fingernails. The results of the survey highlighted the fact that there is a need to establish and implement awareness programmes as soon as food handlers are employed and to raise the morale of and motivate people handling food.

Keywords: commercial outlets, bulk tank, food hygiene, management practices

2.2 INTRODUCTION

Foodborne diseases continue to be a common public health challenge globally and be found more in developing countries because of poor food handling and sanitation practices (Sanlier *et al*., 2011; Haileselassie *et al*., 2012). Several authors indicated that common practices of food handlers contribute towards contamination of food and milk: some of these are improper handling of food, absence of potable water, unsuitable environment for storing milk, inadequate cooling temperature, improper washing of hands, use of unclean equipment, adulteration of milk, mixing leftover milk with new milk and poor personal hygiene (Perez *et al*., 2011; Kibret and Abera, 2012; Tan *et al*., 2013). Milk is one of the most common beverages worldwide and a food product that is important to the consumer. Milk is wholesome and must be contaminant free so as not to cause health problems (Hossain *et al*., 2010). Food handlers must practise good personal hygiene to prevent survival and multiplication of, and cross-contamination by, pathogenic strains (Haileselassie *et al*., 2012; Gaungoo and Jeewon, 2013).

Every year, millions of people die worldwide from consuming contaminated food and it is reported that 70% of diarrhoeal diseases in developing countries are associated with poor handling practices of food by foodhandlers (Abdelhafez, 2013). A study conducted in the United States of America (USA) suggests that improper food handling practices contributed to approximately 97% of foodborne illnesses (WHO 2008; Abdelhafez, 2013). Food handlers are important people when it comes to food safety and their hygiene practices play an important role in the contamination of food, because they can affect a large population (Ababio and Adi, 2012). Food handlers can also play a major role in preventing food poisoning during production, distribution and storage. Lack of knowledge and negative attitude of food handlers suggest, however, that understanding about food safety is minimal and needs to be improved to reduce foodborne illnesses (Nee and Sani, 2011; Kibret and Abera, 2012). Several studies indicate that food handlers appear to have good knowledge about food hygiene but this knowledge is not practiced during distribution and storage of food products. This suggests that food handlers either do not consider many important practices such as the importance of washing of hands and ideal refrigeration temperatures or have a lack of understanding thereof (Abdelhafez, 2013; Alrabadi *et al*., 2013).

Food handlers are the first line of defence in the food safety chain and therefore their training is important (Byrd-Bredbenner *et al*., 2013). Training and education are needed to ensure that food handlers have the necessary knowledge to comply with food hygiene requirements. Such training must cover the need to avoid contamination as well as the epidemiology of microorganisms that can affect the quality of food and ultimately human health (Perez *et al*, 2011). Although there is evidence that training enhances the knowledge of food handlers to avoid contamination, such training must be conducted with more emphasis on food hygiene and handling practices (Gaungoo and Jeewon, 2013). It is vitally important to understand the interaction between knowledge, attitude, behaviour and practices of food handlers to be able to minimise the risk of food contamination and foodborne disease or illness outbreaks (WHO, 2000; 2008).

Microbial proliferation can be inhibited by making use of clean containers and refrigerating milk after the milking process in addition to educating food handlers (El-Demerdash and Al-Otaibi, 2012; Nadia *et al*., 2012). Therefore, the aim of this study was to assess the management and handling practices of handlers of bulk tank milk in commercial outlets in the Mangaung Metropolitan Municipality.

2.3 MATERIALS AND METHODS

2.3.1 Study location

A questionnaire survey was conducted at 28 commercial outlets selling bulk tank milk and these outlets were registered in and around the Mangaung Metropolitan municipal area. Such outlets were found to be selling milk during the time of the study. All outlets listed at the municipality were included in the study with the aim of assessing the status of bulk tanks milk and hygienic handling practices in use at commercial outlets.

2.3.2 Questionnaire

A questionnaire (Appendix A) with open and closed-ended questions was administered to one food handler per outlet totalling 28 food handlers working with milk. At these outlets, one or two employees were handling milk but more that 70% of the outlets consisted of one worker responsible for washing bulk tanks. In most outlets the owner dispensed and handled the milk and the bulk tank without the assistance of a food handler. The questionnaire consisted of 49 questions covering issues such as the demographic profile of food handlers, hygiene, knowledge, attitude, behaviour and practices (KABPs) of foodhandlers in commercial outlets. The respondents were informed that their participation was voluntary and would remain anonymous. The questionnaires were coded after completion and statistical analyses done using Microsoft Excel 2010.

2.3.3 Data collection

Interviews were conducted in person using structured questionnaires, and focusing on product safety and hygiene in general. The purpose of the interviews was explained to both the owners of the outlets (managers) and the people handling milk, where applicable. The average completion time of the questionnaire was 10-15 minutes. The questions were also translated into local languages, specifically Sesotho and Setswana for people who did not understand English. All questionnaires were administered by a well trained and practising Environmental Health Practitioner registered with the HPCSA (Health Profession Council of South Africa).

2.3.4 Data analysis

Scores for the demographic profile data of food handlers, knowledge, attitude, behaviour and practices (KABP's) and the level of hygiene practices concerning the bulk tanks in commercial outlets were calculated based on answers to the multiple choice questions. Data was presented primarily as frequencies and percentages.

2.4 RESULTS AND DISCUSSION

2.4.1 Profile of interviewees

Table 2.1 reflects the demographic profile of food handlers (respondents) who were involved in the study. Out of 28 respondents involved in this research, the results showed that most food handlers were females, who represented approximately 64% of the sample size. According to Annor and Baiden (2011) and Sharif *et al.* (2013), food handlers are mostly females. A large number of food handlers in this study were between the ages of 31 and 40 years (36%). 32% of food handlers were between 20 and 30 of age and the remaining 32% were above 41 years of age. Generally, the fd handlers in the study were found to be black African people (79%) and white people 21% indicating that mostly black people handle the milk at commercial outlets which is in line with South Africa's demographic profile.

The highest educational level recorded was between grade 7 and 12 (57%). 25% of the respondents indicated that their educational level was between grades 1 and 6, followed by 18% having no formal education. 50% of the respondents had 5-10 years working experience, 36% had 2-5 years working experience and the remaining 14 % had 1-2 years working experience. It was noted that only 7% of the respondents had attended training while 93% had not received any form of training about food hygiene and safety. Interestingly, this study is in line with Kibret *et al*. (2012), who reported that lack of training contributed to the cross-contamination of food. Training and/or the refresher are required to minimise possible food contamination by food handlers.

Table 2.1: Demographic profile data of food handlers *(n=28)*

Variable	Demographic characteristics	Response (%)
1. Gender	Male	10 (36%)
	Female	18 (64%)
2. Race	Black	22 (79%)
	Asian	0 (0%)
	Coloured	0 (0%)
	White	6 (21%)
3. Age	Below 20	0 (0%)
	20-30	9 (32%)
	31-40	10 (36%)
	41 and above	9 (32%)
4. Level of education	None	5 (18%)
	Grade 1-6	7 (25%)
	Grade 7-12	16 (57%)
	Tertiary Education	0 (0%)
5. Working experience	Below 1 year	0 (0%)
	1-2 years	4 (14%)
	2-5 years	10 (36%)
	5-10 years	14 (50%)
6. Training received?	Yes	2 (7%)
	No	26 (93%)

2.4.2. Health and hygiene practices by food handlers

Table 2.2 shows the health and hygiene of food handlers (respondents) that were involved in the study. It was noted that, according to the food handlers, 75% of the milk was from farms, 18% from Company A and the other 7% of the respondents did not know the sources of their milk. Even though 100% of the respondents reported that they refrigerate milk immediately upon arrival, according to the practices that were observed in some of the milk outlets, it was noted that refrigeration practices were not performed correctly as milk was left at room temperature after arrival while waiting for tanks to be cleaned. 43% of the respondents agreed that containers brought by consumers when purchasing were sometimes clean and 11% stated that such containers were not always clean and customers refused to go and get clean containers even when advised to do so. Seventy one percent (71%) of the respondents acknowledged that they did not know the required temperature for storing milk; this was worrying because at some outlets the milk was stored at room temperature before it was refrigerated.

Figure 2.1 shows typical containers used to store milk upon reception, which were often left open and unattended. A study conducted by Yuen *et al*. (2012) shows that such practices can cause serious contamination and can affect the quality of the milk. 79% of the respondents indicated that the customers prefer plastic bottle containers because they are easy to wash (as seen in Appendix B). Twenty one (21%) of respondents mentioned that customers use any container. Containers used may be possible contributors to cross-contamination if not cleaned properly.

Table 2.2: Respondents' health and hygiene production practices *(n=28)*

Statement	Answer	Response [number (%)]
1. Where do you get the milk from?	Farm Company A Do not know	21 (75%) 5 (18%) 2 (7%)
2. Do you refrigerate milk immediately after arrival?	Yes No Sometimes	28 (100%) 0 (0%) 0 (0%)
3. How many days does this milk last in the tank?	1 day 2 days 3 days	8 (29%) 16 (57%) 4 (14%)
4. What do you do with that milk?	Sell as Amasi Discard Other (specify)	28 (100%) 0 (0%) 0 (0%)
5. Do you know the required temperature for keeping milk?	Yes No Other (specify)	8 (29%) 20 (71) 0 (0%)
6. What type of containers are used?	Plastic container Bucket Any container	22 (79%) 0 (0%) 6 (21%)
7. Are containers clean at all times?	Yes No Sometimes	13 (46%) 3 (11%) 12 (43%)

Figure 2.1: Milk stored open and at room temperature after arrival

Several authors mention that not all types of containers used have a negative effect on milk quality (Tassew and Seifu, 2010; Salman and Elnasri, 2011; Rahman *et al*., 2012). 57% of the respondents mentioned that milk may remain in the tank for two days without being sold; 29% reported that the milk may remain there for one day, and 14% stated that milk may remain in the tank for three days. All of the respondents (100%) mentioned that left-over milk was sold as amasi (fermented milk) to the customers who want it like that. The respondents suggested that the amount of left-over milk may be the results of numerous outlets selling milk in the same area. Therefore, this indicates that milk is not bought on a daily basis by many outlets.

2.4.3 Knowledge of food handlers regarding food safety and hygiene

Knowledge is an important factor when it comes to the reduction of pathogens and foodborne diseases (Nee and Sani, 2011). Table 2.3 shows the response to questions relating to food handlers' knowledge regarding food safety and hygiene. 57% of the respondents stated that there were no procedures for washing bulk tanks or milk containers, whereas 43% affirmed that they knew the steps on how to wash the tanks. Even though 100% said that they did not mix fresh milk with the previous day's milk, such practices were observed in some areas. The majority of the respondents (86%) stated that they do not wear gloves when washing the tank; the other 14% mentioned that they do use gloves when washing the tank. All of the respondents (100%) indicated that they know the importance of keeping nails clean and short, but it was noticed that some of them did not adhere to the practice.

Table 2.3: Food handlers' knowledge response regarding food safety and hygiene *(n=28)*

Statement	Response [number (%)]	
	Yes	No
1. ***Is there a procedure for washing the tank?***	12 (43%)	16 (57%)
2. ***Do you mix the fresh milk with the previous day's milk?***	0 (0%)	28 (100%)
3. ***Do you use gloves when washing the tank/milking equipment?***	4 (14%)	24 (86%)
4. ***Do you know the impact finger nails have on food?***	28 (100%)	0 (0%)
5. ***Do you wear gloves when handling milk?***	8 (29%)	20 (71%)
6. ***Is it necessary to cover your head when working with milk?***	28 (100%)	0 (0%)
7. ***Do you know what HACCP is?***	18 (64%)	10 (36%)
8. ***Do you wash the mouth of the bulk tank often?***	26 (93%)	2 (7%)

71% of the respondents admitted to not wearing gloves when handling milk as seen in Appendix B, while 29% mentioned that they wear gloves when handling milk. Positive knowledge on the part of respondents was seen where 100% reported that it is necessary to cover one's head when handling and/or working with milk. Even though all respondents were aware of this, the practice was not adhered to in some outlets (Appendix B). Lack of adherence to basic hygiene requirements such as keeping nails short and covering of hair was a concern at some outlets as such lack of adherence has been reported to lead to cross-contamination of milk which could ultimately result in possible foodborne disease outbreaks (Adzoyi and Honyenuga, 2014). Generally, 64% of the respondents mentioned that they knew what HACCP was whilst 36% of the respondents did not know about HACCP. The majority (93%) of respondents had not received training on food safety and hygiene since the commencement of their employment. Literature has shown that lack of training influences food safety practices negatively and it was noticed on observation that some of the food handlers did not even follow proper handling practices during the interview. Gaungoo and Jeewon (2013), state that training in HACCP is important as it assists in the quality control of food. It is thus imperative to train food handlers in the basic principles of food safety in order to improve the quality of food.

2.4.4 Food handlers' attitudes towards handling practices at commercial outlets

Studies have shown that the most important elements that may influence food safety is the behaviour and attitude of food handlers (Egan *et al*., 2007; Mulungeta and Bayena, 2012; Mastrantonio *et al*., 2014). The scores indicating food handlers' attitudes are presented in Table 2.4. 75% of the respondents showed that they cleaned the tank or containers storing milk when empty while 21% cleaned the tank before milk arrived from the seller or before the milk was poured into bulk tanks. Four (4%) of respondents mentioned that they washed the tanks the following day which means that the tanks remain with milk residues that can further contaminate fresh milk if washing is not done correctly. 89% of the respondents agreed that they washed the tanks or containers used to store milk by hand without wearing gloves. 4% responded that they used machine to wash the tanks while 7% of the respondents from the commercial outlets used both hands and machines for cleaning the tanks. The fact that tanks are cleaned without the use of gloves is a serious concern as studies by Haileselassie *et al*. (2012) and Hamuel *et al*. (2014) report that hands that are not sanitised properly are the major source of introducing pathogens into food and causing cross-contamination.

Hand and food hygiene practices are critical in ensuring food safety and studies have shown that unhygienic practices may contribute to food contamination (Mukhopadhyay *et al*., 2012). Half of the respondents (50%) reported that they use ordinary soap to wash the tank while 36% responded that they used a specialised sanitiser to wash the tank; the remaining 14% used both ordinary soap and sanitiser. The respondents further reported that they used ordinary soap when special detergents were finished. Welearegay *et al.* (2012) mention that proper cleaning of equipment with the correct sanitiser is essential to kill pathogens presents in the containers or bulk tanks.

Table 2.4: Food handler's attitude response about food safety and hygiene *(n=28)*

Statement	Answer	Response %
1. When do you wash the bulk tank?		
	Before milk comes	6 (21%)
	When empty	21 (75%)
	Both	0 (0%)
	Following day	1 (4%)
2. How do you wash the tank/ milking equipments?	Manual (hand)	25 (89%)
	Circulation (machine)	1 (4%)
	Both	2 (7%)
	Other (specify)	0 (0%)
3. What do you use to wash the tank?	Ordinary soap	14 (50%)
	Sanitizer	10 (36%)
	Both	4 (14%)
	Other (specify)	0 (0%)
4. How often do you replace the tank?	Four times a year	0 (0%)
	Once a year	2 (7%)
	Never replaced	26 (93%)
	Other (specify)	0 (0%)
5. What kind of water is used to wash the tank?	Hot water	27 (96%)
	Cold water	1 (4%)
	Other (specify)	0 (0%)
6. How long do you wash the tank for?	2 minutes	10 (36%)
	5-10 minutes	8 (29%)
	15-20 minutes	4 (14%)
	30 min -1hour	6 (21%)

A high percentage (93%) of respondents had never replaced the bulk tanks or containers they used to store milk and 7% reported to have replaced the tanks once a year. This was a concern, according Cleto *et al*. (2012), because if tanks are not washed properly, microbes may become attached to the areas in the tanks that are difficult to clean causing contamination of milk. This could result in biofilm formation and consequently contaminate milk throughout the time of use of the affected container (Marchand *et al*., 2012). Even though 96% of the respondents used hot water to wash the bulk tanks or storage containers, 4% of the outlets used cold water, which could lead to insufficient cleaning of milk tanks. 36% of the respondents mentioned that they washed the tanks for approximately 2 minutes, 29% of respondents stated that they washed the tanks for at least 5-10 minutes, 14% reported that they washed the tanks for about 14-20 minutes and 21% of the respondents washed the tanks for approximately 30 minutes to 1 hour. The concern was not the duration of the washing but rather the effectiveness of the washing methods used. It was noted that the washing of tanks was not done according to proper methods which entail the rinsing of the tanks after washing with clean running water.

2.4.5 Food handlers' information regarding hygiene practices

Food service establishments are a major source of foodborne illness with food handlers contributing to most instances of foodborne illness (Issa *et al*., 2010; Aziz and Dahan, 2013; Olumakaiye and Bakare, 2013). According to the World Health Organisation (WHO, 2007), food handlers play an important role in ensuring food safety throughout the chain of food production and storage. Table 2.5 shows that 43% of respondents mentioned that it was not important to clean the area where the tanks are situated because the milk is inside closed the bulk tanks. 39% of the respondents said that they sometimes clean the areas where the tanks are situated and/or when they see that the area has not been cleaned for a long period. Only 18% mentioned that they regularly clean the areas where the tanks are situated.

Half the respondents (50%) stated that they washed the tanks frequently, with, 39% of them reporting they washed the tank once per day while 11% washed the tank twice per day. It was also noted in the current study that 64% of the respondents indicated that the Environmental Health Practitioners (EHPs) do not monitor the hygiene status of bulk tanks. Moreover, the EHPs did not assess the area or take samples for further analysis from where these tanks are situated. On the contrary, 25% of the respondents revealed that samples were taken but not on a regular basis by the EHPs. Eleven percent (11%) confirmed that milk samples were sometimes taken by the EHPs, although they were not sure for what purpose. 100% of the respondents reported that the water they used to clean the tanks or utensils was municipal tap water.

Of the respondents, 67% revealed that they washed their hands after using the toilet, while 25% washed their hands before and after using the toilet; 7%, stated that they only washed hands when they were dirty. 100% of the respondents claimed that no person had fallen sick from consuming milk from their outlets.

Table 2.5: Food handlers' information regarding hygiene practices *(n=28)*

Statement	Answer	Response [number (%)]
1. Is it important to clean the area where the tank is stored?	Yes No Sometimes	5 (18%) 12 (43%) 11 (39%)
2. How often do you wash the bulk tank?	Frequently Once per day Twice per day Other (specify)	14 (50%) 11 (39%) 3(11%) 0 (0%)
3. Does the EHP take milk samples or monitor the health hygiene practices?	Yes No Sometimes	7 (25%) 18 (64%) 3(11%)
4. Where does the water used for cleaning come from?	Tap water Borehole Other (specify)	28 (100%) 0 (0%) 0 (0%
5. When do you wash your hands?	After using the toilet Before and after using Toilet When they are dirty	19 (68%) 7 (25%) 2 (7%)
6. Has anyone fallen sick from drinking this milk?	Yes No Never happened	0 (0%) 28 (100%) 0 (0%)

2.5 CONCLUSION

Food hygiene has become a very important factor that stems directly from the state of personal hygiene and behaviour of the personnel working and handling food (Ifeadike *et al*., 2014). All people who work as food handlers must be informed and made aware of their role in minimising contamination. They have to ensure that they follow safe and sanitised washing practices before starting with their duties. The findings of this study demonstrated that many of the food handlers had good knowledge of the procedure necessary for food hygiene but they did not always put them into practice. For example, it was observed that some food handlers had long fingernails, did not cover their heads, did not refrigerate milk immediately after receiving it and washed tanks with bare hands. Such practices indicate a lack of general hygiene knowledge practices and/or their implementation thereof.

The study indicates that training was urgently needed as the majority of food handlers did not receive food hygiene training before handling milk. The training should focus on information concerning temperature control, proper handling practices, prevention of cross contamination (proper hand washing), suitable clean up procedures and knowledge about microbes that can cause disease to people who will consume such contaminated milk. Food hygiene and safety training should be repeated at regular intervals to ensure that the knowledge is imbedded and that food handlers understand the basic principles in order to put them into practice (Sanlier *et al*., 2011; Afifi and Abushelaibi, 2012). Regular checkups and monitoring of commercial outlets by municipality officials may contribute towards the food handler's level of hygiene and therefore outlook of the outlets. These check-ups should also include keeping the temperature of the milk in bulk tanks low. The EHPs must be strict regarding the required temperature measures, even though this may not going to be easy for some outlets. Other means of cooling should also be considered to prevent milk becoming contaminated by pathogens (Savadogo *et al*., 2011). Subsequent research into how training can change the knowledge, attitude and behaviour of food handlers will be necessary. The EHPs were found not to be regular in monitoring, evaluating and correcting the deficiencies in outlets. This stipulates that milk that was consumed did not reflect the actual standard quality because the hygiene practices in such outlets were not evaluated and samples were not taken on a regular basis.

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CHAPTER 3

THE PREDOMINANCE OF INDICATOR MICROORGANISMS IN BULK TANK MILK IN CENTRAL SOUTH AFRICA

THE PREDOMINANCE OF INDICATOR MICROORGANISMS IN BULK TANK MILK IN CENTRAL SOUTH AFRICA

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3.1 ABSTRACT

Microbial load is a major factor determining the quality of milk as microbes indicate the level of hygiene practised during handling and storage. To produce milk that conforms to a high standard, it is important that milk be collected, transported and cooled in hygienic conditions to limit access of microbes which can spoil the milk. In this study, *Escherichia coli*, total coliform count (TCC), total viable count (TVC) and somatic cell count (SCC) were evaluated. Temperature measurements and adulteration tests from 53 commercial outlets were also examined. The results indicated that 13% of the milk samples collected showed adulteration through water and 57% of the samples taken for temperature measurements did not meet the required standards. SCC was found in 35% of the samples and 50% of samples showed *Escherichia coli*. In the overall samples taken TCC and TVC was present in 76% of the samples. Therefore, the results indicate that the milk did not meet the required standards for a high quality product. Such milk is deemed unfit for human consumption.

Key words: microbes, non-compliance, high standards, milk quality

3.2 INTRODUCTION

Milk is a nutritious food for human beings, but it also a perfect growth medium for many microorganisms such as *Escherichia coli, Staphylococcus aureus, Bacillus cereus, Salmonella typhi, Listeria monocytogenes, Enteroccocus* spp, *Vibrio cholerae, Brucellosis* spp, coliform counts and *Pseudomonas* spp, amongst others. Milk is easily contaminated due to improper refrigeration and inadequate storage systems (Argudin *et al*., 2010; Adil and Hagar, 2013; Awasthi *et al*., 2014). Pathogenic bacteria have occurred in milk since the dairy industry began because it was impossible to prevent contamination (Awasthi *et al*., 2014). Nowadays, farmers as well as milk handlers play an integral role in helping to reduce the microbes in milk (Annor and Baiden, 2011; Nkhebenyane *et al*., 2012).

The hygienic quality of milk is important, more especially at the point of production and in processing areas as these are the places where contamination occurs very easily (Saha and Ara, 2012; Bereda *et al*., 2013). The growth of undesirable contaminating microrganisms not only causes deterioration in the organoleptic properties of milk, but can also cause illness as these pathogens can be harmful to humans (Zagare *et al*., 2012; Bashir *et al*., 2013). The growth of a number of microorganisms is supported by milk residues on surfaces, resulting in biofilm formation. Multiplication of microbes is therefore supported if surfaces are not properly sanitised (Meshref and Mesherf, 2013). Ultimately, as milk passes through milking equipment that is not properly sanitised, it becomes contaminated and its quality compromised. Concomitant with the above, the unclean hands of the milker, dirty containers and improper refrigeration amongst many other things may also result in microbial contamination of milk and milk products (Soliman and Aly, 2011; Mahrous and Mousa, 2012; Anihouvi *et al*., 2013). Clean milk is therefore produced under hygienic conditions free from any extraneous matter that can cause its contamination (Nkambule and Dlamini, 2012; Shibu and Anu, 2013; Tesfay *et al*., 2013).

The microbiological profile of food is closely associated with the quality of the raw material and the hygiene practices both on farms and in food processing plants (Lu *et al.,* 2013; Mdluli *et al*., 2013). It is important that potential sources of contamination be clearly identified in order to develop effective sanitation methods that can be used to control the presence of microorganisms in food. Such sources include waste, bioaerosols, dirty surfaces and containers. By implementing effective cleaning measures, the microorganisms occurring on milk processing equipment can be significantly reduced by up to 99% (Schlegelova *et al*., 2010; Malek *et al*., 2012).

The presence of microorganisms in milk causes changes in the quality of milk which limits the durability of the product and makes it hazardous to human health (Mubarack *et al*., 2010; De Oliviera *et al*., 2012; Finn *et al*., 2013). Heat treatment is required to eliminate such contaminants prior to consumption by the consumer. Boiling raw milk is important and needs to be focused on, especially in rural areas where raw milk is consumed every day without any precautionary measures being taken (Bertu *et al*., 2010; Pathak *et al*., 2012). Microbiological analyses of the milk provide useful information that reflects the conditions under which milk has been obtained, processed and stored (Cleto *et al*., 2012; Samet-Bale *et al*., 2013). A common procedure to judge the hygienic quality of milk is to take swabs of the milking equipment, the storage tanks and the surface area where milk is handled (Ali *et al*., 2010; Hunt *et al*., 2012). The aim of this study was therefore to assess the indicator microorganisms found in bulk tank milk at commercial outlets in the Mangaung Metropolitan Municipality.

3.3 MATERIALS AND METHODS

3.3.1 Sampling site

A total of 54 samples of milk (constituting 100% of registered outlets) were collected from commercial outlets in and around the Mangaung Metropolitan Municipality. The samples were collected from bulk tanks in the required sterile sampling bottles (30ml in duplicate). The sample bottles designed for such purpose were dipped inside the bulk tanks and then closed tightly. They were labelled and placed in a cooler box with ice to maintain the cold chain, then transported within 5 hours of collection to the laboratory for further analysis. At the laboratory the samples were analysed within 24 hours after arrival and *Escherichia coli*, TCC, TVC, SCC and temperature were analysed.

3.3.2 Microbial analysis

Culturing was carried out according to the standard protocol where 25 ml from collected samples was added to sterile tubes containing 225 ml buffered peptone water.

(i) *Escherichia coli* and Total coliform count

For each sample decimal dilutions were carried out as required for microbial assays in 9ml sterile peptone water and plated in duplicate by the spread plate technique on to Violet-Red-Mug-Agar. These were incubated at 37°C for 24 hours, after which plates containing coliforms (pink to dark red colonies) of between 25 and 250 colony forming units (cfu) on the highest dilution were counted and mean values determined from duplicate plates. For the determination of *E.coli* colonies, all plates were evaluated under UV light and those with flourescence were considered positive for *E.coli.* Random colonies from the plate were then transferred to MacConkey agar for the enumeration and incubated at 37°C for 24 hours.

(ii) The total viable count

Total viable count was enumerated by using a decimal dilution of milk samples which was poured plated on 15-20ml SimPlate Count Agar (SPCA) solution and mixed thoroughly. The plated sample was allowed to solidify and then incubated at 30°C for 48 hours. Colonies were counted using a colony counter. Serial dilution of milk samples was carried out to obtain the different dilutions. These milk dilutions were further transferred into sterile nutrient agar petri plates and distributed uniformly. Nutrient agar plates were incubated for 24 hours at 35°C. Bacterial colonies were observed and counted after incubation and then multiplied by the dilution factor.

(iii) Somatic cell counts

SCC were assessed using the Fossomatic 90 instrument (Foss Electric, Hillerod Denmark) with a procedure in accordance with the EN ISO standard 13366-3:1997.

(iv) Temperature

A thermometer was used to determine the temperature of the samples to check whether the milk did not exceed the required limit (not above 5°C for cooling).

3.4 RESULTS AND DISCUSSION

Table 3.1 shows the South African National Standard that is recommended in the dairy industry in order to ensure the safety and the compliance of milk (RSA. National Department of Health, 1972). The results of the study (represented in Table 3.2) from 38 samples taken for measuring temperature in Bloemfontein, show that (45%) of samples did not comply. While this indicates that the majority of commercial outlets in this area complied with the standard limit of temperature for cooling milk, it is clear that the cold chain was broken in some of the outlets. Non-compliant temperature levels may cause microbes in milk to multiply rapidly, thus causing spoilage and shortening the shelf life of milk (Adil and Hagar, 2013). This practice may affect human health when such milk is consumed directly without being boiled to kill any microbes present. Children, the elderly, pregnant women and medical patients are at a higher risk (Sakalle *et al*., 2014).

The results for samples taken to detect if adulteration occurred in milk revealed that 11% of commercial outlets did not comply while 89% outlets complied. The study by Singuluri and Sukumaran (2014) stated that it is harmful to the human body to consume milk that was adultered.

Table 3.1: RSA. National Department of Health, 1972.

Analysis	**Standard limit**
Temperature	5°C
Total viable count	50 000 cfu.ml^{-1}
Total coliform count	Less than 10/100 ml^{-1}
Escherichia coli	0
Somatic cell count	500 000 cfu.ml^{-1}
Water	0

Table 3.2: Microorganisms found in raw milk in Bloemfontein area

Shop designation	Temperature (°C)	Water	TVC ($CFU.ml^{-1}$)	TCC (ml^{-1})	*E. coli* ($CFU.ml^{-1}$)	SCC ($CFU.ml^{-1}$)
1	**7**	0	**5.9×10^6**	**2.6×10^4**	**1**	**6.32×10^5**
2	**7.7**	0	**6.2×10^5**	**4.4×10^3**	**1**	5.03×10^4
3	**6**	0	**5.3×10^4**	**1.7×10^3**	0	3.06×10^5
4	**9**	0	**6.0×10^6**	**9.0×10^4**	**1**	**1.96×10^6**
5	2.5	0	**2.4×10^5**	**4.4×10^3**	**1**	**1.20×10^5**
6	3.5	0	3.6×10^3	1×10^0	**1**	3.84×10^5
7	4	**24.6**	**2.8×10^6**	**3.0×10^3**	0	3.93×10^5
8	4	**5.06**	8.6×10^3	**1.1×10^3**	0	**5.98×10^5**
9	3	0	**5.5×10^6**	**2.3×10^2**	**1**	4.44×10^5
10	**9**	**9.32**	**1.03×10^5**	**1.2×10^4**	**1**	**1.36×10^6**
11	**8**	0	**1.12×10^6**	**3.3×10^4**	**1**	3.35×10^5
12	2	0	4.8×10^3	**4.0×10^1**	**1**	3.38×10^5
13	4	0	6.9×10^3	**1.1×10^1**	0	1.86×10^5
14	**10**	0	**3.5×10^5**	**8.0×10^3**	0	2.04×10^5
15	**7**	**8.42**	**1.29×10^5**	**2.2×10^4**	**1**	2.0×10^5
16	4	0	1.17×10^5	**1.2×10^5**	0	2.34×10^5
17	2	0	2.6×10^4	**2.6×10^4**	0	**7.09×10^5**
18	3	0	3.1×10^4	**3.1×10^4**	0	3.52×10^5
19	**11**	0	**7.6×10^4**	**7.6×10^4**	0	3.02×10^5
20	4	0	**7.4×10^4**	**7.4×10^4**	0	**1.03×10^6**
21	4	0	2.03×10^4	8×10^0	0	**5.65×10^5**
22	5	0	**1.57×10^5**	**3.0×10^2**	0	3.24×10^5
23	**7**	0	**2.23×10^6**	**1.3×10^4**	**1**	**6.83×10^5**
24	**8.8**	0	5.7×10^3	0	0	4.36×10^5
25	4	0	**7.8×10^5**	**1.7×10^2**	0	4.53×10^5
26	**7.8**	0	**1.98×10^5**	**5.8×10^2**	**1**	2.9×10^5
27	5	0	**7.5×10^5**	**1.6×10^2**	0	**6.03×10^5**

28	**5.5**	0	**3.6×10^5**	**1.1×10^2**	0	2.29×10^5
29	3	0	**4.0×10^5**	**5.9×10^1**	0	3.1×10^5
30	**6**	0	**6.6×10^6**	**8.0×10^3**	**1**	2.75×10^5
31	**6**	0	**5.9×10^4**	**5.8×10^2**	**1**	1.84×10^5
32	3	0	2.0×10^3	**1.5×10^1**	0	1.34×10^5
33	4	0	**6.88×10^5**	**7.4×10^2**	0	2.34×10^5
34	5	0	**9.0×10^5**	**1.8×10^3**	0	**5.1×10^5**
35	**10**	0	4.2×10^3	**3.8×10^2**	0	3.1×10^5
36	**5.6**	0	6.3×10^3	**1.5×10^1**	0	2.67×10^5
37	4.6	0	2.1×10^3	**1.1×10^1**	0	2.65×10^5
38	1	0	**1.3×10^7**	**3.8×10^6**	**1**	**9.14×10^5**
Min	1	0	2.0×10^3	0	0	5.03×10^4
Max	11	0	1.3×10^7	3.8×10^6	1	1.96×10^6
Ave	5.3	0	1.3×10^6	1.3×10^5	0.395	4.5×10^5
STD_g	2.6	0	2.7×10^6	6.2×10^5	0.495	3.64×10^5

This poor hygiene practice may introduce microbes to the milk and consequently lead to various diseases such as gastrointestinal problems, for example gastric ulcer, colon ulcer and diarrhoea. Therefore it is important that commercial outlets be encouraged not to use any kind of adulterants in milk (Abbas *et al*., 2013). The study indicates that 43% of the samples showed that milk had been adulterated while 57% of the samples complied.

In relation to TVC, the results indicate that 34% of samples did not comply, while 66% of samples complied with the standard limit of not more than 50 000 CFU.ml^{-1}. TVC presence of more than 50 000 CFU.ml^{-1} in milk may cause rapid deterioration of milk, and such milk is not suitable for human consumption (Saxena and Rai, 2013). Total coliform count indicated non-compliance in 92% of samples and compliance in 8% of samples. This shows poor handling practices and such unhygienic practices could cause milk to deteriorate very quickly (Ibrahim and Falegan, 2013). The study reveals that 39% of samples did not comply and 61% samples complied with the standard limit of 0 counts for *E. coli*. Requirements are that such pathogens should not be detected in milk.

People who consume milk containing this pathogen may be greatly affected as it can cause severe diarrhoeal diseases and even death in the case of consumers with a weak immune system. It is essential that milk intended for human consumption and found to contain *E. coli* be discarded as this pathogen significantly reduces milk quality (Momtaz *et al*., 2012). The study also shows that 29% of samples did not comply and 71% samples complied with the 500 000 CFU.ml^{-1} of SCC. Presence of SCC in milk means that the quality of milk is affected and may cause disease such as brucellosis, tuberculosis and typhoid fever which can be transmitted from the cow to the milk used by consumers.

From the results represented in Table 3.3 of the samples taken from Botshabelo commercial outlets, it was revealed that of the 7 samples taken, 14% did not comply with temperature minimum requirements of > 5°C. The total viable count showed that 100% of samples did not comply and this is not acceptable as the milk was contaminated. *E. coli* was not present in 29% of the samples that complied, while it was present in 71% of the samples that did not comply. The study indicates that 43% of the samples complied and 57% did not comply with SCC. The findings of the study in the Thaba 'Nchu area reveal that, of the 9 commercial outlets where temperature checks were done, only 11% of the sample complied and 89% did not comply (Table 3.4). This shows that the milk was not refrigerated immediately after arrival, or the milk was kept at room temperature for a while before being refrigerated. 100% of the samples tested for adulteration complied, showing that nutritive value of milk was not affected.

The study shows that TVC, Total Coliform and *E.coli* samples did not comply and this suggests that the milk was contaminated with microorganisms. It is also noted in the study that for SCC, 67% of the samples did not comply. However, as stated before, food handlers should be trained about the importance of keeping milk at low temperatures and improving hygiene practices from the farm to the outlet.

Table 3.3: Microorganisms found in raw milk in Botshabelo area

Shop designation	Temperature (°C)	Water	TVC ($CFU.ml^{-1}$)	TCC ($CFU.ml^{-1}$)	*E. coli*	SCC ($CFU.ml^{-1}$)
1	**7.8**	**9.14**	**5.4×10^6**	**6.0×10^4**	**1**	**7.11×10^5**
2	**8.6**	**5.74**	**4.2×10^5**	**8.3×10^2**	**1**	3.35×10^5
3	4.4	0	**2.7×10^6**	**1.18×10^4**	0	2.35×10^5
4	**5.1**	0	**1.4×10^5**	**2.4×10^3**	**1**	**7.7×10^5**
5	**5.5**	**4**	**2.7×10^5**	**3.3×10^3**	**1**	9.54×10^4
6	**9.5**	0	**3.8×10^6**	**3.9×10^4**	0	**1.87×10^6**
7	**6**	0	**1.6×10^6**	**4.7×10^4**	**1**	**6.38×10^5**
Min	6	0	2.7×10^5	8.3×10^2	0	9.54×10^4
Max	6	4	5.9×10^6	2.6×10^5	1	1.87×10^6
Ave	6	0.8	2.31×10^6	5.2×10^4	0.71	6.54×10^5
STD_g	N/A	1.79	2.01×10^6	9.36×10^4	0.49	5.89×10^5

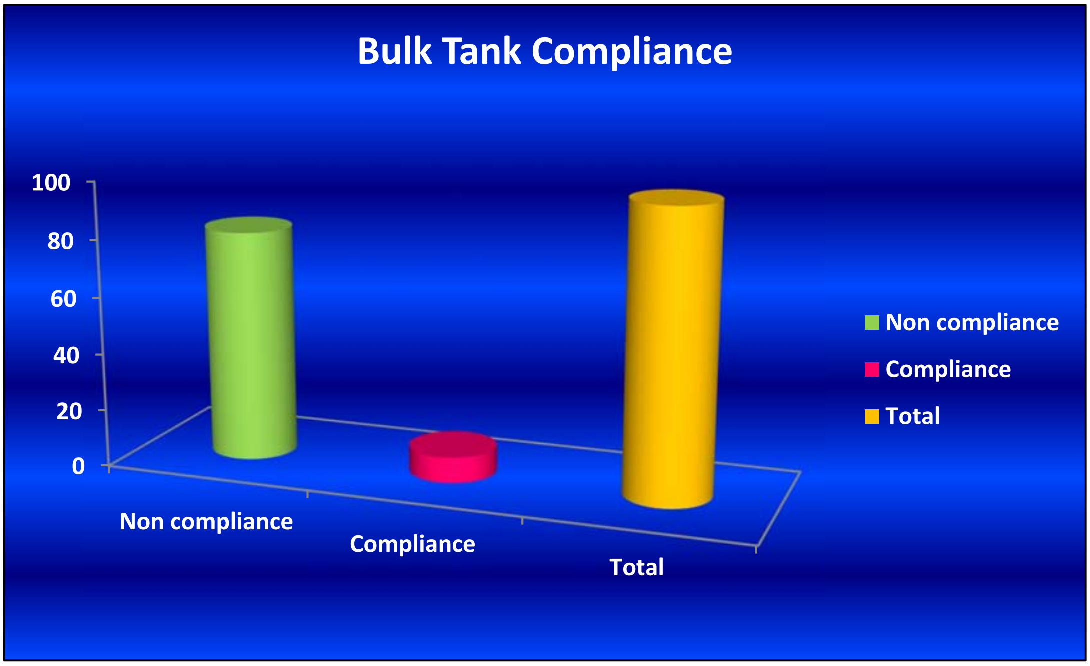
Table 3.4: Microorganisms found in raw milk in Thaba-Nchu area

Shop designation	Temperature (°C)	Water	TVC (CFU.ml^{-1})	TCC (CFU.ml^{-1})	*E. coli*	SCC (CFU.ml^{-1})
1	**6**	0	**1.7×10^5**	**2.7×10^3**	**1**	1.61×10^5
2	**10**	0	**2.32×10^6**	**5.4×10^3**	**1**	**2.28×10^6**
3	**12.5**	0	**4.2×10^5**	**2.7×10^3**	**1**	**6.74×10^5**
4	**8**	0	**1.7×10^7**	**2.8×10^6**	**1**	1.8×10^5
5	**7**	0	**1.4×10^7**	**3.3×10^5**	**1**	**6.89×10^5**
6	**7**	0	**2.6×10^7**	**5.99×10^2**	**1**	2.58×10^5
7	**7**	0	**1.07×10^7**	**4.4×10^6**	**1**	**6.02×10^5**
8	**23**	0	**1.53×10^8**	**1.5×10^8**	**1**	**5.6×10^5**
9	1	0	**1.4×10^7**	**3×10^4**	**1**	**6.9×10^5**
Min	1	0	1.7×10^5	5.99×10^2	1	1.6×10^5
Max	23	0	4.2×10^5	3.3×10^5	1	9.1×10^5
Ave	8.6	0	2.8×10^5	6.8×10^4	1	5×10^5
STD_g	6.3	0	1.3×10^5	1.46×10^5	0	2.0×10^5

This was a concern as it showed that milk in Thaba ’Nchu was not fit for human consumption. Figure 3.1 below reflects the overall percentage compliance as well as individual microbes’ compliance for the entire study. Furthermore, Figure 3.2 shows at a glance the overall picture for all microbes. However, *E. coli* is not reflected as the values were either 0 or 1 and that could not be captured in a logarithmic graph.

3.5 CONCLUSION

The study identified high levels of indicator organisms in milk which are evidence of poor handling and storage of milk in commercial outlets. Therefore, the need to improve the hygiene and handling practices in commercial outlets must be emphasised. The results of the study clearly indicate that the microbial load was unsatisfactory and the safety of raw milk was questionable. The presence of such microbes in milk indicates poor hygiene practices (Waghode and Garode, 2012; Hatta *et al*., 2013). On their own, these findings suggest that educational efforts must be made to improve the hygiene practices of bulk tank milk in commercial outlets. The study revealed high counts in terms of non-compliance of *Escherichia coli* in Botshabelo (71%) and Thaba ’Nchu (100%). This can be attributed to negligence in respect of proper sanitation practices in the commercial outlets. This finding concurs with the observations of Mhone *et al*. (2012), where high levels of bacteria in bulk tank milk indicated a lack of and emphasised the need of proper hygiene practices.



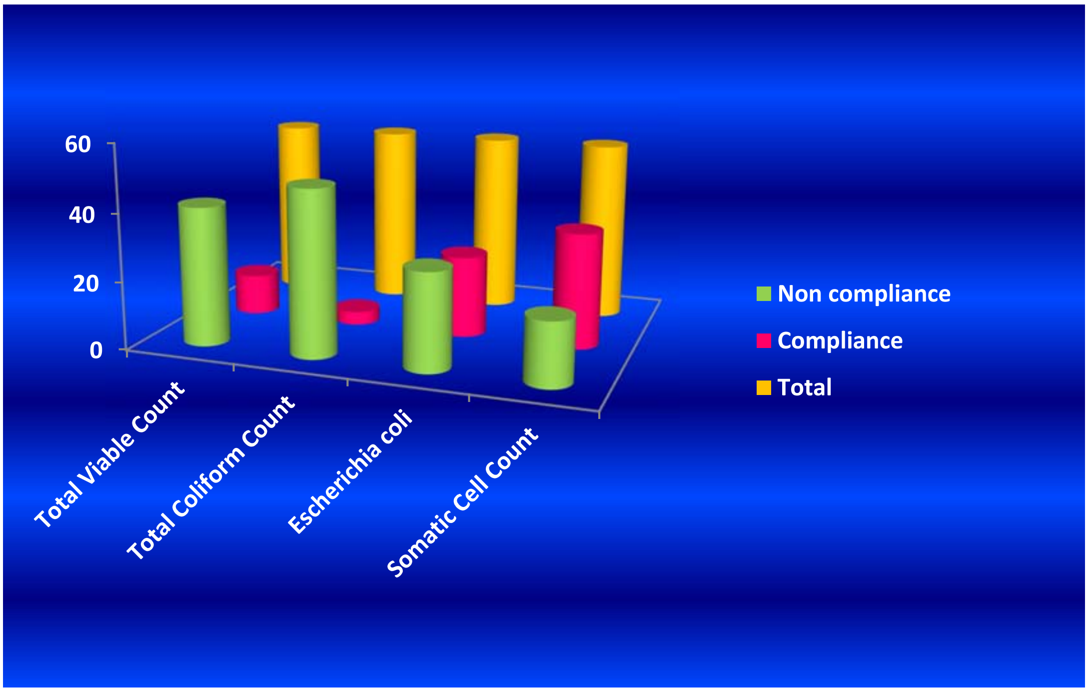


Figure 3.1: Overall percentage compliance at a glance and for individual microbes

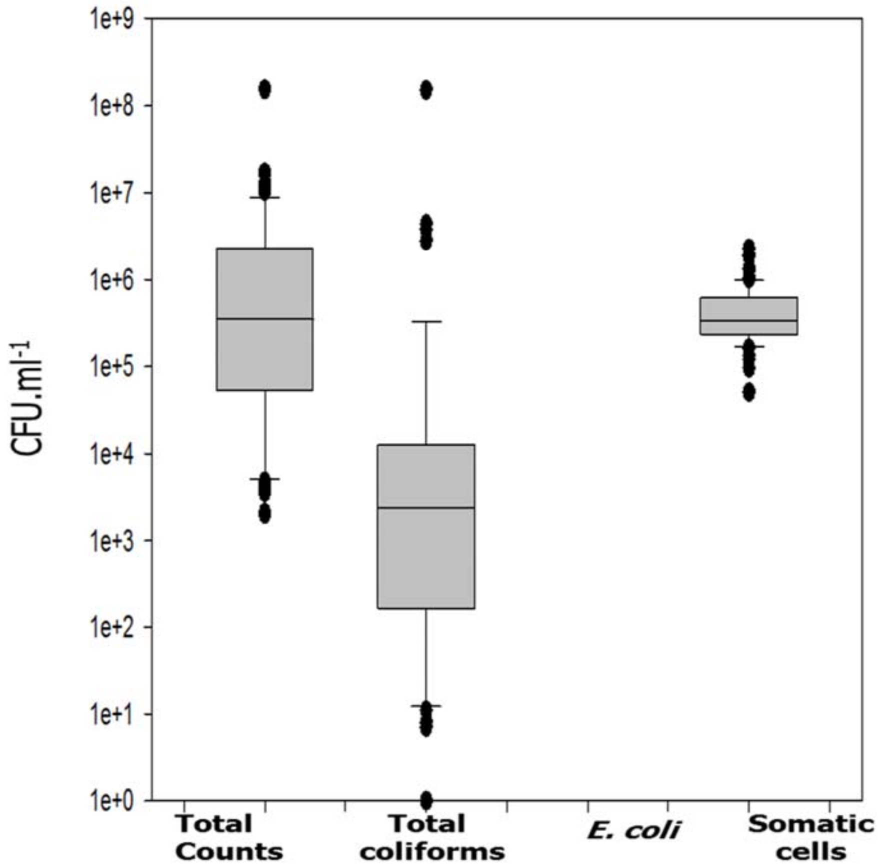


Figure 3.2: Overall at a glance picture of microbial analysis for bulk tank milk

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CHAPTER 4

The physicochemical composition of commercial bulk tank milk in Central South Africa

THE PHYSICOCHEMICAL COMPOSITION OF COMMERCIAL BULK TANK IN CENTRAL SOUTH AFRICA

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4.1 ABSTRACT

Milk is a major constituent of the human diet and a highly perishable commodity that can pose potential health risks to consumers if handled inappropriately. To improve the quality of milk, it is important to ensure that the physicochemical properties of milk are within the required limits. This study focused on components of milk such as fat, protein, ethanol, phosphates and inhibitory substances. The study revealed that out of 54 samples from commercial outlets, 74% did not pasteurise milk while 17% of the samples tested positive for ethanol content. Furthermore, the study showed that there was no inhibitory substance found in the milk. 6% of samples did not comply with the fat content requirements while 100% of samples complied for protein content. In conclusion, these results indicate that most of samples taken within the Mangaung Metropolitan Municipality area had low levels of non-compliance. However, some samples contained harmful substances that could result in possible carcinogenic effects on human health.

Key words: adulteration, physicochemical, commercial outlets, milk, quality monitoring

4.2 INTRODUCTION

Milk is an important source of food, rich in nutrients required by the human body. However, it deteriorates easily, becoming unsuitable for human consumption (Mahmood and Usman, 2010; Srujana *et al*., 2011). Ramesh (2008) indicates that the major constituents of milk are water (87.4%) and milk solids (12.6%). Milk essentials may vary according to the cow's breed, environment, age, interval between milking and stage of lactation. Good quality milk can be achieved by handling and producing milk in hygienic conditions. Quality control is the most neglected aspect leading to poor milk quality in commercial outlets (Salman and Hammad, 2011). The quality of food products has a critical impact on human metabolism and health (Mocanu *et al*., 2011; Apurva *et al*., 2012), and physicochemical analyses are some of the most useful tools for monitoring such quality.

Several authors report that the adulteration of milk is still common in commercial outlets where the addition of water has been detected. Other products such as urea, penicillin and chemicals (hydrogen peroxide and bicarbonate of soda) have been found to be present in low quantities. The reasons for their presence have always been associated with preservation to make milk remain fresh for a longer period, whitening the milk and increasing the final volume of milk (Souza *et al*., 2011; Chanda *et al*., 2012; Dos Santos *et al*., 2012; Vasan *et al*., 2012; Naveernray *et al*., 2013). Adulteration of food may affect human health as it negatively affects its nutritional value and involves the possible introduction of microorganisms (Kartheek *et al*., 2011; Singuluri; Vasan *et al*., 2013 and Sukumaran, 2014). Because of the high demand for milk, owners of milk outlets believe that adulteration of milk will increase their profit margin, but addition of possibly contaminated water to milk will cause major health setbacks (Dehinenet *et al*., 2013; Shaikh *et al*., 2013). Dirty adulteration practices also occurs where contaminated ice is added to milk giving it a foamy appearance, as well as vegetable oil to increase the fat content in milk (Afzal *et al*, 2011; El-loly *et al*., 2013; Faraz *et al*., 2013).

Several reports have shown that disinfectants, detergents, herbicides and pesticides known to be harmful to the human body are amongst the contaminants often found in milk (Afzal *et al*., 2011; Kalla *et al*., 2015). These chemicals are known to cause diseases such as allergic reactions, cancer, heart disease, Alzheimer's disease and Parkinsonism amongst others (Khaniki, 2007; Kurunthachalam, 2013; Muhammad *et al*., 2013). Some chemicals are found in milk because of residues left from cleaning of the equipments and from containers that are not washed properly, as well as from agricultural activities on the farms. These chemical are known to affect the quality of the milk (Driehuis, 2013; Muhammad *et al*., 2013; Manzoor *et al*., 2012).

The production of milk that does not meet the required standards has serious implications for the economy and should therefore be an important focus for farmers: consumers demand nutritionally enriched milk that is fit for human consumption (Hossain and Dev, 2013). Satisfactory milk quality for consumers means milk that is free from chemicals, additives and foreign substances. Quality control measures are needed from the point of processing to that of selling, so as to ensure that milk quality is not compromised (Javaid *et al*., 2009; Anderson *et al*., 2011).The aim of this study was to evaluate the physicochemical properties of bulk tank milk from different commercial outlets in central Free State.

4.3 MATERIALS AND METHODS

4.3.1 Sampling site

A total of 54 samples of milk were collected from commercial outlets in and around Mangaung Metropolitan Municipality. The samples were collected from bulk tanks using sterile sampling bottles and placed in a cooler box with ice to maintain the cold chain. Samples were transported to the laboratory immediately for analysis and quantification where they were examined within 24 hours after arrival. Samples were taken from 38 outlets in Bloemfontein, 9 outlets in Thaba-Nchu and 7 outlets in Botshabelo. All analyses were done in duplicate and Microsoft Excel 2013 used for data capturing.

The analyses done were for detecting fat, protein, ethanol, inhibitory substances, disinfectants and making phosphate tests.

4.3.2 Chemical analysis

(i) Fat analysis

Ten millilitres of sulphuric acid were placed in a butyrometer followed by 11 ml of well mixed milk. One millilitre of Amyl alcohol was added and the butyrometer agitated carefully until the curd dissolved. The butyrometer was placed in a water bath at 65ºC for a few minutes and it was then centrifuged for 5 min at 1100 rpm. The butyrometers was removed from the centrifuge, placed in a water bath again and maintained at 65ºC for 3 min before reading and recording results. The fat column was read from the lowest point of the meniscus of the interface of the acid-fat to the 0-mark of the scale.

(ii) Protein content

Protein content was determined using the Kjeldahl method as explained by the Association of Analytical Communities (AOAC) in 1990. This process involves three steps mainly digestion, distillation and titration, as well as calculation of the final content.

(iii) Ethanol content

The test was done by mixing equal amounts of milk and 68% ethanol solution in a test tube. This test was done to evaluate and trace whether any chemical adulterants could be found in milk.

(iv) Inhibitory substances

The qualitative *Bacillus subtilis* disc assay method (American Public Health Association, 1992) was used as a general method as follows: Milk samples were heated at 80°C for 5 min to inactivate the naturally occurring inhibitory substances in milk and to eliminate the possibility of false-positive results. After cooling, one-tenth of each milk sample was applied in a circular well in Bacto-Pm indicator agar inoculated with *B. subtilis* organism. The plates were examined for violet coloured inhibition zones after 2.5-3.0 h incubation at 65°C. Presence of zone of inhibition was recorded indicating a positive result.

(v) Disinfectants

One to two drops of bromocresol purple solution were added to 5ml of milk in the test tube and mixed well. Any appearance of colour indicated the presence of disinfectants in milk.

(vi) Phosphate test

The buffer substrate solution was prepared according to the prescribed method (in Annexure B) of R1555 of 1997 (RSA. National Department of Health, 1997). One millilitre each of milk sample was poured into test tubes containing 5 ml of the buffer substrate solution and incubated for 2 hours at 37°C. With each series of samples, one control sample was incubated, prepared from 5 ml of the buffer-substrate and 1 ml of boiled milk of the same type as that undergoing the test. After incubation, the test tubes were removed from the water bath and their contents mixed well. The control sample was placed on the left hand ramp of the stand and the test sample on the right. The readings were then recorded in the reflected light by looking down on to two apertures, with the comparator facing a UV light. The discs used were agitated by revolving until the colour of the test sample was similar to the control sample. Readings were then recorded as per R1555 of 1997 method in Annexures A and B.

4.4 RESULTS AND DISCUSSION

Fat plays a huge role in the human body as it forms part of cell membranes and hormones to provide energy storage. It has been revealed that fat from milk appears to be effective in promoting muscle growth (Sarkiyayi and Shebu, 2011). However, the presence of bad fat in the body may damage the heart and cause the body to be easily prone to disease. The results of the study (Bloemfontein area) are shown in Table 4.1, where, of the 38 samples from Bloemfontein, 97% complied with the requirement for fat content, indicating that the milk was nutritive to the consumers.

The study showed that all (100%) samples complied for protein content and this implies that consumers received milk of high nutritional value. Proteins have essential amino acid content which is important for digestibility as well as growth and maintenance of the body. Adverse effects to the human body, where protein intake exceeds the recommended dietary limit, include the possibility of liver, renal and bone disorders (Delimaries, 2013).

Table 4.1: National standard applicable to milk (RSA. National Department of Health, 1972).

Analysis	**Standard limit**
Fat	2.5
Protein	2.94
Ethanol	0
Phosphate test	10^1 cfu.ml^{-1}

Furthermore, the study indicated that 8% of samples from Bloemfontein did not comply with the requirement for ethanol content in milk, while 92% samples complied.

Even though a high number of samples complied, it is important to note that no chemicals should be found in milk because such milk may be harmful to everyone, although more especially to pregnant women, the unborn foetus, children and the elderly with immunocompromised systems (Kandpal *et al*., 2012). Chemical content in milk is dangerous as it can cause vomiting, diarrhoea and abdominal pain (Afzal *et al*., 2011). It can also affect the optic nerve causing blindness and is one of the most potent carcinogens (Barham *et al*., 2014).

The study reveals however those inhibitory substances were not found in the samples suggesting that the milk was compliant to the minimum requirements in R1555 of 1997 (RSA. National Department of Health, 1997). Inhibitors are considered to be undesirable substances which include drug and antibiotic residues that are normally used on farms for treating diseases and infections (Sulejmani *et al*., 2012). The presence of inhibitory substances in milk indicates poor farm management practices. These substances are known to result in allergic reactions in individuals and also to have negative effects on the composition of the human intestinal flora (Nikolic *et al*., 2011; Ali *et al*., 2012). In the Bloemfontein region (Table 4.2), 37% of the samples complied while 63% samples did not comply with the minimum requirements for pasteurisation.

Table 4.2: The physicochemical parameters of bulk tank milk in Bloemfontein area.

Shop designation	Fat (%)	Protein (%)	Ethanol (%)	Phosphate Test
1	3.78	3.16	**1**	**> 42**
2	2.45	3.38	0	**> 42**
3	3.54	3.1	0	**> 42**
4	3.26	3.2	0	**> 42**
5	3.54	3.29	0	0
6	3.24	3.16	0	**18**
7	2.2	2.48	0	**> 42**
8	3.36	3.06	0	**> 42**
9	2.42	3.76	0	**> 42**
10	2.71	2.93	0	**6**
11	3.14	3.1	0	**> 42**
12	3.52	3.13	0	**> 42**
13	3.07	3.2	0	**> 42**
14	3.38	3.15	0	**> 42**
15	3.33	2.96	0	**> 42**
16	3.36	3.08	0	**6**
17	3.4	3.09	0	0
18	3.45	3.24	0	0

19	3.42	3.21	0	0
20	**0.12**	3.04	0	0
21	3.09	3.03	0	0
22	3.19	2.74	0	0
23	2.74	2.51	0	0
24	2.51	3.45	0	0
25	3.45	3.42	0	**> 42**
26	3.42	2.86	0	**> 42**
27	2.86	3.54	0	**> 42**
28	3.54	3.12	0	**6**
29	3.12	3.56	0	**> 42**
30	3.56	3.14	**1**	**6**
31	3.14	3.12	0	0
32	3.12	3.21	0	0
33	3.21	3.43	0	0
34	3.43	3.43	0	0
35	3.43	3.43	0	0
36	3.72	3.72	0	**> 42**
37	3.51	3.51	0	**> 42**
38	3.69	3.69	**1**	**> 42**

Pasteurisation helps in eliminating harmful bacteria and prevents fermentation in raw milk (Oyekale *et al*., 2013).

Concomitant to the Bloemfontein region scenario, the results of the study showed that of the 9 samples taken from Thaba Nchu region, 11% did not comply for fat content whilst 89% samples complied (Table 4.3). Hundred percent (100%) of samples showed compliance with regard to protein content and inhibitory substances in milk. Furthermore, the results revealed that 56% of the samples did not comply with the ethanol test with the remainder (44%) of the samples complying. This indicates that certain chemicals were detected in milk and this may cause health problems to consumers. The phosphate test showed milk to be non-compliant in all samples in this region, indicating that milk was not pasteurised.

In the third region of Botshabelo the results of the study in Table 4.4 show that out of 7 samples taken, 14% of the sample did not comply for fat content and 86% samples complied. The study showed that all samples complied with protein content and inhibitory substances. 14% of samples complied with the ethanol requirement and the remainder did not. The study further revealed that 100% of samples for the phosphate test also did not comply. Together with Thaba-Nchu, these two areas may both be using raw milk or combining raw milk with pasteurised milk.

Table 4.3: The physicochemical parameters of bulk tank milk in the Thaba-Nchu area.

Shop designation	**Fat (%)**	**Protein (%)**	**Ethanol (%)**	**Phosphate test (%)**
1.	2.81	3.21	0	**> 42**
2.	2.61	3.18	0	**> 42**
3.	3.52	3.27	0	**> 42**
4.	2.46	3.22	**1**	**> 42**
5.	3.15	3.12	**1**	**> 42**
6.	**2.19**	3.21	0	**> 42**
7.	0.23	4.22	**1**	**> 42**
8.	2.75	3.2	**1**	**> 42**
9.	3.69	3.18	**1**	**> 42**

Table 4.4. The physicochemical parameters of bulk tank milk in the Botshabelo area

Shop designation	Fat (%)	Protein (%)	Ethanol (%)	Phosphate test (%)
1.	4.14	2.94	0	**> 42**
2.	3.33	3.04	0	**> 42**
3.	**2.19**	3.27	0	**> 42**
4.	5.21	3.22	**1**	**> 42**
5.	2.63	3.09	0	**> 42**
6.	5.12	3.17	0	**> 42**
7.	3.65	3.17	0	**> 42**

Failure to sell good quality milk to the consumers may result in deleterious health implications, especially for those with compromised immune systems. Figures 4.1 and 4.2 below reflect overall compliance and an glance overview of the entire physicochemical analysis.

4.5 CONCLUSION

The results obtained from the study show that milk intended for consumers was contaminated and not fit for human consumption. The results also show that not all compositions tested meet the recommended standards. Even though there was no presence of inhibitory substances found in the milk, the milk was considered not fit for human consumption because it contained ethanol content in some outlets, especially in the Thaba-Nchu and Botshabelo regions which are semi-urban areas compared to Bloemfontein which is urban. Pasteurisation was not done in most of the outlets. Based on the observations made during this study, it was evident that improper hygiene and poor farm management practices contributed to non-compliance values in milk samples in some outlets

It is recommended that the EHPs conduct frequent inspections of the marketed milk to check whether it meets the minimum legal standards. They should also monitor the overall hygiene conditions surrounding the production and handling of milk. Realistic standards for milk need to be devised and appropriate training should be given to the milk producers in hygienic handling. Improving the hygiene practices may reduce non-compliance levels of milk in rural areas.

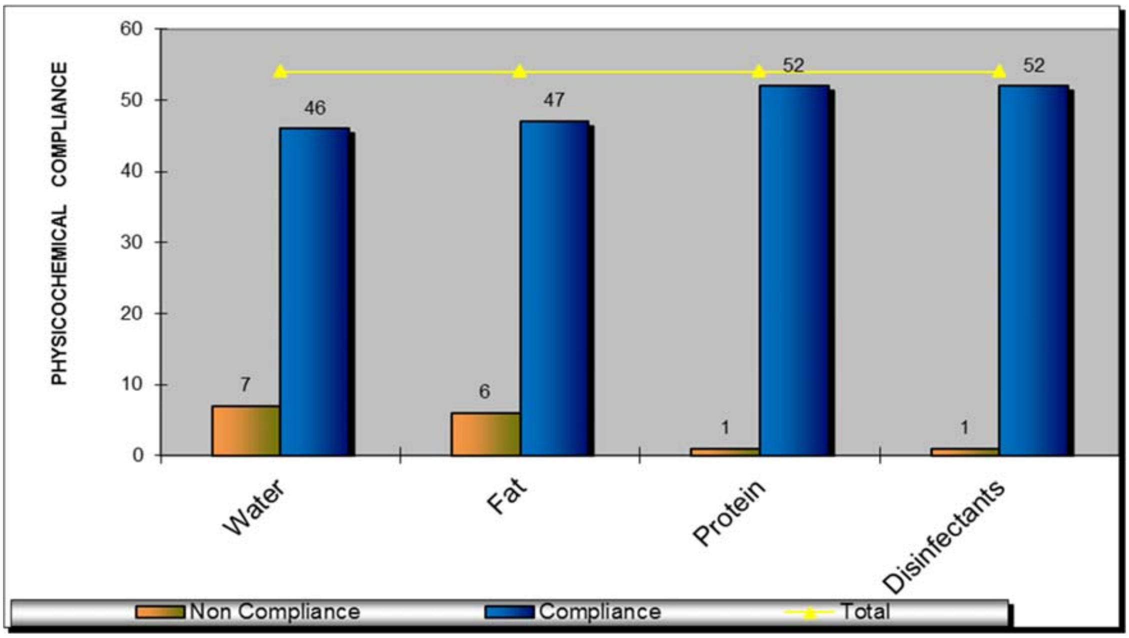

Figure 4.1: Overall compliance for proximate analysis

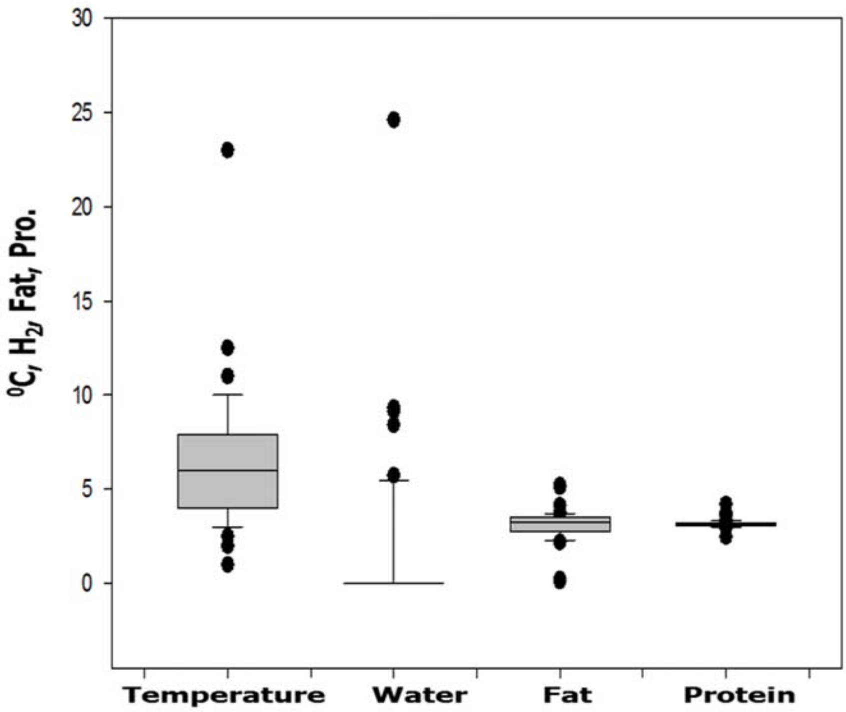

Figure 4.2: Overall at a glance view of the entire physicochemical analysis

It would be of great interest if further investigations could be carried out to examine the actual composition of milk sold to consumers in light of the non-compliance issues recorded in this study.

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CHAPTER 5

COMPARING PRODUCERS AND DISTRIBUTORS:

CASE STUDIES OF SELECTED FARMS IN CENTRAL SOUTH AFRICA

COMPARING PRODUCERS AND DISTRIBUTORS:

CASE STUDIES OF SELECTED FARMS IN CENTRAL SOUTH AFRICA

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5.1 ABSTRACT

Five different dairy farms were sampled and evaluated to assess their hygiene and management practices. Milk samples were obtained for the assessment of temperature, inhibitors, ethanol content, fat content, total coliform count, *Escherichia coli* and somatic cell count. The results showed that the temperature of the milk in the vehicle milk tank on Farms 1, 3 and 5 exceeded the required limit, while on Farms 1 and 4 the temperature of the milk in the bulk tank also did not meet the required temperature. Farm 1 had a high coliform count in the bulk tank and in the vehicle tank, which meant that this farm did not comply with the standard limits. The study revealed that all farms complied with required *Escherichia coli* counts in bulk tank and vehicle tank. The somatic cell counts exceeded the standard limit on Farm 2 and TVC showed non-compliance on Farm 1. The results from the samples taken showed that no inhibitory substances were present in milk. Furthermore, the results indicated a low level of non-compliance regarding the presence of ethanol content in milk. Farm 1 showed non-compliance to phosphate test, which indicated that the milk was not pasteurised on this farm. Therefore, all samples that that handling and storage practices were not done properly and were non-compliant, with Farm 1 being the least compliant.

Key words: dairy farms, temperature, milk, hygiene practices

5.2 INTRODUCTION

Milk plays an important role in feeding the population due to its high nutritive value (Anderson *et al*., 2011; Welearegay *et al*., 2012). However, it is prone to contamination if not handled properly. In rural areas milk is sold on farms and levels of hygiene for milk production are not often met (Lues *et al*., 2012). The safety of milk produced on farms is a concern around the world as outbreaks of foodborne disease have occurred due to milk contamination at these facilities (Dinki and Balcha, 2013; Lawan *et al*., 2012). Dairy farms should aim to produce high quality milk that is safe for consumption, and functions such as hand milking, transportation of milk and keeping milk at the correct temperature on the dairy farms should be priority areas in terms of ensuring safe milk.

Common unhygienic practices that can lead to milk that is not suitable for consumption should be avoided and implementation of good hygiene practices should be ensured (Khan *et al*., 2013; Ababio and Adi, 2012). Good dairy farming practices are an important practical tool used on farms world-wide in order to ensure that the farms produce milk that is safe and of good quality to satisfy the expectations of the consumers (Chinogaramombe *et al*., 2008; Omondi and Meinderts, 2009; Oloo, 2010). On dairy farms, milk needs to be in perfect condition to maintain a high level of milk production and, likewise, good farming practices assist in helping to decrease or to eliminate the incidence of infections in dairy herds (Swai and Schooman, 2013). Routine farm inspections are important to monitor and evaluate the level of microorganisms present in milk. Maintaining the cold chain of milk on farms is also an important factor that needs to be correctly followed (Baldock *et al*., 2011; Kulkarni and Kaliwal, 2013). The majority of farmers remain unaware of new technical knowledge practices that need to be adopted to produce milk that will be acceptable for human consumption (Ashraf *et al*., 2013).

Diseases outbreaks associated with the consumption of raw milk occur every year in various parts of the world. Consumers in rural areas are especially, at high risk. Milk is a daily source of food and, should the milk be contaminated, foodborne diseases such as diarrhoea, vomiting, liver and kidney failure and possibly even death will follow (Neeta *et al*., 2014; Lye *et al*., 2013). The incidence of foodborne disease is likely to be higher in developing countries (Hanson *et al*., 2012; Saba and Gonzalez-Zorn, 2012), where milk hygiene is not practised properly from farm level. Outbreaks of foodborne disease incidence are often underreported, which is partly due to a lack of resources for investigations (Ifeadike *et al*., 2012). Although there may be unreported cases, attention is required to improve hygienic conditions in rural areas and efforts should be made by farmers to provide milk that is safe for consumption.

Lack of farm inspection by EHPs also contributes to poor farm management and poor hygiene practices in dairies. The aim of this study was to investigate the prevalence of bulk tank milk practices on farms and to assess the indicator microbes as well as selected physicochemical parameters from farms to selling points. The purpose was to shed a light on aspects of food industry, especially in terms of ensuring the production of wholesome milk from its starting point on the farm, to the point of consumption by the consumer.

5.3 MATERIALS AND METHODS

Five dairy farms (representing 50% of the main suppliers of milk in the area under consideration) were randomly selected and tests were conducted on selected parameters and/or factors such as the temperature of the bulk tank at the farm, the temperature of the vehicle tank, total coliform counts, *Escherichia coli*, somatic cell count, total viable count, ethanol presence, phosphate presence and the presence of inhibitory. The temperatures of the milk in the bulk and vehicle tanks were taken using a thermometer, and always in duplicate. The samples were immediately taken to the laboratory for further analysis.

5.3.1 Microbial analysis

Culturing was carried out by mixing 25 ml each from collected samples to 225 ml buffered peptone water in sterile bottles. All diluted samples were then plated on various media as detailed below:

(i) *Escherichia coli* and total coliforms

Both *Escherichia coli* and total coliform were enumerated on Violet-Red-Mug-Agar followed by incubation for 24-48 hours at 35°C (Houghtby, 1993).

(ii) Total viable count

The total viable count was enumerated by using a decimal dilution of milk samples which was poured-plated on 15-20ml SimPlate Count Agar (SPCA) solution and mixed thoroughly. The plated sample was allowed to solidify and then incubated at 30°C for 48 hours. Colony counts were done counted using a colony counter.

(iii) Somatic cell counts

SCC was assessed using the Fossomatic 90 instrument (Foss Electric, Hillerod Denmark) with a procedure in accordance with the EN ISO standard 13366-3:1997.

(iv) Temperature

A normal thermometer was used to determine the temperature of the samples in order to check if the milk did not exceed the required limit (not above 5°C for milk intended for consumption).

5.3.2 Chemical analysis

(i) Fat analysis

Ten millilitres of sulphuric acid were added to the butyrometer followed by 11 ml of well mixed milk. One millilitre of Amyl alcohol was added and the butyrometer agitated carefully until the curd dissolved. The butyrometer was place in the water bath at 65ºC for few minutes and centrifuged for 5 min at 1100 rpm. The butyrometer was removed, put in a water bath and maintained at 65ºC for 3 min before reading and the results. The fat column was read from the lowest point of the meniscus of the interface of the acid-fat to the 0-mark of the scale.

(i) Protein content

Protein content was determined using the Kjeldahl method as explained by the AOAA in 1990. This process involves three steps namely digestion, distillation and titration, as well as the calculation of the final content.

(ii) Ethanol content

The test was done by mixing equal amounts of milk and 68% of ethanol solution in a test tube.

(iii) Inhibitory substances

The qualitative *Bacillus subtilis* disc assay method (American Public Health Association, 1992) was used as a general method. Milk samples were heated at 80°C for 5 min to inactivate the naturally occurring inhibitory substance in milk and to eliminate the possibility of false-positive results. After cooling, one-tenth of each milk sample was applied in a circular well in Bacto-Pm indicator agar inoculated with *B. subtilis* organism. The plates were examined for violet coloured inhibition zones after 2.5-3.0 hours incubation at 65°C. Presence of zone of inhibition was recorded as a positive result.

(iv) Disinfectants

One to two drops of bromocresol purple solution were added to 5ml of milk in the test tube and mixed well. Any appearance of colour indicates the presence of disinfectants in milk.

(v) Phosphate test

The buffer substrate solution was prepared according to the prescribed method in R1555 of 1997 (Annexure B). One millilitre each of milk samples was poured into test tubes containing 5 ml of the buffer substrate solution and incubated for 2 hours at 37°C. With each series of samples, one control sample was incubated, prepared from 5 ml of the buffer-substrate and 1 ml of boiled milk of the same type as that undergoing the test. After incubation, the test tubes were removed from the water bath and their contents mixed well. The control sample was placed on the left hand ramp of the stand and test sample on the right. The readings were then recorded in the reflected light by looking down on to two apertures, with the comparator facing a good source of light. The discs used were agitated by revolving until the colour of the test sample became similar to the control sample. Readings will be recorded as per R1555 method in Annexures A and B.

5.4 RESULTS AND DISCUSSION

The results of the study, shown in Table 5.1, reveal that temperatures of the milk in the vehicle tanks transporting the milk to commercial outlets from Farms 1, 3 and 5 were compromised and exceeded the required limit of 5°C. This result indicates that the temperature requirements were not adhered to on these farms. This failure could be due to lack of knowledge and/or attitude of food handlers. The temperature of the milk in the vehicle tank from Farm 4 was not recorded and this gives an indication of poor recording of temperature measurements on that farm. This provides an indication that hygiene practices were not followed on farms regarding temperatures not exceeding the recommended limit.

This may indicate that the milk was not refrigerated correctly at the farm. Cold chain maintenance is an important factor which influences the safety and quality of milk (Sayin *et al*., 2011; Munsch-Alatossava *et al*., 2012). Several authors have found that a large number of pathogens can grow at low temperatures and this may affect the quality, and also decrease the shelf life, of the milk (Pacheco *et al*., 2012; Samarzija *et al*., 2012). Overall, the study shows that 60% of samples taken for temperature values did not comply and this suggests poor milk conditions and storage practices on the farms. Such poor practices may well introduce microorganisms into milk and thus render the milk unfit for human consumption. The results of this study show that urgent measures are needed to ensure clean and safe milk production at farm level, including the promotion of good hygiene practices.

Table 5.1: Physicochemical parameters of milk produced in farms.

	Temperature (°C)		Ethanol (%)		Inhibitors (%)		Phosphate test (%)	
	Farm	**Vehicle**	**Farm**	**Vehicle**	**Farm**	**Vehicle**	**Farm**	**Vehicle**
Farm 1	5	**5.5**	0	0	0	0	**14**	**14**
Farm 2	3.8	4.2	0	0	0	0	0	0
Farm 3	4	**7.4**	0	0	0	0	0	0
Farm 4	**8.5**	-	0	0	0	0	0	0
Farm 5	4.5	**5.2**	0	0	0	0	0	0

Measures would preferably need to focus on efficient farm management practices such as handling, storing, cooling and hygiene practices. The study further reveals that no ethanol or inhibitory substances were found in the samples taken from either the bulk tank or the vehicle tanks on the farm. This shows that no chemicals and adulterants were used in the milk for any purpose. On Farm 1, the milk failed the phosphate test at both the bulk and vehicle tanks. Therefore the results from the farm are not in agreement with the physicochemical study, where 71% of samples taken for phosphates did not comply. This indicates that milk was not pasteurized at most of the commercial outlets and such milk is considered as dangerous to human health because pathogens are still present in milk.

The results of the study, shown in Table 5.2, indicates that the SCC from the bulk tank and the vehicle tank on Farm 3 exceeded the required standard limit and therefore did not comply with the regulation (RSA. National Department of Health, 1977). Therefore, this indicates that contamination of milk occurred and that this milk was of poor quality. This study concurs with the study by Ruegg and Pantoja (2013) which reports that the presence of udder infections, milking of dirty udders, and use of contaminated water, unsanitary milking practices and ineffective cleaning of areas where milk is produced has the significance of increasing the pathogens and affect the quality of milk.

Table 5.2: Microbial cell count in raw milk produced in farms and during transportation.

	SCC ($CFU.ml^{-1}$)		TVC ($CFU.ml^{-1}$)		TCC ($CFU.ml^{-1}$)	
	Farm	**Vehicle**	**Farm**	**Vehicle**	**Farm**	**Vehicle**
Farm 1	4.95×10^5	4.50×10^5	6.7×10^4	4.1×10^4	8.00×10^1	8.20×10^1
Farm 2	5.12×10^5	5.04×10^5	7.00×10^1	7.00×10^1	0	0
Farm 3	7.80×10^4	8.54×10^4	2.90×10^2	5.40×10^2	5.00×10^0	9.00×10^0
Farm 4	2.14×10^5	1.89×10^5	2.20×10^3	3.70×10^3	0	0
Farm 5	3.31×10^5	3.10×10^5	1.80×10^2	1.70×10^2	0	0

This is a concern to farmers because milk that is found containing this pathogen may not be sold to the public and farmers suffer loss of profit. It was evident that SCC was present on the farm, with 52% of milk samples taken for indicator microorganisms study not complying. Therefore it was not surprising that half of the milk sold to consumers at commercial outlets had SCC, giving an ndication that the quality of the milk from the farm was of poor and unsuitable for human consumption. Based on these findings, it is strongly recommended that milk should be sampled for these pathogens on a regular basis on farms to avoid contaminated milk being sold to consumers. Various aspects such as animal health, the environment and the sanitary state of food handlers should be addressed to reduce contamination of milk at farm level.

The study also indicates that Farm 1 did not comply with TVC requirements, as seen from samples taken from the bulk tank at the farm. The results indicate that milk was not of good quality on this farm. Seventy five percent (75%) of all samples taken showed non-compliance in terms of TVC, indicating a problem with regards on the required limit for the indicator microorganisms. TVC in milk is evidence of poor farm management practices during production and also of a generally poor hygiene condtions. It should be pointed out that in this study the milk was highly contaminated by this pathogen.

The total coliform count did not comply in either the bulk or the vehicle tank on Farm 1. Therefore it is understood that the significantly high percentage of indicator microorganisms found in milk samples show non-compliance. The presence of pathogenic bacteria in milk not complying with standards right from farm level, have emerged as major public heath concerns. High coliform counts in milk could be due to the milk being collected under the unsanitary conditions and because of poor general hygiene practices. Based on the exceedingly high levels of non-compliance in this study, it may be concluded that the milk posed a definite health risk to consumers in the study area. The results of the study indicated that no *Escherichia coli* were found in samples taken at the farm, even though the presence of this pathogenic microorganism was found in the study of indicator microorganisms, indicating that personal hygiene practices such as washing of hands and equipment were not followed at commercial outlets. The milk from the farm complied with the standard limit of *Escherichia coli.*

The results from this study highlighted the fact that of all the samples taken from 5 different farms, 90% meet the required standards. Based on the samples that were collected from these farms, we can say that most of the milk samples were compliant and were satisfactory for consumption, even though there were farms where the bulk and vehicle tank measurement did not comply with the required standards. This shows that most of the farms complied with the recommended limits and farmers practiced good farming and hygiene practices that were of acceptable level. Farm 1, however, was non-compliant in most of the analyses, showing that there is a need for constant monitoring to make sure that the milk is not contaminated, hygiene practices are followed and storage facilities continue to comply.

5.5 CONCLUSIONS

It is important that health and safety authorities evaluate the farms and management practices used on the farms on a regular basis to enforce the best hygiene practices. The handling of milk at farm level is crucial as milk is a perishable food and is an ideal medium for bacterial growth. Good hygienic quality of the milk for consumers requires good hygiene throughout the chain of milk production, from the farm to the consumer. Non-compliant samples identified in the study were due to measures that can be rectified such as maintaining the correct cooling temperatures in bulk tanks and vehicles transporting milk, and good personal hygiene. Where samples did not comply, the farmers must take into consideration the hygiene management practices and try to establish points where contamination occurs. This is where a critical control point should be put in place by farmers to establish where the milk is becoming contaminated.

This study reveals that possible reasons for non-compliance with regards to handling of milk and milk hygiene may be lack of knowledge and training, and insufficient monitoring. It is essential that hygienic milk production and processing on farms, as well as personal hygiene be improved. The achievement of hygiene in dairy farm directly influences the production results and therefore it is recommended that health training and guidance be given to farmers and their workers.

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CHAPTER 6

General discussion and conclusion

6.1 INTRODUCTION

Milk is a commonly available source of food and people either consume it directly or use it to make other products. Milk is nutritious; but its quality is easily compromised by contamination agents that render it unfit for human consumption (Filimon *et al*., 2011; Wubet *et al*., 2013; Lucey, 2015). Contamination is often caused by bacterias such as total coliform count or *Staphylococcus sp*., indicating, amongst other things, that poor hygiene practices are common. Many studies have shown that poor handling and hygiene practices such as unsanitary working conditions and the use of unclean equipments, found to be more common in rural areas, can lead to contamination of milk (Swai and Schooman, 2013; Welearegay *et al*., 2012; Gemechu *et al*., 2014; Kuma *et al*., 2015). The hygienic quality of milk has serious implications for its economic value as well as for public health. There are three types of hazards that can affect the quality of milk during production: biological, chemical and physical hazards. These hazards, if not monitored and controlled, can pose a great risk to the quality of milk, and dairy farmers must have the knowledge to determine the critical control points where milk may become contaminated (Azar and Rofehgari-Najad, 2009; Moshoeshe and Olivier, 2012; Kuma *et al*., 2015).

The contamination of milk may occur at any point as a result to poor transportation, production, storage or handling practices at the farm or in processing plants. Food handlers' behaviour, attitude and lack of knowledge may contribute to the contamination of milk (Gaungoo and Jeewon., 2013;

Khairuzzaman *et al*., 2014). Ineffective cleaning of containers used to store milk, unsterilized utensils and dirty working surfaces may also contribute to milk contamination. The level of awareness amongst farmers and food handlers regarding the importance of proper handling practices to avoid the occurrence of foodborne disease is low in rural areas (Gizaw *et al*., 2014 Tessema *et al*., 2014; Adesoka *et al*., 2015). Futhermore, a lack of knowledge about milkborne diseases can put the lives of people consuming milk at risk. Therefore, it is imperative that owners of farms and food handlers be aware of milkborne diseases, the risks associated with of consuming contaminated milk and the diseases that can affect human health after consumption of such milk (Franciosi *et al*., 2009; Mosalagae *et al*., 2011).

Food is a basic human need even though there might be pathogenic microorganisms that can affect its quality (Oranusi *et al*., 2013). Since the year 2000, 2.1 million people worldwide have died from diarrhoeal disease. These deaths have been attributed to ingestion of contaminated milk (WHO, 2000). Diarrhoeal diseases are caused by uncontrolled temperatures, poor handling and selling of milk in dirty conditions (Oladipo and Adejumobi, 2010). Worku *et al*. (2012) observed that door to door milk delivery in rural areas is common and that no evident quality control measures are taken. This could increase the incidence of foodborne diseases. The business of selling milk is increasing and milk handlers lack an adequate understanding of basic food safety practices (Grimuad *et al*., 2007; Park *et al*., 2010; Rane, 2011). Poor milk handling practices and unsanitary conditions can lead to the spread of common bacterial pathogens such as *Bacillus cereus*, *Clostridium perfringens*, *Staphylococcus aureus*, *Salmonella* and *Escherichia coli* that result in food poisoning. The presence and multiplication of such identified microorganisms in milk is harmful to the health of the consumer, and more especially any immune-compromised indviduals (Cawe, 2006; De Oliveira *et al*., 2012; Neeta *et al*., 2015).

The purpose of this study was to assess the quality of commercial bulk tank milk and associated management practices in and around the Mangaung Metropolitan Municipality in central South Africa. Chapter 2 reports on the management and handling practices of bulk tank milk in Mangaung, Free State. Chapter 3 reports on the predominance of indicator microorganisms in bulk tank milk in Central South Africa, and Chapter 4 reports on the physicochemical composition of commercial bulk tank milk in central South Africa. Finally, Chapter 5 provides a report on the producers and distributors, comparing and contrasting the practices on selected farms in central South Africa.

6.2 SUMMATIVE REMARKS: CHAPTER 2

Chapter 2 reports on the management and handling practices of bulk tank milk in Mangaung, Free State. A questionnaire survey was administered at 28 different commercial outlets selling milk and then analysed. The results were categorised into different sections which included the food handlers' demographic profile data, their attitudes and behaviour related to handling practices at outlets, as well as the level of knowledge of the food handlers regarding food hygiene and safety. The results reflected that food handlers showed negativity towards hygiene, also revealing that they only washed the containers once a day (when empty). Moreover, they washed the containers storing milk with their bare hands although they reported that they wash their hands more often. Washing milk containers or tanks with ordinary soap and cold water could result in the contamination of milk as ordinary soap does not have the effect of properly sanitising, or killing microbes. Furthermore, cold water does not remove fat residues adequately and this may introduce biofilms. In most of the outlets, containers that stored milk were left overnight without being cleaned. The behaviour of food handlers showed that training is required. Their knowledge regarding hygiene was insufficient as it was evident that they did not use clean cloths to wipe containers.

With regard to food safety, food handlers knew that they were not supposed to mix new and old milk. It was also clear that gloves were not worn by some food handlers while handling milk. It was found that the food handlers were not aware of washing techniques, correct refrigeration temperatures or HACCP principles, amongst others things. Results in this chapter indicate that, although the food handlers were aware of the importance of common practices such as washing of hands, covering of wounds and washing the bulk tanks, they lacked training on aspects which could lead to contamination. It was also reported that

Environmental Health Practitioners did not make visits to collect samples of milk for evaluation.

6.3 SUMMATIVE REMARKS: CHAPTER 3

Chapter 3 reports on the predominance of indicator microorganisms in bulk tank milk in central South Africa. The study revealed that half of the samples taken for temperature measurements did not comply with the required standards for safe keeping of milk as prescribed by R1555 of 1997 (RSA. National Department of Health. 1997). This indicates that temperature was not properly regulated at most outlets. *Escherichia coli* and the coliform count were found in half of the samples: these are indicators of possible faecal contamination. While results reflect that adulteration of milk did not occur in Botshabelo, in Thaba Nchu, three samples were found to contain water and in the Bloemfontein area there were four samples containing water. The study further shows that all samples from Thaba 'Nchu and Botshabelo exceeded the standard limit for Total Viable Counts (TVC). This chapter highlights the fact that milk ingested by the consumers did not meet quality standards and could have been detrimental to consumers' health. Even though there were no reported cases of illness due to the consumption of this milk, food handlers and people who consumed raw milk on a daily basis should be educated about the possible dangers of exposure to microbial pathogens.

6.4 SUMMATIVE REMARKS: CHAPTER 4

Chapter 4 reports on the physicochemical composition of commercial bulk tank milk in central South Africa. Compositions such as fat, protein, inhibitory substances, as well as ethanol and phosphate tests were analysed. The results indicate that only inhibitory substances meet the standard and complied in all commercial outlets. The study indicates that there were fewer non-compliant outlets than there were compliant outlets. While some outlets showed evidence of phosphate presence in the milk, there were a number of outlets where the milk sold was pasteurized. These analytical tests are important for monitoring the quality and checking whether the milk is suitable for consumption and such findings of the study revealed that the milk at these outlets was not suitable for human consumption. Poor physicochemical compositions in milk are common in areas where milk is in high demand.

6.5 SUMMATIVE REMARKS: CHAPTER 5

Chapter 5 reports on comparing producers and distributors: case studies of selected farms in central South Africa. Temperatures for the bulk tanks and vehicle tanks were also recorded. Samples were taken for microbial and physicochemical analysis. It was found that the results of the ethanol and phosphate tests, and also the *Escherichia coli* and inhibitory substance samples, all complied with the required standards on all farms that were evaluated. This chapter also reveals that the temperatures of the bulk tank did not comply on one of the farms and the temperature of the milk in the vehicle tank did comply on two of the farms. This could suggest that there may have been a rise in the temperature of milk when it was transferred from the bulk tank to vehicle tank used to distribute the milk to outlets. It is also clear that the cold chain was broken, due either to lack of knowledge or lack of technical ability. The bulk tank temperature on farm 4 did not comply with the required standard and it was found that the temperature of the vehicle tank used on this farm was not recorded. The study also reveals that the temperature of the vehicle tanks exceeded the limit (not above 5°C for milk intended for consumption) on Farms 1, 3 and 5, which gives an indication of lack of knowledge by food handlers on the importance of temperature regulation. The milk sample from Farm 1 did not comply with the total coliform count (TCC) standard limit and this indicates that milk on this farm did not comply. On Farm 2, the sample for somatic cell count (SCC) exceeded the required standard, while on the other farms the SCC levels were within the required standard limits.

6.6. CONCLUSIONS

From all the chapters of the study, the results show that 81% of samples from the bulk tank milk did not comply, with only 19% complying. This indicates that the milk was not suitable for human consumption. Effective educational programmes are needed by farmers and food handlers to prevent contamination of milk. Non-compliant samples could have been caused by poor handling practices, transportation and/or storage, unclean holding tanks, incorrect temperature levels and lack of knowledge by food handlers.

In the microbial analysis (total viable count, total coliform count and *E. coli)* non-compliance values were found, indicating that general hygiene practices and temperature control were not properly maintained, especially where milk was produced handled and stored. The quality of the milk was therefore negatively affected and unsuitable for human consumption. At the same time, the compliance values for the chemical qualities of milk such as ethanol, inhibitory substance and SCC, show that these milk samples were compliant and therefore of good quality in relation to these factors. The results reveal that milk was not pasteurised in most of the samples, as shown by the lack of compliance indicated by the phosphate test. This could cause contamination of milk and such contaminated milk may be the source of harmful bacteria. While the pasteurisation process is intended to kill pathogenic microorganisms in food, it also helps to slow down the multiplication of microorganisms and to prolong the shelf life of milk. Based on the above, it can be concluded that milk used from the outlets was not of good hygiene standard.

6.7 RECOMMENDATIONS

People in rural communities have always consumed raw milk and this practice is likely to continue. It is therefore important to create awareness of potential sources of contamination, related diseases and the precautionary measures people should take to ensure that the milk is free from microbial contamination, especially pathogens. More emphasis should be placed on boiling milk before consumption in areas where pasteurisation is not practised. Minimum safety standards should be implemented at outlets selling raw milk and interventions are crucial in identifying and establishing the hygiene status of these outlets. The results of the study have proved interesting as they show an alarmingly high percentage of milk samples of poor microbial quality and not conforming to the national legislation for milk sold to consumers. The following points were identified as possible ways to improve food hygiene and quality at commercial outlets as well as on dairy farms. These recommendations highlight possible improvements which may also be implemented by other commercial outlets where the survey was not done:

- The cleaning of containers keeping milk should be done properly and adequately with the correct sanitiser to kill all organisms that may cause contamination. The areas where milk is stored must be kept clean at all times and monitored.

- All food handlers and owners of commercial outlets should know the temperature at which milk should be stored in order to prevent microbial proliferation in milk. The tanks used must be installed with a monitoring alarm temperature device to detect when the temperature is below the standard limit. Food handlers must know that certain microorganisms can grow at low temperatures hence a need for a monitoring device and adherence to regulations.

- Handling practices of milk from the farm to commercial outlets should be monitored carefully as poor handling practices can occur and may contribute significantly to the contamination of milk.
- Training and awareness campaigns for the benefit of food handlers and farm owners should be done on a regular basis (atleast quarterly) with regard to food hygiene and practices that may cause contamination. Employees who show a positive change in attitude and behaviour could be given an incentive award.
- An Environmental Health Practitioner (EHP) should take milk samples on a monthly basis at the outlets to identify whether milk is fit for human consumption. Such tests will help to identify the level of quality and also any microbes found in the milk.
- Food handlers working with milk should be monitored more frequently to check their health status. They should also be provided with appropriate protective clothing, and the wearing of this made compulsory. They must be taught that when they are sick with a cold or intestinal sickness, they must not handle milk and must immediately report their health status to their line managers.

- Dairy farms should be monitored and evaluated on a regular basis (at least twice a year) by an Environmental Health Practitioner to assess the farm management practices and all health parameters.
- Good personal hygiene practices on the part of food handlers must be encouraged.
- Transportation of milk from the farm to the commercial outlets should be done in an appropriate vehicle that has the ability to cool milk during transportation. These vehicles must be kept in clean condition to transport milk and must have a temperature sensitive device to alert if them temperature is below the standard.
- Legislative guidelines and standards concerning milk quality practices should be made clear to food handlers handling raw milk and it should also be made clear that poor practices will result in the closure of the outlets.

6.8 FUTURE RESEARCH

The study has opened up the following further research opportunities:

- Implementing awareness programmes for the benefit of all food handlers selling raw milk in rural areas.
- Expansion of the study to cover outlets and distributors in other municipalities in South Africa.

- Investigating the relationship between the microorganisms affecting milk quality and the areas that may have an impact on the contamination of milk such as the storage area and the containers used to store milk.
- Follow-up study on all outlets selling milk in South Africa should be performed to check the overall hygiene status of bulk tank milk.
- Serotyping of microbial population during the production, processing and transportation of milk.

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APPENDIX A

(QUESTIONNAIRE USED FOR DATA COLLECTION DESCRIBED IN CHAPTER 3)

A SURVEY OF FOOD HANDLER'S HYGIENE AND HANDLING PRACTICES OF BULK TANK MILK IN AND AROUND MANGAUNG METROPOLITAN MUNICIPALITY.

Thank you for taking part in this survey. The aim of this survey is to determine your practices regarding the management and handling of bulk tank milk at commercial outlets in and around Mangaung Metropolitan Municipality. Your answers will be treated confidentially and will not be used against you. You are requested to mark your answer/s with "x" in blocks provided, unless otherwise specified.

Questionnaire number…………………. Name of outlet…………

A. DEMOGRAPHIC PROFILE DATA OF FOOD HANDLERS

1. Gender?

Male	Female

2. Race?

Black	Asian	Coloured	White

3. Age?

Below 20 years	20-30 years	31-40 years	41 and above

4. Level of education?

None	Grade 1-6	Grade 7-12	Tertiary education

5. Working experience?

Below 1 year	1-2 years	2-5years	5-10 years

6. Training received?

Yes	No

B. HYGIENE AND PRODUCTION PRACTICES

7. Where do you get the milk from?

____

____

8. Do you refrigerate milk immediately upon arrival?

Yes	No

9. If no, please specify what do you do

____

10. When does the milk get finished?

Same day	1-2 days	3 days

11. How long is the milk stored in the tank before discarded as unfit for human consumption?

2 days	3 days

12. What type of container do you use to keep the milk?

Plastic container	Bucket	Any other container

13. Why do you prefer that container?

____

14. How often do you wash the working areas near the bulk tank per day?

Always	Once per day	Twice per day

15. Do customers bring their containers to buy milk?

Yes	No	Sometimes

16. Are these containers clean at all times?

Yes	No	Sometimes

17. What do you do when the customer's container is not clean?

18. When do you wash the used milking equipment?

After use	Before using	Before and after use	Do not know

19. For how many minutes do you wash the bulk tank/containers keeping milk?

2 min	5 min	Few minutes	Do not know

20. When do you wash the tank?

Before milking	When empty	The following day

21. How is the milk extracted to the consumer's container?

Using tank tap	Scooping milk with another container

22. When washing the bulk tank what do you use?

Soap	Acid	Sanitiser	All of the above	None

23. Which cleaning methods do you use when washing the bulk tank milk?

Manual	Circulation	Both	Do not know

24. Is there a procedure for washing the bulk tank?

Yes	No

25. If yes, please specify?

____

26. What do you normally do if you have a wound?

Report it	Cover it with cloth	Apply dressing

27. How often do you replace the tank or the containers holding milk?

Four times per year	Once a year	Never replaced	Regularly

28. How often do you wash the tank/ containers?

After milking	Twice per day	Regularly

29. Do you mix the new (arriving) milk with the previous (old) one?

Yes	No	Sometimes	Always

30. Do you use gloves when handling milk?

Yes	No	Sometimes	Often

31. What kind of water do you use for washing the tank?

Cold	Hot	Both

32. Where do you normally get this water from?

River	Wells	Tap

33. Do you check the temperature of milk in the tank?

Yes	No	Always

34. When do you wash your hands?

After using a toilet	Before and after using a toilet	When they are dirty

35. How do you keep your nails?

Short and clean	Long

36. Do you know the risk the nails pose to food?

Yes	No

37. Is it necessary to cover your head when extracting milk from the bulk tank?

Yes	No	Do not know

38. How long have you being doing this?

1 year	2-5 years	6-10 years	Do not know

39. Do you drink this milk?

Yes	No	Sometimes

40. Do you know the required temperature that should be used for keeping milk?

Yes	No

41. Is it important to clean where the tank is stored and why?

____

42. Does the Environmental Health Practitioner (EHP) come and monitor milk hygiene and take samples?

Yes	No	Sometimes	Always

43. Regarding the water used for washing the tanks or containers: are water samples taken by the EHP's?

Yes	No	Sometimes	Always

44. Do you have a certificate of acceptability for selling milk?

Yes	No

45. What do you do with the leftover milk or milk that is not fit for selling?

Sell again the next day	Throw it away	Give to the customers for	Combine with the new milk

		free	

46. What action do you take when your consumers fall ill as a result of drinking this milk from your outlet?

____

47. Do you know what HACCP means?

Yes	No	Do not know

48. Does the milk always taste the same?

Yes	No

49. Do you wash the mouth of the bulk tank?

Yes	No	Sometimes

APPENDIX B

(PICTURES OF BULK TANKS AND HYGIENE IN OUTLETS DESCRIBED IN CHAPTER 3)

Source: Commercial outlet where the study was conducted

Figure B1: Handling of milk with jewellery on and no apron worn

Source: Commercial outlet where the study was conducted

Figure B2: No covering of the hair and gloves are not worn

Source: Commercial outlet where the study was conducted

Figure B3: Different type of tank used in some of the outlets

Source: Commercial outlet where the study was conducted

Figure B4: Common tank found in most of the commercial outlets