

MICROBIAL COMPOSITION OF MILK AND RELATED HYGIENE PRACTICES ASSOCIATED WITH THE PRIMARY FEEDING SCHOOL PROGRAMME IN MASERU

by

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Declaration

I, Lizzy Khali, identity number ##### (student number #####), declare that this dissertation submitted to the Central University of Technology, Free State, for the Degree, Master of Health Sciences in Environmental Health, is my original work. This work complies with the code of Academic Integrity, as well as other relevant policies, procedures, rules and regulations of the Central University of Technology, Free State. I therefore declare further that this work has not been previously submitted by myself or any other person in its entirety or partially at any other institution or organisation in respect for a qualification.

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List of abbreviations

AIDS	Acquired immunodeficiency syndrome
BLA	Brilliance <i>Listeria</i> Agar
BPA	Baird Parker Agar
BIDPA	Botswana Institute of Development Policy Analysis
CFU	Colony forming unit
<i>E. coli</i>	<i>Escherichia coli</i>
EPA	Environmental Protection Agency
FPE	Free Primary Education
GMPs	Good Manufacturer's Practices
GSFPS	Ghana School Feeding Programme
HACCP	Hazard Analysis and Critical Control Points
HIV	Human Immunodeficiency Virus
MRS	De Man Rogosa and Sharpe Agar
NSFPS	Namibia School Feeding Programme
Pap	Bland soft food consisting of maize
PCA	Plate Count Agar
RBC	Rose Bengal Chloramphenicol Agar
Samp	Coarsely ground corn
SC-UK	"Save the Children" United Kingdom
SDGs	Sustainable Development Goals
SFPs	School Feeding Programmes
SOP	Standard Operating Procedure
SSRP	School Self Reliance Projects
TBC	Total Bacterial Counts
TLV	Threshold Limit Value
TNTC	Too Numerous To Count
UK	United Kingdom
US	United States
USA	United States of America
WFP	World Food Program

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Abstract

Background

The number of hungry school-aged children is unknown, though it seems to be increasing annually, especially after the massive hit of the global pandemic of *Covid-19*. The World Food Programme has taken a lead in investing in school health and has established strategic means to meet the need of most of the disadvantaged school-aged children, through School Feeding Programmes across the globe. This study conducted in Maseru, Lesotho, involved 16 primary schools and investigated the knowledge, attitude, and behaviour of food handlers at schools, while employing a common food product (milk) obtained from the same source.

Methodology

The sampling consisted of two batches of milk samples collected at the end of summertime and at the beginning of winter. Each milk sample was monitored from the point of collection at the dairy to the various schools. The milk samples were analysed to determine the presence of various microorganisms, including total viable counts, *Listeria*, yeast and mould, *Enterococcus*, Coliforms and *Escherichia coli*, *Lactobacillus* and *Staphylococcus* spp. Structured questionnaires were administered to the food handlers to evaluate their knowledge, attitude, and self-reported behaviour.

Results

The temperature and distance variances showed a very weak positive correlation, the more distance covered the higher the temperature change occurred. All the tested microorganisms occurred in milk samples in the range 2×10^0 CFU ml⁻¹ to $>9 \times 10^5$ CFU ml⁻¹. Total bacterial counts were the highest with 9.95×10^5 CFU ml⁻¹ while *Listeria* was the lowest with 2×10^0 CFU ml⁻¹. On average 81% of the questionnaires were answered correctly, 13% of the respondents expressed lack of knowledge on the diseases that can be transmitted through contaminated milk, less than 50% of the study population believed that cold milk means safe milk even when not refrigerated.

Conclusion

Specifically, *Enterococci*, *Lactobacilli*, *Staphylococcus*, *E. coli* and *Listeria* species were detected in some of the samples with levels above threshold limits allowed by legislation for a particular organism. Such findings present with risks to human health

as foodborne illnesses are ascribed to contamination of food, which can occur at any stage of the food production chain, as well as during production, storage, transportation and or handling to serve. Monitoring and evaluation of School Feeding Programmes can play an important role in food safety to yield the desired results.

Keywords: School feeding programme, milk, food handlers, microbiological quality, Lesotho

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CHAPTER 1

Introduction

1.1 Background

In 2016 a quarter of the Lesotho population was food insecure, (Kingdom of Lesotho population and housing census' (Kingdom of Lesotho, 2016); 'Lesotho country analysis working document final draft', 2017) with 360 000 orphans and vulnerable children. Consequently, the scarcity of food left these vulnerable children to be prone to several psychosocial factors, which can eventually even diminish their right to education to be pursued (WHO, 2015). The developed countries and organisations instituted the "School Feeding Programmes" (SFPs) to improve on the education and nutrition status of the children (Africa, 2019). The School Feeding Programmes were established long before 1961, and are defined as interventions aimed to provide both educational and health benefits to the most vulnerable children (Taylor and Ogbogu, 2016; Data and Cia, 2017).

The fundamental objectives of the SFPs include to deliver a meal or snack to the children in the school setting; to improve on the children attendance, enrolment rates and also to mend the nutritional status of the school children (Jomaa *et al.*, 2018). The programme has advanced, especially in the developing countries so much that it encompasses every child at school. The feeding programmes are justified as a direct contribution to directly address at least 3 goals in the Sustainable Development Goals (SDGs), while more other goals are indirectly linked ('How School Meals Contribute to the Sustainable Development Goals', 2017). The SDGs are a collection of 17 global goals reputed by the United Nations in 2015, which are aimed at transforming countries as well as eradicating poverty and hunger, in addition to a realization of the human right to a standard of adequate living to improve on both health and well-being.

Research has indicated that both acute and chronic hunger affect children's access to school, educational outcomes, attention span and general behavioural patterns in the

class (Jomaa *et al.*, 2018). It further indicates that children suffering from short-term hunger, as a result of skipping breakfast have various problems such as concentrating in the class and performing complex tasks during the day (Ghattas *et al.*, 2017). Nowadays, hunger is viewed as one of the most prevalent and destructive phenomenon that affects a large population of children, making cognitive learning at schools impossible (Webb *et al.*, 2018).

Lesotho alongside the relevant stakeholders concluded that in support to the SFPs, food baskets that may be even more precise for the good development of the children can be introduced (Olowu, 2020). These forms of improvements are pretty good though they should also be closely monitored and evaluated so as to include strategies relevant to combat the challenges that may arise in the long run. Proper food handling techniques enhance long life to the children and the public at large (Brief, 2018). Improvements on nutrition can only be achieved if proper steps are followed in order to attain the desired goal encompassing proper food quality.

In addition, there are two types of SFPs; the on-site meals and take-home rations (Nets, 2018). Descriptively, on-site meals are foods that are distributed to the children while still on school campus, but the take-home rations are a collection of basic food items that are usually given to the children from vulnerable households to cook at home; however, Lesotho routines comprise only with the on-site meals. The meals include beans, peas, samp, eggs, vegetables, and milk; amongst which milk is a major concern, hence it is the only food that is served cold. The choice of menu plays a critical role in nourishing the children; hence it is very imperative to provide the children with a balanced diet (Villalpando *et al.*, 2017).

Milk is proven to be one of the most nutritious foods due to its high content of calcium, protein, vitamins and other minerals that are essential for growth, bone density and overall health. It is one of the proteins that are affordably accessed hence most schools are serving milk within their menu (Mourad and Bettache, 2019). Milk has been identified as the source of almost three times more hospitalisations than any other foodborne disease source, making it one of the world's most dangerous food products (Thakur *et al.*, 2018). This is because it serves as a great nutritious medium capable of harbouring microorganisms and facilitating their growth, thus becoming

contaminated and able to cause infections and diseases to consumers upon its consumption (de Arauz *et al.*, 2017).

Microorganisms are ubiquitous in nature, and they can be either pathogenic or beneficial. The pathogenic types of microorganisms cause infections in plants, animals and in humans (Dong *et al.*, 2021) while the beneficial microorganisms are usually used in food processing to yield desired end products, e.g. yeast in the fermentation of beer, wine, bread and *Lactobacillus* in yoghurt production (Todeschini *et al.*, 2018). Some of the beneficial microbes living in the human bodies do occur as normal flora and do not cause any illnesses on their original hosts, while living at their original sites. More elaborately, the pathogenic microbes require an appropriate port of entry in order to cause an infection (André *et al.*, 2017).

It is worth mentioning that the same bacteria that produce beneficial actions while on the skin, can still cause a fatal illness when ingested, inhaled or navigated through an open wound. Additionally, microorganisms require various nutritional, physiological and environmental factors (e.g. pH, temperatures and water activity) in order to grow and multiply (Mohamed *et al.*, 2018). There are, however, large groups of bacteria and viruses that must be prohibited from gaining access into the milk in a bid to avoid foodborne illnesses.

Moreover, upon secretion from the udder, milk is sterile, but it gets contaminated by bacteria the very moment it leaves the udder since, bacteria are pervasive (Wochner *et al.*, 2018). Except in the case of mastitis or other infections, where the milk will be contaminated with disease-causing microorganisms from within (Knight-Jones *et al.*, 2016). Further contamination of the milk by microorganisms can take place during milking, handling, storage and other pre-processing activities; as a consequence, there must be recurrent food safety programs for food handlers aimed at improving on the culinary skills (Rebouças *et al.*, 2017). The regulations and standards in the production of milk must be followed throughout the whole production process.

Lesotho Dairy uses pasteurisation at 72°C for 15 minutes. Subsequently, the milk is quickly heated and cooled rapidly to 4°C or below to eliminate any proliferation of microorganisms (Standards *et al.*, 2015). Pasteurisation is aimed at destroying

pathogenic microorganisms and extend the shelf life of the milk; this can be achieved only if the milk is properly handled and also stored at the optimum temperatures (Pan *et al.*, 2017). Different limits for both fresh and sour milk must be adhered to in a milk production plant (Chaudhry *et al.*, 2018)

Consequently, milk must be handled, transported, and stored in a way that replication of microorganisms becomes prohibited. The distance travelled with milk while the cold chain is not maintained, has a direct impact on the milk (Knight-Jones *et al.*, 2016). Clearly, the rise in temperature directly influences the escalation of the numbers of microorganisms in food, especially the mesophiles and the thermophiles (Melin *et al.*, 2019).

Of great consideration, foodborne diseases are a leading public health problem in both the developed and the developing countries; they are among the major causes of morbidity and mortality, and a significant drawback to socioeconomic development, worldwide (Vitale and Schillaci, 2016). Foodborne illnesses are triggered by the consumption of food that had been contaminated with microorganisms, secreting toxins or replicate to cause diseases (Kovac, 2019). It is known that proper handling of food provides food that will not pose any disease or discomfort to the consumer, therefore, adequate knowledge of food safety is very fundamental in nurturing healthy communities (Rebouças *et al.*, 2017).

In this light, food handlers have an undeviating paramount role in generating and guaranteeing safe food. In order to prepare wholesome food, adequate frequent trainings are necessary (Khera, 2017). It is the responsibility of each country to strengthen food safety programmes in order to prevent foodborne illnesses. The proverbial saying “You are what you eat” (Teasdale *et al.*, 2018) comes a long way, but still in context today, as the consumption of food loaded with pathogenic microorganisms is fatal.

Hunger, poverty and poor education are inter-reliant; when children are hungry, the chances that they will attend school are questionable, and without education, the chances of them breaking the poverty trap are significantly reduced (Lambie-Mumford, 2018). Food scarcity negatively affects the brain development of the children and

impedes the chances of educational success later in life. In relation to obtaining solution to this problem, SFPs had been put in place in many developing countries across the globe (Nets, 2018), although, there is a catch there too, that the food that is prepared especially for a large group of people usually ascribes to foodborne illnesses (Lund, 2019).

The major problem that is usually encountered in the SFPs is failure to follow up procedures, yet the best results are expected. The aim of improving on the nutrition of the school children through SFPs by developing countries, can be achieved with an ongoing systematic monitoring and evaluation. Appropriate precautions must be taken to ensure that the food provided will enrich the children's life (Africa, 2019). It is a serious challenge when a need is identified together with the anticipated solution, yet, the procedures toward attaining the best results is not followed, therefore, the exercise becomes futile (Yoon *et al.*, 2016).

With proper food handling across all the various stages, foodborne illnesses can be avoided. Adequate knowledge, proper attitude and appropriate behaviour are the most imperative attributes to good quality milk production (Neal *et al.*, 2018). These attributes must be demonstrated by every individual who handles food, alongside possessing a valid food handlers' certificate for safe food production (Tull and Plunket., 2018). At this juncture, it is worth mentioning that proper food handling is crucial. Factors that can affect or compromise food safety include among others, food preparation time, temperature control, transportation, and storage (Gong *et al.*, 2016).

The theory of planned behaviour (TPB) is a psychological theory that links beliefs to behaviour and has successfully managed to explain and predict behaviour in a multitude of behavioural domains, from physical, social to mental activities (Neighbor and Lindgrest, 2021). The theory maintains that three core components: attitude, subjective norms, and perceived behavioural, all these combined shape an individual's behavioural intentions (Conner and Norman, 2022). TPB assumes that individuals act rationally, according to their attitudes, subjective norms, and perceived behavioural control (Neighbor and Fossos, 2023).

These factors are not necessarily actively or consciously considered during decision-making but form the backdrop for the decision-making process (Conner and Norman, 2022). Whenever the attitude toward any activity is positive so will be the attitude, and the intension would also be strong too leading to the prediction of positive behaviour (Neighbor and Fossos, 2023). Therefore, this theory emphasizes that the portrayed behaviour magnifies the intent and plans of humans and had been employed in this study too.

1.2 Identified gap

Milk in its raw form has the potential to harbour pathogens or contaminants that can harm the consumers, therefore, it must be handled aseptically throughout all the stages (André *et al.*, 2017). There is a very bad inclination in the country of not following the set standards, at various food processing levels, including milk handling, transportation, and storage (researchers' observations). This tendency yields bad consequences in human health (Carrasco *et al.*, 2017). Quite a number of people working in the milk industries know that milk must be transported while the cold chain is maintained, but the opposite is executed (Farmers and July, 2016). Consequently, milk is subjected to contamination by various microorganisms that could be fatal in the process.

Recently, there is a paucity of information on milk consumption at primary schools in Lesotho, yet milk is served in almost all the schools. Additionally, the transportation mode and the storage of the milk at all these schools, partaking in the SFP do not tally with the set standards. There are records of children absenteeism in schools following the consumption of milk, but, there are neither clinical records nor further investigations in relation to the gastrointestinal infections observed (Tan *et al.*, 2018).

In developing countries, primary school children are among the most unguarded populations, and the maturity level of the immune system added to the personal hygiene, play an imperative role to their vulnerability (Lund, 2019). The gastrointestinal infections are amongst the leading conditions in primary schools, however, the sources have not yet been documented or traced. As milk can also serve as an excellent medium for the growth of many kinds of microorganisms at favourable

conditions (Quinlan, 2019). The maintenance of the cold chain during transportation and refrigeration of milk at the precise temperatures are very crucial in the prevention and the control of foodborne microorganisms ascribed to milk consumption (Ohkubo *et al.*, 2019).

1.3 Aim and objectives

Against this background, this study sought to investigate the microbial content of milk served to children through the School Feeding Programmes in some primary schools located in Maseru as well as assess knowledge, attitude and self-reported behavioural practices of food handlers in relation to milk. The findings obtained from this study will ultimately serve as relevant information to policy makers and public health practitioners to develop recommendations, priorities and regulations that will improve on the implementation of the feeding programme.

1.3.1 Specific objectives

To address the overall objective, the following specific objectives were put forth:

- To provide extensive overview of the hygiene status of the feeding programme in the primary schools.
- To quantify the bacterial burden of milk served to children in selected primary schools.
- To assess the knowledge, attitude, and self-reported behavioural practices on milk handling.

1.4 Chapter layout

Chapter 1: Introduction

The chapter embodies information on the background of the study, which explains the reason and the prospect of the School Feeding Programme conducted in Maseru, Lesotho. In addition, the types of food provided to the children in the primary schools that partook in this feeding scheme were listed, amongst which, milk was distinguished for this study with reasons giving to back such a decision. Details on the composition of milk and its implications was equally deliberated.

Chapter 2: Literature Review

The SFP across the globe had been reviewed in this chapter, together with the nutritional status of Lesotho, the hunger implications and the impact which the feeding programmes have in schools. The possible reasons for milk contamination have been explored such as its high protein and water content making it easy for microorganisms to thrive in, many microorganisms can live in milk, a selection was monitored namely, total viable counts, *Listeria*, yeast and mould, *Enterococci*, coliforms and *Escherichia coli*, *Lactobacillus* and *Staphylococcus* spp.

Chapter 3: Assessment of the predominant microorganisms in milk served to children through School Feeding Programme

The microbial analysis of milk of this study was expounded in this chapter. Pasteurised milk samples were taken from the 16 primary schools end of summer season and beginning of winter season to investigate the presence of various microorganisms. Both temperature and distance were measured and there was not an evident increase in microbial counts in relation to temperature and distance. All the investigated samples contained various levels of the selected microorganisms with *Lactobacillus* spp. being most prevalent in all the samples.

Chapter 4: Knowledge, attitude and self-reported behaviour of the food handlers

A formal structured survey was carried out at 16 primary schools which receive milk from the same source. Questionnaires were administered to investigate also the knowledge, attitude and self-reported behaviour of the food handlers of which mostly (44%) believed that pasteurised milk cannot transmit diseases and lacked knowledge of the diseases that can be transmitted through contaminated milk consumption. Furthermore, only 6% of the schools did proper hand washing with running water and soap. There is an urgent need to reinforce various hygiene aspects on the food handlers engaged in the SFP.

Chapter 5: General conclusion and recommendations

The SFP strategy is a good initiative which can bring forth the best results especially when the issues of food hygiene are taken into full cognizance. The microbial analysis reported in this study should be considered by both provider (dairy) and food handlers. Food handlers must be equipped to develop the relevant competencies in food handling for prevention and control of foodborne illnesses.

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CHAPTER 2

School Feeding Programmes (SFPs) internationally, regionally and locally

2.1 Background of Lesotho

The Kingdom of Lesotho is also among those countries affected by poverty and malnutrition. It is classified under the Least Developed Countries, whereby 57.1% of its population, lives below the national poverty line of 138 Maloti per month ('Lesotho country analysis working document final draft', 2017). About 25% of the population is HIV positive and it had been classified as the second highest prevalence rate in the world. This explains the high number of orphans (47%) since most parents lost their lives due to HIV and AIDS, though there are still a large number of children, 24% that are already vulnerable (Data and Cia, 2017).

A quarter of the population, 447,000 people, was said to be food insecure in August 2014 (Stephen *et al.*, 2018). Stunting affects 39.2% of children, of which 14.8% of cases is in its severe form. Children (47%) aged six to 59 months suffer from iron, calcium, vitamin A and B, folic acid and zinc deficiency (Lesotho Demographic and Health Survey, 2014). Most of the children in Lesotho are nutrient deficient, therefore, nutrient replacement can be attained through forms that would be affordable; provision of milk through SFP is one of the forms (Tibbo, 2020).

Fig. 2.1 below depicts the country of Lesotho with all the 10 districts. The School Feeding Programme had begun in 1961 and had been disseminated throughout all the districts, and Maseru as the capital city is at the benefit of being around the funders, therefore, all the primary schools are covered by the programme ('12 things you may not know about WFP', 2019). The schools that are covered by the SFPS in Maseru are 219 schools and are widely dispersed throughout the whole district.

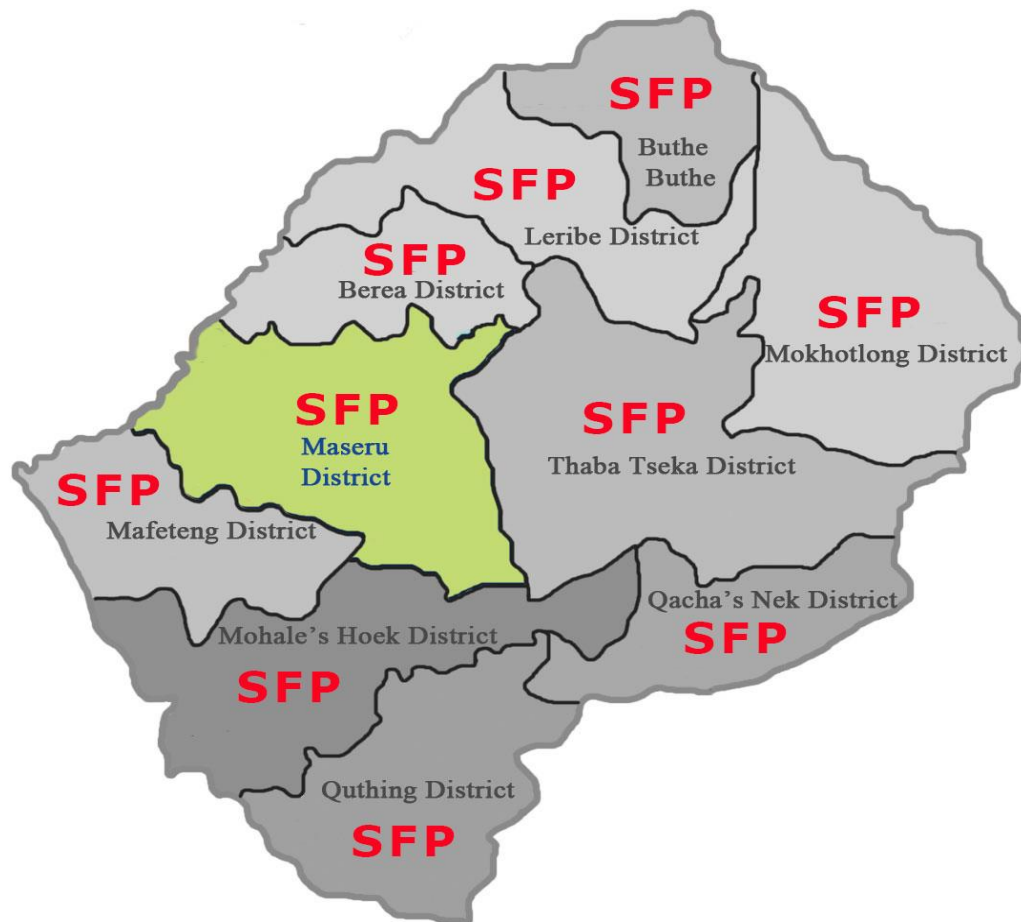


Figure 2.1: Map of Lesotho by SFPs coverage with Maseru district. Green indicates the study area.

2.2 International history and status of the School Feeding Programme

In the United States of America (USA), the Children's Aid Society of New York instigated serving lunch to children as far back as 1853 (Oloruntoba and Musah, 2014). A lot of foodborne infections occurred but could not be traced back to the food that children consumed at school. France equally initiated the school lunch programme for the needy children in 1867, which was established in about 464 areas. Similarly, in Philadelphia, the Star Center Association began serving penny lunches in one school in 1894, of which a lot of outbreaks were associated with the consumption of the food served in school with no tangible proof (Lambie-Mumford, 2018).

The National school feeding schemes were introduced in the 1930s in the United Kingdom (UK) and the United States (US) with the explicit aim of improving on the growth of children (Melin and Wagner, 2015). In the UK, a programme that subsidized milk for school children was initiated in 1934 and milk was provided free from 1944 onwards (King, 2017). In one of the schools in Northern Ireland, the school was shut down because more than 200 children had gastroenteritis; this condition only occurs if one had consumed a contaminated food or drink (Londonderry and Agency, 2019). The caterers were warned to reinforce the general hygiene practices.

2.2.1 Ghana school feeding programme

The Ghana School Feeding Programme (GSFPS) is dated back to 2005 and it is facing expansion and project piloting (Awojobi, 2019). During this period, pupils of several Catholic primary and middle schools were given take-home rations from food aid. The Ghana SFPs is still encountering various challenges in terms of food safety, as children absent themselves from school after eating certain foods (Ababio and Lovatt, 2015). This had been a wake-up call that a foodborne infection must be investigated though little efforts have been made to respond to this (Ghattas *et al.*, 2017).

2.2.2 Kenya school feeding programme

The Kenya school milk programme started in 1980, but went more robust in 2009, due to high costs and the introduction of the Structural Adjustment Programme ('Concept note of the proposed national school milk conference', 2015). The school milk programme was discontinued due to an ideology that children are becoming sick after milk consumption (Approach, 2021). The challenge was never addressed to verify if milk was really a source (Neervoort *et al.*, 2017). A school feeding partnership between the Government of Kenya and the United Nations, WFP started in 1980. The introduction of Free Primary Education in January 2003 came along with food handlers' training package and the monitoring and evaluation to ensure compliance (Centre, 2017).

2.2.3 Mali school feeding programme

School feeding is not new in Mali and it is said to be in a state of transition. It was first institutionalized in 1962. An estimated 62,863 school children were benefiting from

the Malian Government school feeding programme, in 2009–2010 (Aurino *et al.*, 2018). In Mali, each region of the country has regional offices of the Ministry of Education called Centers of Educational Support. These offices address issues, relating to food quantity and programme integrity, maintain school attendance records, track the number of children that are eligible for take-home rations, and coordinate with community leaders (Africa and Africa, 2017).

Studies conducted in Mali revealed that there is a need for guidelines on nutrition and menu designs to be provided. These guidelines can best serve Mali, hence the Centers of Education support are performing well and can therefore have an upper hand to ensure compliance (Aliyar *et al.*, 2015). Similarly, the guidelines may also address the long-standing challenge of food safety in the SFPs, which had been overlooked simply because the feeding programme is usually referred to as a safety net (Tull and Plunket, 2018).

2.2.4 Namibia school feeding programme

The Namibia School Feeding Programme (NSFPS) began as a pilot programme in 1991 (Sulemana *et al.*, 2018). Following the success of the pilot programme, a four-year national school feeding program was launched by the United Nations WFP in co-operation with the Government of Namibia in 1992 (Melin *et al.*, 2019). Today, the programme continues to grow in accordance with national plans to expand the number of beneficiary learners to 300,000 by 2015 — a target which was achieved in 2013. The programme currently supports over 300,000 pre- and primary learners, mainly orphans and vulnerable children in 1,300 state and private schools across the country (Ministry of Education and Training Lesotho, 2020).

Namibia is one of the countries in Southern Africa that has transitioned its School Feeding Programme from being reliant on external funding to a sustainable model that is fully funded and managed by the government (Approach, 2021). One of the challenges prominent in Namibia SFPs is the lack of storage and kitchen facilities at schools. This is one of the major factors contributing to the contamination of food served to children in schools (Stephen *et al.*, 2018a).

2.2.4 Botswana national school feeding programme

The Botswana government has successfully implemented its National School Feeding Programme by itself, since 1998. The SFPs in Botswana initially started with the assistance of WFP in 1965 in response to the widespread malnutrition among children, resulting from a continuous five-year drought period (Lewis, 2017). The country was also not self-sufficient in food production like other African countries; however, the country is doing quite well, lately. The foodborne outbreaks which can be linked to milk consumption are not well reported of (Abusheliabi *et al.*, 2017).

The Botswana National School Feeding Programme has complete coverage and reaches school children in all the government-owned and public primary schools in the country, providing one meal a day to over 330,000 school children (Melin *et al.*, 2019). There are fewer cases occurring in schools since the food handlers at schools in Botswana are routinely monitored and evaluated (Dudeja *et al.*, 2017). Proper care is taken to ensure proper handling of food, with clear schedules denoting the food handlers who cooked and served what for each day (Lee, *et al.*, 2017).

2.2.6 South Africa national school nutrition programme

The school feeding scheme was introduced in 1940 by the pre-Apartheid United Party-led government, but discontinued in 1957/1958, which was within the Apartheid era except for those children considered, particularly needy (Stephen *et al.*, 2018b). The South African school feeding programme has been in existence since 1994, when the first democratic government was elected, and it is fully funded by the government up to date. More than 8,821,392 school children in the primary and the secondary schools have been covered, annually (Africa, 2019).

One study conducted in South Africa revealed various challenges that are interrelated to SFPs (Sibanyoni *et al.*, 2017). The fact that the feeding programmes has less or no impact on the quality of education provided to the children, stigmatism and social exclusion can affect the children receiving meals at the schools (Hochfeld *et al.*, 2016). It was further unveiled that the distribution of the food provided was biased, stale or there were no variety of foods (Qila and Tyilo, 2016). All these factors mentioned can adversely affect both the psychosocial and the health facet of a child.

2.2.7 Lesotho school feeding programme

There are four main objectives of SFPs in Lesotho, which include:

- (1) Hunger and malnutrition reduction.
- (2) Increase in the school enrolment and attendance as well as decreasing drop-out rates.
- (3) Local food production and the local economy promotion.
- (4) Provision of jobs for communities around the schools (Stephen *et al.*, 2018b).

In all the four objectives, the significance of hygienic preparation of food is not flagged out, whereas the entire oversight can be lethal (Bisholo *et al.*, 2018).

School Feeding Programme (SFPs) has a history in Lesotho (Africa, 2019). It can be traced back to at least 1961, when “Save the Children” United Kingdom (SC-UK) began to provide meals for ten schools in the country’s lowlands. In 1965, the WFP provided meals to primary schools in the highlands, and a year later (1966), after the country’s independence, WFP began sourcing food from abroad for distribution to the schools across the country (FAO, 2019).

The feeding programme covered almost all the primary schools in the country until the 90s, when the government and WFP decided to phase out, the WFP feeding in the lowland and foothill regions and replaced it with the School Self Reliance Projects (SSRP), based on providing the schools with farm inputs in order to encourage them to grow their own supplies for school meals (‘12 things you may not know about WFP’, 2019). The School Feeding Program runs through the entire country with the exception of private schools.

The food menus in Lesotho are invented by the Ministry of Education (Goals, 2015). The fact that the School Feeding Programmes run for a fixed number of days in a year, it often has a pre-determined food basket (Stephen *et al.*, 2018b). In Lesotho, the caterer’s model is used, whereby people are to compete toward the tender. This is the second model, which is usually used in the lowlands of Lesotho.

The total number of government, churches and community primary schools in Lesotho is 1,478; this is exclusive to the private schools. Maseru is having the highest number

of primary schools among all the other districts in Lesotho (Lesotho and Ministry of Education and Training, 2016). There are approximately, 219 primary schools in Maseru, that are covered by SFPS and the programme is only functional in the schools that occur within the Free Primary Education (FPE) system (Bisholo *et al.*, 2018). The schools are widely dispersed across the district, especially those that are within the FPE.

This system of FPE was first introduced in 2000, in Lesotho (Examinatton *et al.*, 2017). The Free Primary Education policy was an initiative to eliminate school fees on an annual incremental basis, beginning with grade one in 2000 and it was completed in 2006, wherein the entire primary education was free from then. The SFPs menu for the whole week is clearly stipulated and the menu is standard throughout the country and all the schools adhered to it. Every school has a SFPs committee, which includes a teacher (as a food manager), the principal and 3 parents.

Presently, there are three models of the School Feeding Programme used in Lesotho. Firstly, is the World Food Programme Feeding model, which operates in the mountains and at the foothills of the country. In this model, the government works jointly with the WFP to facilitate the feeding of the pupils at various schools. People that do the cooking are usually identified from the community and will eventually be rewarded for the job. This feeding programme provides children with sweetened porridge in the morning hours added to pap and bean or peas every single day (Report, 2015).

The second model is called the caterer model and is used in the lowlands. Here, the caterers compete toward the tender to cook for the children at schools. They are rewarded but the compensation is better than that of the WFP model (Lesotho and Ministry of Education and Training, 2016). The menu of this model entails pap and vegetables, bread and soup, pap, vegetable and eggs, samp mixed with beans or peas as well as pap and milk. The food commodities are varied over the 5 school days.

Lastly, the National Management Agent model. This model is still being piloted in all the 10 districts to establish whether, it is the appropriate model to be adopted and, therefore, be used to rule out the first two models (Lesotho and Ministry of Education and Training, 2016). The companies are given a chance to identify individuals that can

be recruited to prepare the meals in various schools. These individuals are to be paid by the pre-nominating companies. The Ministry of Education provides these companies with money to procure food and to pay the caterers (Finance, 2020).

2.3 Lesotho nutritional status

Lesotho is generally food deficient, therefore, addressing hunger is imperative in developing the country (Finance, 2020). For this reason, Lesotho is classified at level 3 of the Integrated Food Security Phase Classification (FAO, 2019). Overall, the rural population remains exposed to situations of chronic food and nutrition insecurity, especially, those heavily dependent on subsistence farming and on other rural non-farm activities. Malnutrition usually originates from overconsumption or hunger, of and our study focused on the latter. Both (overconsumption or hunger) account for nearly half of the death rate of preschool children, worldwide with approximately, 26% of the undernourished children residing in Africa (Costs, 2015).

The human body requires lots of different vitamins and minerals that are crucial for both body development and disease prevention. These vitamins and minerals are not naturally synthesized in our bodies, they are provided by various diets that human consumes (Narwal, 2017). When the body does not absorb or get the required amounts of the micronutrients, it becomes nutrient deficient. 15% of Lesotho households are food insecure (Webb *et al.*, 2018) and many households, likely lack access to diverse diets, year round.

Most of these nutrients needed, can be found in milk, given that milk has long been known as nature's most complete food (Mourad and Bettache, 2019). Milk amongst other food commodities is a nutrient-dense food. Energy, protein together with a range of essential micronutrients (especially calcium, magnesium, potassium, zinc, and phosphorus) are readily provided by milk (Hanna *et al.*, 2019). To supplement some of the nutrients and vitamins in children, who have already started school, milk was chosen to be added in the food basket for SFP ('concept note on the proposed national school milk conference nyali international beach hotel', 2015).

2.3.1 Hunger and its implications

Children who come to school hungry have a greater likelihood of becoming distracted, portray the lack of interest in learning, resulting in failure and diminished attentiveness as well as low academic achievements (Galindo *et al.*, 2018). Evidence indicates that hunger leads to psychosocial dysfunction in children, particularly increasing their levels of aggression and anxiety (Miller *et al.*, 2016). Many countries and development organisations have devoted substantial resources, providing free school meals to the less fortunate children, in both the less-developed and the richer countries ('How School Meals Contribute to the Sustainable Development Goals', 2017).

2.3.2 The impact of feeding programmes in schools

The number of hungry school-age children is unknown, but hunger is likely to be a significant problem in various developing countries (Galindo *et al.*, 2018). Factors that contribute to hunger in school children include: the long-distance children must travel to school, cultural meal practices that embrace no or little breakfast or the lack of family time or the resources to provide adequate meals to children before or during the school day. Alleviating hunger in school children helps them to perform better in school (Mwenwa and Gori, 2019).

Although the school feeding programme has demonstrated potential to improve on nutrition and health, enrolment, attendance, and cognitive development; there are some areas that need to be addressed and further improved. These challenges arise because of the lack of effective monitoring and evaluation (Nyarko, 2019). Close monitoring and evaluation of food handlers and their consequent activities in the school feeding programmes will definitely limit the challenges and improve on the quality of food (Dudeja *et al.*, 2017).

School feeding seeks to reverse the rising vulnerability by helping to break the intergenerational transmission of poverty and vulnerability (Neervoort *et al.*, 2017). The meals are also an opportunity to improve on micronutrient deficiencies hence improve on the quality of life as well as the nutritional status of the children. In order to achieve this goal, from January 2014, WFP started providing school children with a mid-morning snack and a lunch meal (FAO, 2018b).

The Ministry of Education and Training introduced the Free Primary Education in 2000 and committed itself to, among others, the provision of feeding for primary school pupils (Lesotho and Ministry of Education and Training, 2016). This new policy introduced a variety of menus to various schools, especially in the lowlands (Morojele, 2012). Increased community involvement in schools, particularly, where the feeding programmes depend on the community to prepare and serve meals to children are more effective than schools with less community involvement (Ministry of Education and Training Lesotho, 2020).

There is no 'one size fits all' for school feeding programmes; a programme that can work best in one country might dismally fail to function in another country (Hochfeld *et al.*, 2016). Therefore, any other model that seems to perform best for any country can be adopted and tested. School feeding programmes can impact communities by stimulating the demand for schooling (Africa, 2019), particularly in settings where, school attendance is low and where children come from rural, and relatively, low socioeconomic backgrounds (Drake *et al.*, 2016).

Additionally, School Feeding Programme is an integral intervention, verified to have succeeded in addressing some of the nutrition and health problems of school-age children (Kendall *et al.*, 2017). The feeding programme alleviates short term hunger in malnourished or otherwise well-nourished school children, helping them to increase their attention span and produce gains in cognitive function and spatial memory capacity, thus increasing a learner's potential to process and retain academic information (Taylor and Ogbogu, 2016).

2.4 Hygiene practices for raw and pasteurised milk

2.4.1 Plan for safe milk production

Milk quality control involves the utilisation of approved tests to ensure that only the approved practices, standards and regulations concerning the milk and milk products are employed (Tibbo, 2020). The tests are designed to ensure that the milk products meet acceptable set standards and the tests can be either a visual inspection

or a microbiological analysis (Boor *et al.*, 2017). The microbial analysis yields the most accurate results, revealing the true microbial nature of the milk (Bengoa *et al.*, 2019).

Compliance with the good hygiene practices guarantees exclusion of microbiological hazards into the milk (Bisholo *et al.*, 2018). Therefore, there are appropriate measures that should be put in place or undertaken to ensure the production of safe milk. The importance of employing appropriate control measures when handling milk needs no emphasis, hence, it is widely known, but should not be missed (Campbell *et al.*, 2015).

Among the various strategies that can be used to render milk safe, one famous and reliable strategy is called pasteurisation (Lewis, 2017). Pasteurisation is the process of heating milk up and then quickly cooling it down to eliminate certain pathogens and to extend the shelf life of the milk (Westhoff, 2016). The required temperatures for pasteurisation can either be 63 °C for 30 minutes or heating to a higher temperature of 72 °C for 15 minutes. Post pasteurisation is significant to carry out tests to evaluate its effectiveness (Ohkubo *et al.*, 2019).

Milk safety should be taken into account starting on the farm where the milk is produced up to when it is being consumed. Whenever milk is received by the milk manufacturer from different farms, it must pass various tests to qualify for further processing (Knight-Jones *et al.*, 2016). The testing procedures that are performed on raw milk establish whether milk is fresh enough to be further processed and also disclose if it had not been adulterated. Elevated bacterial counts noted for milk denote that hygiene procedures and production practices are in need of improvement; such milk must be condemned (Chaudhry *et al.*, 2018).

The physical tests include embarking on the freezing point of the milk; this is the only reliable parameter to establish whether the milk is not diluted with water (Litwin and Florek, 2018). The freezing point of the unadulterated milk should exist in the range between -0.54 to -0.59 °C. However, if the freezing point occurs closer to 0°C, it indicates that there are very high chances that water might have been added, causing the freezing point of milk to rise. As little as 0.5% of water added to milk can influence the freezing point results (Lewis, 2017). Fresh milk is a little more acidic and must elicit

an average pH of 6.7 (Ortiz-Rivera *et al.*, 2017). The table 2.1 depicts some tests which must be carried out at the dairy plant to determine the milk quality.

Table 2.1: Milk tests that are done on both raw and pasteurised milk to detect milk quality

Names of tests	Purpose
Acidity	Determines the final acceptance or rejection of milk.
Ethanol (alcohol)	Determines the heat stability of milk and pH.
COB (clot on boiling)	Determines the heat stability of milk.
Dye-reduction (MBR or resazurin)	Determines the extent of bacterial contamination and growth of milk
Bactoscan	Measures the individual bacterial cells
Standard plate count (SPC)	Determines the extent of bacterial contamination.
Lactometer	Detects the adulteration of milk with water
Freezing point	Detects the adulteration of milk with water
pH, Fat, SNF, T.S.	Checks the raw milk specification before acceptance
Organoleptic	Determines the freshness of the raw milk
Phosphatase	Determines the effectiveness of pasteurisation
Alizarin	Determines the pH of milk, colour and coagulation

2.5 Aseptic handling of milk

2.5.1 Food handlers

A food handler is defined as a person who directly engages in a food facility and performs any duty that involves the handling, the preparation, the storage or handles surfaces that are likely to come into contact with food in a food facility (Sibanyoni *et al.*, 2017). Food handlers are usually handling food that is to be consumed in exchange for funds or is prepared for many people. The behaviour of food handlers' may have a direct effect on consumers' safety, whenever compliance is strictly followed, the health and safety of humans is guaranteed (Vitale and Schillaci, 2016). This succinctly indicates the reasons for appropriate, and on-going training provision for food handlers (Adane *et al.*, 2018).

Food handlers can contribute to milk contamination and the spread of foodborne infections, whenever their knowledge, behaviour and attitude have not been moulded through an effective and an adequate training (Mawela and van den Berg, 2018). They must therefore be people that are ready to learn and who can depict the knowledge and the skill that they acquired. They should be competent on how to store foods, know the correct way of thawing, which foods are more perishable and they must be able to maximise their performance in general hygiene (Latorres *et al.*, 2016).

Whenever all the processes of food handling, transportation, storage and preparation are performed with particular care to produce safe food; food poisoning can be history in the food production field (Allam *et al.*, 2016). Food handlers suffering from upper respiratory tract infections can easily contaminate their hands with microorganisms by coughing, sneezing, and touching their nose or mouth (Khera, 2017). The food handlers should therefore have adequate knowledge of when to handle food and when not to.

Food handlers must be highly trained on personal, food and environmental hygiene. These entail the correct hand washing techniques, handwashing frequencies, correct procedures in the preparation, cooking, serving of food and cleaning procedures in the food facilities along with the skills to avoid cross contamination as much as possible (Hunt *et al.*, 2018). Hand washing is the primary method for preventing diseases, as it plays the most fundamental aspect in food safety. The five keys to safer food is one of the popular strategies in food handling that can still be proven to work if correctly utilised (Fontannaz-Aujoulat, Frost and Schlundt, 2019).

2.5.2 Milking equipment and vicinity cleanliness

It is very imperative to carefully select the type of equipment to be used in the milk facilities. Some equipment are designed not to harbour bacteria and can be easily cleaned and or be sterilised while still maintaining its texture and made (Tan *et al.*, 2018). This equipment is best suited to avoid cross contamination in a food industry. The stainless steel equipment is durable, does not crack, break or dent easily, it is therefore, most preferred in the milk industry (Hassan and Frank, 2019). These equipment can prevent dirt and bacteria from gathering and building on it, and can

withstand abrasion due to corrosive chemicals in addition, to remain spotlessly clean (Boor *et al.*, 2017).

Food handlers must clean and sanitise work surfaces, utensils, clothes, aprons and hands to avoid the possibility of cross-contamination (Nnebue *et al.*, 2020). The prevalence of bacteria on surfaces can have an adverse effect on human health when adequate and effective cleaning does not take place. Continuous training and education is needed to prevent food-borne diseases and to improve on the knowledge and attitude of the food handlers' in all areas of food preparation and more so, in primary schools (Ngivu, 2016).

Milk jars are to be thoroughly cleaned before and after use to prevent contamination (de la Fuente and Juárez, 2015). A partially cleaned bottle that has been capped for a while, will have a distinctive odor when opened. This characteristic can be used to establish whether the containers are thoroughly cleaned and gives an indication of the freshness of milk. This is called the organo-leptic test (Ziyaina *et al.*, 2017). It is very imperative to have existing guidelines that need to be followed during the cleaning of various equipment. These usually entail all the necessary precautions that are to be taken into account during the process, the type of detergent, the temperature of water, the time and intervals of cleaning should be clearly stated (Nada *et al.*, 2018).

2.5.3 Milk transportation and storage

Milk is the most inexpensive protein available; consequently, it is imperative to ensure its availability at schools for SFPs, but it must be transported, stored, and prepared properly. The type of vehicle used in transporting the milk must be suitable for the purpose, and it must meet all the requirements for transportation (Connor and Goulding, 2018). Whenever, milk is loaded on a truck for distribution, the alizarin test (see table 2.1) must be conducted on the milk sample that is to be loaded. The temperature of the milk must also be taken and recorded at the time of departure and on arrival to the destinations (Hassan and Frank, 2019).

The number and locations to be served, the distance between the depot and the consumers, together with the type of vehicle used, play a crucial role in the safety of

the milk distributed (Connor and Goulding, 2018). The fundamental principle of handling fresh, pasteurised or unpasteurised milk is to maintain the cold chain throughout (Ahmed, 2015). This aspect of risk management begins with the immediate rapid cooling of milk after milking and continue through all the steps of dispensing, transporting and storage (Mukundan *et al.*, 2016).

Moreover, in cases where the milk is transported from the dairy farm to the consumers, the same standards should be maintained (Standards, Safety and Officer, 2015; Chaudhry *et al.*, 2018). No milk should be bought for a large population of people and be transported while the cold chain aspect is not fully complied with Milk should be transported to their destinations at least within 4 hours from the producer (Mukundan *et al.*, 2016)

The processes of preparation, transportation and storage of milk, especially for a large group of people, for instance, case of schools, must be done with adequate knowledge, attitude and skills to ensure food safety (Aliyar *et al.*, 2015). If milk remains at temperatures of 32°C or higher, it will only be fit for consumption for less than an hour. The growth of dangerous bacteria associated with foodborne illness will take place, subsequently (Wochner *et al.*, 2018).

Pasteurised milk requires refrigeration at or below 4.4°C if unopened and can survive for five to seven days when refrigerated below 4°C (Ohkubo *et al.*, 2019). Whenever the temperature is increased beyond 4.4°C, the microbial quality will be affected, leading to increased proliferation. Temperature and time for milk storage have influence on each other (Tiwari *et al.*, 2017).

Milk containers must always be closed and stored away from strong-smelling food items hence milk can pick up several strong odours (Lewis, 2017). Whenever possible, milk should be kept in its original container to safeguard its flavour and nutritional value. It should not be exposed to direct light because light destroys certain vitamins, such as vitamin D and riboflavin. To avoid spoilage, unused milk should not be returned from a serving pitcher to the original container (Vitale and Schillaci, 2016).

It is extremely crucial to bear in mind that raw milk with high microbial numbers will likely lead to finished products that would not meet established shelf-life standards (Shokri and Torabi, 2017). High-quality raw milk that is stored at low temperatures, processed and packaged under good sanitary conditions provides the basis for milk consumer acceptability. Storage areas for milk must be well ventilated, cool and easy to clean for the maintenance of optimum hygiene. Also, the area must be pests and rodent free (Dimond and Kendall, 2017). Milk packaging materials are to be stored under strict hygienic conditions even before use; this prevents them from getting in contact with any form of contaminants that can harm human life (Wochner *et al.*, 2018).

The quality of milk can be affected by packaging at all costs; it is therefore stipulated that packaging is a major factor contributing to the quality and the safety of the milk (André *et al.*, 2017). The used packaging materials can also compromise the quality and the safety of the milk. They can expose the milk to microorganisms, inappropriate temperature, light, oxygen and permeability, which may result in lowered shelf-life (Ziyaina *et al.*, 2017). Proper storage of the packaging material should also be taken into consideration to achieve optimum results in avoiding milk contamination by all means (Hassan and Frank, 2019).

2.6 Mitigating the challenges involve in milk production

Procedures for maintaining food safety and food quality must be taught and managed to yield best results in the provision healthy food (Centre, 2017). Food safety entails the essence of ensuring that the product is safe for human consumption, while food quality meets the required specifications and design in the food production (Merwan *et al.*, 2018). These two aspects are salient and of mutual worth. The importance of supplying safe food to school children and a safe working environment for employees must be monitored by means of well established procedures (Navarro, 2020).

Every school feeding programme must have its own approach to hygienic preparation of food such as routine refresher courses and trainings for the newly recruited, with monitoring and evaluation tools to assess the areas that will need improvement (Africa and Africa, 2017). There are various fundamental procedures that must be followed in every food industry. They include Standard Operation Procedures (SOPs), Good

Manufacturer's Practices (GMPs) and Hazard Analysis and Critical Control Points (HACCP) (Campbell *et al.*, 2015).

2.6.1 Standard operation procedures

The standard operating procedures are a set of step-by-step instructions, created in any business to help workers carry out routine operations. The purpose is to achieve efficiency, quality output and uniformity of performance, while reducing miscommunication and failure to comply with the regulations of the industry (Ashbrook, 2017). These standards should be available for any company that needs to yield quality products. SOPs is a document which describes the regularly recurring operations relevant to the quality of the activity being performed. Its purpose is to carry out the operation, correctly and always in the same manner (Houck *et al.*, 2019)

The SOPs should be available at the place where the work is done. This document is a compulsory instruction, which does not give room for negotiations but only leads to carrying out activities as outlined (Marchand *et al.*, 2018). Every employee in the milk parlour must adhere to the SOPs without any resistance, hence the lack of compliance after training must lead to immediate disciplinary hearing which might be tantamount to total dismissal (Lee *et al.*, 2017). Checklists for SOPs cut across personal hygiene, preparation, cooking, cleaning and serving to facilitate monitoring and evaluation (Campbell *et al.*, 2015).

2.6.2 Good manufacturer's practices

Good Manufacturer's Practices include processes and facilities that must be in place before the HACCP program can be implemented (Pascal, 2021). GMPs focus on aspects, including the design of facilities that must be appropriate for the type of operation. In the milk parlour, both the GMPs and the HACCP should be complied with, equipment maintenance, sanitation and transportation that must be kept of an uncompromised quality (Fonseca *et al.*, 2019). Food may be contaminated by naturally occurring microorganisms or pathogens transferred to food during harvest, slaughter or a food preparation step; while everything that could be done to avoid food exposure is done (Vitale and Schillaci, 2016).

The layout of the food premises can also contribute to compromising food safety and quality. It must be ensured that the layout of a kitchen is conducive to a GMP's plan, it allows a continuous flow of product without any crossovers between clean and dirty processes. These should be the case even when preparing school meals (Fischer *et al.*, 2021)). Food processing designs and the food handling processes must be in such a way that the hygienic flow of food is adequate and uninterrupted (Nnebue *et al.*, 2020). The raw food area must be kept totally separate from the area reserved for food preparation to prevent cross contamination (Ngwa, 2017).

Food premises and equipment that are not kept in good repair and condition are a potential source of microbiological and physical contamination of food. Furthermore, dilapidated premises and equipment cannot be cleaned effectively (Nada *et al.*, 2018). Poor maintenance may allow the entry of other sources of physical, microbiological, and chemical contaminants such as water, pests, and dust. Poor maintenance can have adverse health and safety implications for the workers (Nnebue *et al.*, 2020). Procedures are needed to minimize the risk of hazards causing illnesses to the consumers.

Establishing that the building meets set building standards will promote the safe handling of food. Floors, walls and drains should be easy to clean (Pricope-Ciolacu *et al.*, 2019). Floors must be waterproof, and non-absorbent without crevices or cracks as they can harbour pests, which would be the best vehicle for the transmission of pathogenic microorganisms (Trematerra and Fleurat-Lessard, 2019). Surfaces should be smooth, impervious, non-toxic, non-absorbent, and resistant to damage by cleaning agents. Equipment must be in a good working condition (de la Fuente and Juárez, 2015).

One latrine and one hand basin must be available for every ten staff members (Stephen *et al.*, 2018b). Hand washing facilities shall be provided with cold and or hot water for the washing of hands by the workers on the food premises together with a supply of soap, and hand drying material or equipment. A hand towel is not acceptable rather a roll of disposable paper towels (Adane *et al.*, 2018)

Waste management problems can result in severe foodborne outbreaks at schools, therefore, waste must be collected and disposed safely so that it would not attract any form of rodents and pests (Rada *et al.*, 2016). The refuse containers must be liquid proof, easy to clean with close-fitting lids suitable for the hygienic storage or refuse removal from the food handling area (Merwan *et al.*, 2018). The storage space, or facilities and equipment for the hygienic storage of food and a suitable separate area for the hygienic storage of refuse containers on the food premises must be made available (Hamilton Ekeke *et al.*, 2017).

Proper waste management is an integral part of producing food that is safe (Sareen, 2019). The room in which food is handled must not have a direct connection with any area in which gas, fumes, offensive odours or any other impurity is present or may arise in such a manner that food in the food-handling room could be contaminated or spoiled (Hart, 2018).

2.6.3 Hazard Analysis and Critical Control Points

The implementation of Hazard Analysis and Critical Control Points in the food industry is a very fundamental tool, if it can be well understood by the food handlers and be practiced, sufficiently (Khalid, 2015). HACCP is a science-based food system, whereby potential hazards are identified, critical limits are established and subsequent actions are taken to prevent or correct these hazards (Fonseca *et al.*, 2019; Standards, *et al.*, 2015). This programme is a scientific and systematic approach to identify hazards and employ correct control measures to ensure the safety of food (Radford *et al.*, 2019).

The implementation of HACCP will have to take place within the existing constraints of the organisation with regard to time and resources (Krishnakumar, 2012). The implementation process is approached by breaking it down into a number of key tasks for management. All personnel must have an understanding of the HACCP concept and how it affects the particular working environment (Singh *et al.*, 2018). Compliance to GMP will mean that personnel must understand how their commitment is important for overall food safety management (Principles, 2018; Sareen, 2019). To reduce costs and to internalise the process, it is important to capacitate the trainer to educate other

personnels. Food handlers must be trained to create an awareness of their role within the food safety management programme (McElhatton and Sobral, 2021).

The HACCP program monitors the hygiene and safety practices in food production from raw materials through processing to end products and serving based on controlling time and temperature, which are factors that when mismanaged are known to contribute to food borne disease outbreaks (Khalid, 2015). The effect of temperature and time must be considered throughout the programme. Microorganisms normally observe changes whenever the temperature chain and time are not closely monitored (Fonseca *et al.*, 2019).

2.7 Possible milk contaminants

Milk is dominant in most people's diet across the globe and is of greatest concern since it contains a natural microbial flora (Hassan and Frank, 2019). The origin of contamination by pathogenic bacteria varies depending on the state of milk, the mode of production and the processing involved (Zribi *et al.*, 2021). Contamination of fresh milk by pathogenic microorganisms can be of endogenous origin, following excretion from the udder of an infected animal. It may also be of exogenous origin through direct contact with infected food handler or through contaminated environment (de la Fuente and Juárez, 2015). Proper treatment and processing of milk can inhibit the proliferation of microorganisms (FAO, 2018a).

Milk should be received and stored in a cool environment, and it must be served within or less than 4 hours of its arrival at the school (Orwa *et al.*, 2017). The milk containers should be properly covered so that no foreign matter will be introduced to the milk (Fischer *et al.*, 2021). On the other hand, poor hygiene during handling of milk and undesirable practices, including adding of water and other substances can introduce the bacteria that will cause the milk to spoil (Vidal *et al.*, 2017).

2.8 Microbial variation in milk

Milk is extremely susceptible to microbial spoilage due to its nature of high moisture because of its high water activity, which is a fundamental need that allows a very broad spectrum of microorganisms to grow in foods (Vitale and Schillaci, 2016).

Clearly, cow's milk consists of a variety of nutrients such as fats, proteins, minerals, vitamins, carbohydrates and water (Hanna *et al.*, 2019). Bacteria can be introduced to milk from a wide variety of sources, including workers, the infected cows' udder, faeces and dust in barns, milk containers or other equipment. Some microbes can serve as disease causing agents when present in milk (FAO, 2018a).

The microbiological quality of milk and milk products not only affects shelf life but it also affects the health and safety of the consumers (Lu and Wang, 2016). The types and number of microorganisms occurring in milk are equally imperative hence they facilitate the determination of the microbial quality of milk (André *et al.*, 2017). The presence of a specific group of microorganisms in milk is closely associated with the subsequent spoilage and possible foodborne infections (Yoon *et al.*, 2016). Certain psychrotrophs produce lipolytic and proteolytic enzymes (Ziyaina *et al.*, 2017).

Milk can be contaminated by a wide range of bacteria, e.g. *Mycobacterium bovis*, *Brucella species*, *Streptococci*, *Coxiella burnetti* from infected cattle (Knight-Jones *et al.*, 2016). Bacterial agents from human sources such as *Salmonella species*, *Shigella species*, *Corynebacterium diphtheriae* and *Streptococcus species* can also be presented in milk, originating from improper handling of milk (Boor *et al.*, 2017). The presence of these microorganisms in pasteurised milk indicates poor sanitation. Psychrotrophic microorganisms are the most important group of microbes present in milk and dairy products (Garedew *et al.*, 2019).

2.9 Microorganisms of concern in milk

Whenever bacteria are present in milk and milk products they may cause diseases or spoilage; these microbes do not include the bacteria that are deliberately added to milk and other dairy products as live cultures or probiotics (Thakur *et al.*, 2018). The human illnesses acquired from milk borne pathogens are usually associated with the consumption of raw milk or products made from unpasteurised milk (Martin *et al.*, 2016). This does not rule out the possibility of recontamination of milk and its products after pasteurisation, as well as with other environmental factors that may expose the milk that had been prepared safely (Ziyaina *et al.*, 2017).

Bacteria have various effects on milk and humans have to bear the repercussions. Hence contamination with such microorganisms cannot be seen with naked eyes; only heavy infestation with yeast and mould may be visible (Vitale and Schillaci, 2016). Lactic acid bacteria produce a sour flavour and smell, proteolytic bacteria cause bitterness and putrefaction; in addition, lipolytic bacteria produce rancidity, gas producing microorganisms can further cause gassy milk, ropy bacteria cause chewy milk and above all, sweet curdling bacteria can coagulate milk (Melin *et al.*, 2019).

Some yeast and mould foodborne illnesses may also be lethal to human health due to their ability to produce mycotoxins, which are stable compounds that cannot be easily destroyed (Maiworé *et al.*, 2019). Some microorganisms that have been frequently implicated in foodborne outbreak include *Listeria monocytogenes*, Coliforms, *Yersinia enterocolitica*, *Escherichia coli* 0157:H7, *Mycobacterium bovis*, *Mycobacterium paratuberculosis*, *Brucella* species, psychrotrophic bacteria, *Campylobacter jejuni*, *Salmonella spp.*, *Coxiella burnetti* in addition to yeast and mould (Hoffmann *et al.*, 2022). Only a few microorganisms are discussed in this chapter, which is guided by the interest or objective of our study.

Certain microorganisms produce chemical changes that are desirable in the production of dairy products such as cheese, yogurt, sour milk etc. These are desirable microorganisms that maybe deliberately introduced to the milk (de Vegt, 2015). High numbers of bacteria in milk while not controlled can cause spoilage of the product even if the bacteria are desirable, therefore, the control of microorganisms is very crucial (Khera, 2017).

The microbial content of milk can be used to evaluate its level of sanitary content through all the levels of milk handling (Wochner *et al.*, 2018). Lastly, the presence of pathogenic microorganisms in milk may result in foodborne illnesses therefore, control measures must be made to minimise the possibilities of pathogenic microorganisms gaining entry into the milk (Bisholo *et al.*, 2018).

Table 2.2: The microorganism that can be found in milk and their effects

Organisms	Diseases	Symptoms	Sources	Reference
<i>Listeria monocytogenes</i>	Listeriosis	Flu-like symptoms, still births, spontaneous abortion, foetal death, and miscarriage	Soil, environment and water	(Lee <i>et al.</i> ,2019)
<i>Escherichia coli</i>	Gastroenteritis	Bloody diarrhoea, abdominal pain, kidney failure and possibly death	Faeces and intestinal tract.	(Ariyanti <i>et al.</i> ,2022)
<i>Staphylococcus aureus</i>	Gastrointestinal illness	Vomiting, nausea, stomach cramps and diarrhoea	Nose, skin and respiratory tract.	(Gebremedhin <i>et al.</i> ,)
Coliforms	Gastroenteritis	Flu-like symptoms, fever, abdominal cramps, and diarrhoea	Faeces and intestinal tract.	(Sharma, 2022)
<i>Bacillus cereus</i>	Gastrointestinal illness	Abdominal pain, occasionally nausea, vomiting and malaise (sometimes followed by watery diarrhoea)	Environment	(Tirloni <i>et al.</i> ,2022)
Yeast and mould	Candida allergies and	Candidiasis, thrush, sneezing, itchy eyes, runny or stuffy nose	Environment.	Beniamino <i>et al.</i> ,2021
Enterococci	Endocarditis, urinary tract infections, etc.	Fatigue, flue-like symptoms, shortness of breath, lower abdomen discomfort, frequent, painful urination, blood in urine	Environment.	(Terzić-Vidojević <i>et al.</i> ,2021)

2.9.1 *Staphylococcus* spp. in milk

Staphylococci are gram-positive, round shaped bacteria and can become one of the normal flora of the human body (Knight-Jones *et al.*, 2016). Are usually found in the environment (soil, water and air) and is also found on the skin, in the nose and the respiratory tract of humans (Abuseliabi *et al.*, 2017). The bacteria can produce toxins responsible for food poisoning; depending on the strain, the bacterium is also capable of secreting several exotoxins (Valihrach *et al.*, 2019). These are toxins that the bacteria secrete outside its surrounding cells. The toxins are highly potent and can damage the host.

When food are not refrigerated and left for longer than 2 hours, *Staphylococcus* spp. replicates (Hunt *et al.*, 2018). *Staphylococcus* spp. survives well at the optimum temperature of 37°C. It is resistant to freezing and endures in foods stored below -20°C. However, the availability of these organisms can be reduced at a temperature range from -10°C to 0°C. *Staphylococcus* spp. can be destroyed through cooking and pasteurisation (Yaniarti *et al.*, 2017).

2.9.2 Faecal coliform bacteria

Coliform bacteria are a group of bacteria found in the environment and are known as indicator organisms, hence their presence in foods or water denotes that there had been some contamination (Boehm and Sassoubre, 2019). Faecal coliform bacteria are a broad class of bacteria found in the environment, including in the intestinal tract and on the skin of man and other warm-blooded animals (Payus and Nandini, 2018). Coliforms have three main groups, namely, Total coliforms, Faecal coliform and *Escherichia coli*. This study was focused on the latter two classes only.

Faecal coliform bacteria are facultative anaerobes with an optimum growth at 37°C. They are quite a large group of bacteria (Seo *et al.*, 2019). They are indicator organisms eliciting possible faecal contamination and potential health risk. They are closely associated with the presence of pathogens but not necessarily pathogenic themselves (Martin *et al.*, 2016). They also can cause rapid spoilage of milk because they are able to ferment lactose with the production of acid and gas, as well as able to degrade milk proteins (Rizani, 2018).

They can be destroyed by pasteurisation, therefore, their presence after treatment is indicative of contamination (Abusheliabi *et al.*, 2017). *Escherichia coli* is an example belonging to this group. Pasteurised milk should have no coliforms (McCollum *et al.*, 2019). Faecal coliform bacteria can be present in milk but their numbers can be minimised by good sanitation. Also, coliform bacteria compete poorly with lactic acid bacteria, so their numbers rapidly decrease in the presence of a rapidly growing lactic acid culture (Tan *et al.*, 2018).

2.9.3 *Escherichia coli*

This is a strain from a large family of bacteria as it is considered to be amongst the faecal coliforms, hence their presence in milk is undesirable (Makvana and Krilov, 2015). *Escherichia coli* is a rod-shaped, anaerobic gram-negative bacterium, found in many areas, but most importantly, in environments contaminated with faecal matter, including water, sediment and mud. Furthermore, it can be found in the gastrointestinal tract of man and warm blooded animals (Cho *et al.*, 2018).

Escherichia coli can be destroyed by pasteurization. Its occurrence in pasteurised milk presents high chances of recontamination (Dalmas *et al.*, 2015). The prevalence of *E.coli* has been reported for bulk tank pasteurised milk samples in South Dakota, where 15 % of 46 tested samples were positive (Kabiru *et al.*, 2015). *E. coli* can cause bacteremia, travelers' diarrhoea, urinary tract infections and many more.

2.9.4 *Listeria monocytogenes*

Listeria monocytogenes is a rod-shaped, Gram-positive bacterium that occurs in short chains. The bacterium can be resistant to freezing, drying and heat (Coelho *et al.*, 2019). The organisms found in the environment, specifically in raw foods such as unpasteurised milk, raw vegetables and poultry. Its presence in processed milk usually occur through cross contamination because the bacterium can be destroyed by pasteurisation (Tahoun *et al.*, 2017). This organism can cause mild to fatal infections such as symptoms of abortion, neonatal death, septicaemia, and meningitis. The entry of the organism into the food, especially that is going to be eaten without preheating, should be prohibited at all costs (Tahoun *et al.*, 2017).

2.9.5 *Bacillus cereus*

Bacillus cereus is an aerobic, Gram-positive, rod-shaped organism that produce toxins (Pal and Hundera, 2020). It has the ability to form spores, when environmental conditions are not suitable and these spores are more resistant to environmental stress, including harsh environments during normal cooking temperatures (Tewari and Abdullah, 2019). The organism can be found in the soil, especially, where there is also vegetation growth.

Bacillus cereus is a common contaminant of many food ingredients and can cause spoilage of a variety of processed food products, resulting in gastrointestinal infections (Glasset *et al.*, 2016). The level of contamination with these organisms may be controlled by a low initial spore count, cooling after pasteurisation and limiting the storage time (Salem *et al.*, 2018). Both the storage time and the storage temperature are largely under the control of the consumer (Tirloni *et al.*, 2017).

2.9.6 Yeast and mould in milk

Mould is a type of fungus that grows in multicellular filaments, while yeast is a type of fungus that grows as a single cell (Pal, 2019). The tubular branches of moulds have multiple, genetically identical nuclei, which form a single organism called a colony (Lavoie *et al.*, 2021). The ability of these organisms to attack many foods is due in part to their relatively versatile environmental requirements and are therefore important in food production. Both yeast and mould have positive and negative effects on food; their introduction in food is deliberate for the positive impact (Garnier *et al.*, 2017). On the contrary, yeasts can cause diseases like ringworm, *Candida* infections etc.

Yeast and mould can cause various degrees of decomposition and deterioration of foods. They can invade and grow on virtually any type of food at any time (Büchl and Seiler, 2018). Growth of yeasts is mostly undesirable in milk and dairy products, because these microorganisms harbour a high risk of spoilage (Garnier *et al.*, 2017). Yeasts grow in a broad range of environments, precisely, in dairy products due to their low pH. Therefore, cause spoilage, however, various species of yeast occur at neutral pH (Naranjo-Ortiz and Gabaldón, 2019). Yeasts are introduced to the milk as

contaminations during the milking process or as recontaminations after the heat treatment (Gelli and Espejo, 2017).

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CHAPTER 3

Assessment of the predominance microorganisms in milk served to children through School Feeding Program

3.1 Introduction

Milk is significant to children since it is a very important source of protein. It boosts calcium and vitamin D levels, which are supplements that help to promote bone health, treat calcium deficiency and protect against osteoporosis. Milk also boosts cognitive performance while improving on the general nutrition and promoting brain growth. The benefits of milk consumption for bones and teeth may be well known, while missing the current evidence that increased calcium intake protects people from a variety of dangerous medical conditions, including hypertension, colon cancer, breast cancer, ovarian cancer, kidney stones, insulin resistance syndrome, obesity and lead poisoning.

Milk quality can largely be affected by the hygiene practices around the milking, storage, transportation and preparation processes (Tahoun *et al.*, 2017). Personal hygiene plays the most integral part in the control of milk contamination and food poisoning together with the handling and storage of milk following the milking process. Transporting milk while the cold chain is broken is another factor which can affect the quality of milk whether the milk is contaminated or not (Lurdes *et al.*, 2021). Furthermore, sick cows increase the chances of having pathogenic microorganisms being secreted into the milk during the milking process (Garnier *et al.*, 2017).

Milk is the most inexpensive protein. For any food commodity that is offered to children, they consume it without questioning the quality of such food (Hettiarachi, 2017). At this early age, their food safety knowledge is very limited, and they can still be easily deceived even if a crash course on food hygiene and safety can be offered to them Herber *et al.*, 2020). Many a times milk can harbour pathogenic microorganisms and still taste, smell and appear normal. The major problem usually occurs once milk is consumed and the microorganisms start to proliferate, resulting in disease manifestations (Wochner *et al.*, 2018).

Milk quality refers to the standard of milk measured against the recognised requirements used to promote safe healthy practices in the production of milk (Zribi *et al.*, 2021). The quality control system for milk should be used particularly, during the transportation and the storage of milk, and not only during production (Knight-Jones *et al.*, 2016). Within the context of food and particularly milk, there is a relationship between the proliferation of microorganisms, the increase or decrease in temperature and the distance travelled with milk, especially, if the cold chain is not maintained (Banibrata and Rakhi, 2018). These aforementioned factors are to be exhaustively discussed and analysed in this chapter.

Temperature control is the fundamental factor in milk production that must be maintained during all the processes; all the way through the distribution chain till the consumption phase (Tirloni *et al.*, 2017). This simply stipulates that when high temperature is required for pasteurisation, it should be optimum and available to meet the desired procedure, same follows thereafter. The transportation and storage of milk must be done at the appropriate temperatures (de Oliveira *et al.*, 2015).

In many countries of the world, the dairy industry is one of the most important food sectors and it had been very successful in providing safe products (de la Fuente and Juárez, 2015). Nevertheless, the dairy sector, like other food sectors, also has its challenges, relating to the movement of the milk from the farm to the point of consumption, in that the dairy products can become contaminated with a broad range of microbial and chemical particles (Boor *et al.*, 2017). The sources of contamination are multiple, and the pathways are complex.

Contamination of milk can occur directly by dairy animals shedding pathogens into the milk, or indirectly, whereby contamination of the milk occurs during the milking process, collection and transportation (Martin *et al.*, 2016). Infected animals or asymptomatic carriers can shed bacterial pathogens in the faeces that will eventually contaminate the milk through the environment. Other sources of environmental contamination include water, pests, soil, pets and contaminated feed. Infected farmers with poor personal hygiene are also a potential source of contamination of milk (Lemma *et al.*, 2018).

During milking, collection and transportation, milk can be subjected to further contamination by the equipment and or be subjected to time-temperature effect, creating optimum conditions for microbial growth (Hettiarachi *et al.*, 2017). Hence, ensuring the safety of milk and dairy products starts on the farm with animal health, quality of feed, a hygienic environment and, in general, good animal husbandry. Nonetheless, pasteurisation of milk is necessary to kill any surviving organisms or reducing the organisms to threshold levels not harmful upon human ingestion thereby, reducing the risk of illness (Gopal *et al.*, 2018).

This chapter aimed to assess the microbial content of milk supplied to children by monitoring Total viable counts, and the presence of *Listeria spp.*, yeast and mould, *Enterococcus*, total coliforms and *E. coli*, *Lactobacillus* and *Staphylococcus* species.

3.2 Materials and methods

3.2.1 Research design

In the cross-sectional phase of this study, both qualitative and quantitative designs were carried out under which questionnaires were administered to gather pertinent data from the respondents. The questionnaires were self-prepared by the researcher and translated by a qualified linguisticians into the local language. The linguisticians were engaged to ensure that the meaning of what was to be investigated using the questionnaires will not be lost, while the questionnaire was to be translated to accommodate even those food handlers which could not understand English.

The primary schools were the source for the data and sample collection needed. The choice of schools participating in the study was based on convenience during sampling. The milk samples and data collection were obtained in two batches; the first, in March and then April, during which the maximum atmospheric temperatures in Maseru were 28°C on the 15th of March and 23°C on the 12th of April, respectively.

In addition, seven data collectors were deployed and orientated on the procedures of milk sample collection, administration of questionnaires, measurements of temperature added to the recording and the completing of the observational tool which was printed in the English language. The thermometer that was used to take the first sample temperature was to be reused in taking the second reading. The actual practices and behaviour of the food handlers were taken into consideration alongside the conditions of the kitchens and the storerooms. The information was recorded appropriately, in order to ensure clarity.

3.2.2 Sampling Protocol

The primary schools were selected based on their proximity to the dairy, which was the sole source of sample collection. Seven data collectors were orientated prior to sample collection to assist with sample collection as the schools were not in proximity for the activity to be done by one person. A pilot study was conducted to test the research protocols and competence in data collection techniques. Subsequently, a laboratory dry run of the targeted sampling procedure was equally performed. All the samples were collected aseptically to ensure that no contamination occurred. Samples

were collected in two intervals, at the end of the summer and at the beginning of the winter seasons.

In addition, a total of seventeen (17) samples was collected; the first sample was collected at the dairy and the temperature of the milk was recorded, and other samples were collected from each school. Accordingly, the second temperature measurement was taken on arrival at the schools and the second temperature was taken when the children were ready to have their lunch, then a milk sample was taken at each school prior to serving. Distance travelled from the dairy to each school was also noted.

All the 16 schools were represented using alphabets to maintain confidentiality. They were denoted as; A, B, C D, E, F, G, H, I, J, K, L, M, N, P and Q, while the letter O was used to represent the dairy. O1 represented the first sample from the dairy and O2 corresponded to the sample obtained from the dairy in the second batch. The labelling of the samples was consistent throughout the whole study. After collection, the samples were transported to the lab on ice to maintain the cold chain, until further analysis took place.

3.2.3 Ethical Considerations

The researcher acquired a consent from the dairy management to conduct the study on their produce. The schools and food handlers that took part in the study willingly agreed to participate. The ethical approval was acquired from Research Department (Ministry of Health) to conduct the study.

3.2.4 Microbial Analysis

The microbial analysis of the milk samples was conducted via serial dilution (Louis & Chester, 2020). While observing aseptic conditions, each milk sample was thoroughly mixed by shaking and 1 ml of milk was transferred into sterile bottles containing 9 ml of phosphate buffered saline (PBS), using a sterile pipette (Chemlab, South Africa). The content in each sterile bottle was ten (10) fold serially diluted to include dilutions ranging from 10^{-1} to 10^{-3} . This was guided by the findings of a trial-run that was performed with the milk from the dairy plant before the actual sampling could be done. Dilutions were plated on different rich and selective different media.

All the media used were prepared aseptically according to the manufactures' instructions. The media were poured into sterile petri dishes (Chemlab, South Africa), which were allowed to cool and solidify. Several rich and selective media were used for enumeration. Plate Count Agar (PCA) is growth medium universally used to assess total bacterial and not considered selective (Ltd., 2018). Brilliance Listeria Agar (BLA) was used for enumeration, isolation and presumptive identification of *Listeria* species (Agar, 2017). Rose Bengal Chloramphenicol Agar (RBC) is selective for the enumeration of yeast and mould. The chloramphenicol in the agar is used as a selective agent to inhibit the growth of bacteria (Mentese *et al.*, 2016). Slanetz Bartley Agar Base (SBA) is a selective medium used with supplement for the enumeration, detection and selective colony count of intestinal *Enterococci spp.* in drinking water and other samples (Slanetz, 2015). Harlequin E. coli/Coliform Agar (HCM) was used to simultaneously enumerate *Escherichia coli* and coliforms. This medium makes it easy to distinguish different colony type in one plate, it even allows the identification of other colonies rather than the mentioned coliforms (Lee and Wolfman, 2020). De Man Rogosa and Sharpe Agar (MRS) is an selective medium that provides colony counts and a characteristic colony size for *Lactobacilli spp.* and for other mesophilic lactic acid bacteria (Merck KGaA, 2019). Baird Parker Agar (BPA) allowed for the is a selective isolation and enumeration of *Staphylococcus* species (Laboratorios Britania S.A.).

Streak plating using hockey stick was performed using 1 ml of raw milk on all the 7 media agar, the spread of the raw milk was made using sterile hockey sticks (Biolab Diagnostics, South Africa). Each milk sample was analysed in triplicate. PCA plates were incubated at 37°C for 72 hours, BLA and HCM plates were incubated at 37°C for 24 hours, SBA and BPA plates were incubated at 37°C for 48 hours as well as RBC and MRS plates were incubated at 30°C for 48 hours and 72 hours, respectively. After incubation, the colonies were counted from each plate both manually and with the use of a Scan® 1200 Automatic HD colony counter (interscience, France) and recorded on respective tables as colony forming units per millilitres (CFU ml⁻¹).

3.2.5 Data analysis

Microbial enumeration data was captured in Microsoft Excel and presented as composite figures. Descriptive statistics and Persons Correlation Coefficient was calculated using the SPSS statistical package (version 26, 2019).

3.3 Results and discussions

3.3.1 Influence of distance travelled and temperature on the milk

Temperature variances can be pivotal in allowing microorganisms present in a milk sample to proliferate (Navarro, 2020). Milk samples were taken from one source (dairy) and were delivered to 16 different primary schools, which are of varying distances from the dairy in question. The pasteurised milk was transported while the cold chain was not maintained. This action is one of the reasons that aroused and propelled investigation into the microbial quality of the milk. The samples were taken during two seasons: at the end of the summer and the beginning of winter seasons. Temperature, among others is one of the most important environmental factors affecting microbial growth and activity in food, water and soil; if temperature increases in the environment, it positively contributes towards a rapid proliferation of microorganisms and a decrease halts microbial growth. According to Kriztberg and Bååth (2022) and Messing (2015), seasonal temperature fluctuations affect proliferation with increase or decrease with moisture content of the food giving positive effects, furthermore if the water is of a lake can also have more proliferation than that from a portable source hence the nutrient concentrations are plenty in the lake water yielding prompt bacterial growth (Schostag *et al.*, 2015) indicates that summer season even have an increased rate of food poisoning cases due the faster bacterial growth. The sample taking in summer and in beginning of winter was to infer on the impact of temperature variations. Summer sampling (first sampling event) entailed school A to H while winter included samples (second sampling event) from I to Q exclusive of the letter O, which denotes the dairy.

The distance travelled from the dairy to the various schools differed greatly as these schools were markedly apart, it ranged from 5.9 km to 78.7 km. The temperature of the milk was measured at the dairy after collection before being transported (3.8°C). The milk was transported in 25 L sealed plastic bags using a bakkie which was not

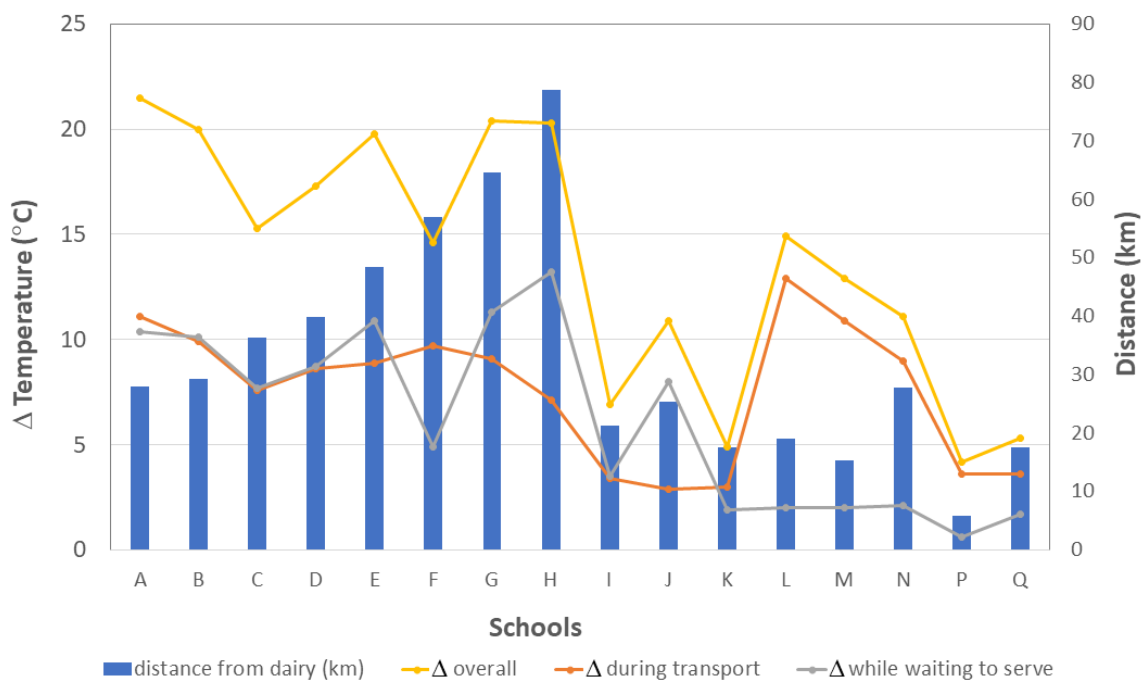


Figure 3.1: Comparison of distance and temperature variance during transportation, storage before serving and overall in milk sampled at all the schools

provided with the necessary conditions to maintain the temperature of the milk. The milk was transported from the dairy at 6:00 am and upon arrival at

the various schools, was kept unrefrigerated until lunch time. It should be noted that lunch occurred at different times in all these schools (5-6 hours after milk delivery). The results revealed that the temperature variance was fairly broad (Fig. 3.1).

The change in temperature during transportation did not differ for the two sampling events. During the first sampling event (end of summer season) the highest temperatures variation was 11.1°C and the most remote school was 78.9 km away from the dairy. During the second sampling event (beginning of winter season) the highest temperature difference was 12.9°C and the longest distance travelled was 27.8 km. The highest temperature of the milk was 17°C on arrival at school L. The milk was not refrigerated in any of the 16 schools; it was kept either in the plastic bucket or wheelbarrow while waiting for the pupils to go out for lunch. Temperature measurements were also taken before the milk was served and the highest noted

temperature was 25.3°C at school A. Fig. 3.2A illustrates the changes in milk temperature during transportation, storage before serving and the overall change.

Although it is tempting to assume that there is a correlation between distance travelled and temperature increase, fluctuation during storage may be more influential in temperature change than transportation. Pearson correlation coefficient was used to determine if there is any association between the change in temperature and distance travelled from the dairy. Only a weak correlation (R value = 0.2677) was established and the scatterplot (Fig. 3.2B) and p -value of 0.3162 illustrated no significance (Edwards *et al.*, 2017; Schober & Schwarte, 2018).

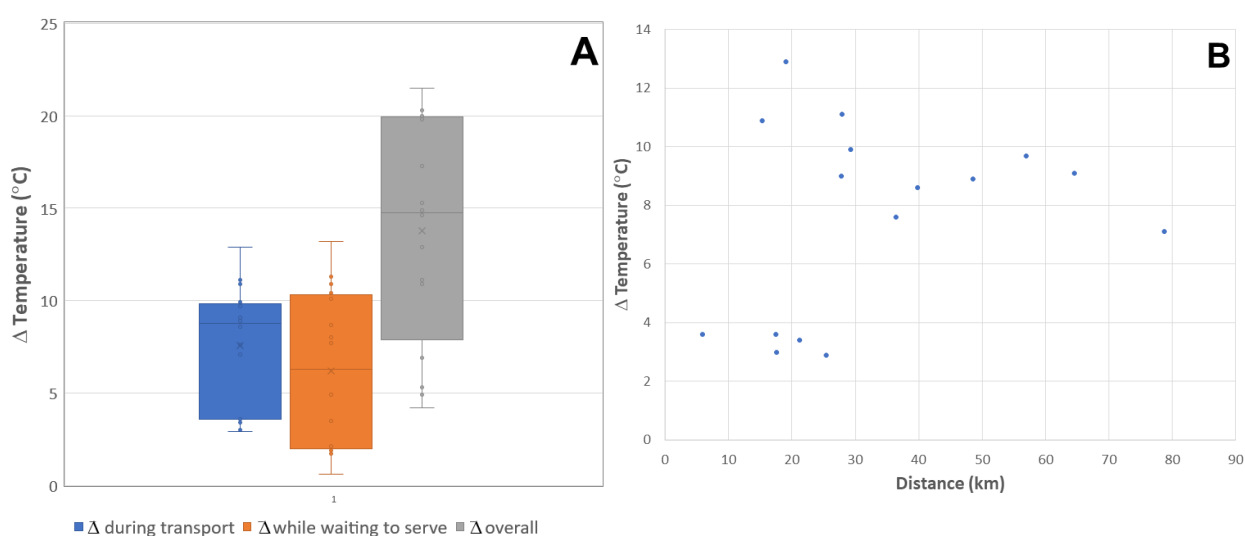


Figure 3.2: (A) Illustrates changes in temperature during transportation (blue), storage before serving the milk to children (orange) and overall temperature changes (grey). (B) Scatterplot displaying the strength, direction, and form of the relationship between distance and change in temperature (weak Pearson correlation coefficient $R=0.2677$).

Mesophilic bacteria indicate quality and hygiene parameter of raw and pasteurised milk, of which the high number of these microorganisms revealed the poor conditions in production, storage, and processing of the milk, and also the possible presence of pathogens (Navarro, 2020). Even though the dairy stated that the milk was pasteurised, various microorganisms were detected in the milk dispatched to schools from the dairy (Fig. 3.3). Especially the milk provided during the second sampling event (O2) that also contained *Enterococci spp.* which the milk from the first sampling event did not (O1). This high microbial load coupled with the lack of cold chain

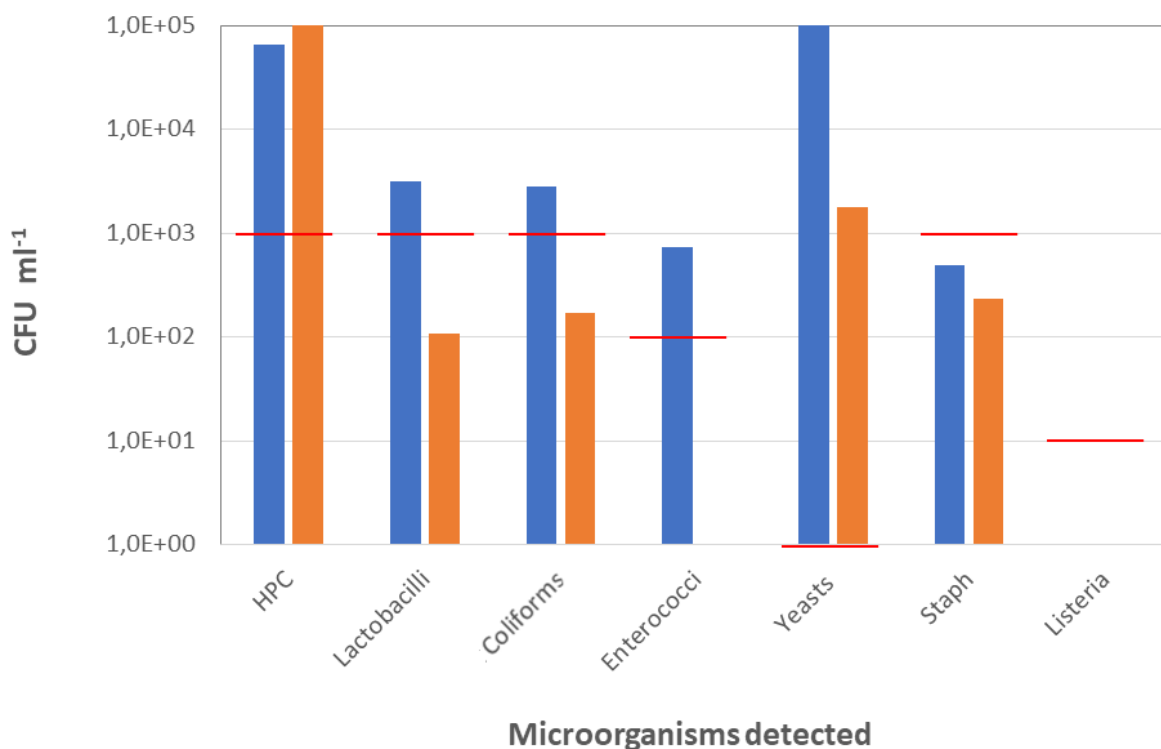


Figure 3.3: Microbial composition of the milk collected from the dairy during the first sampling event (O1 – orange) and the second sampling event (O2 – blue). The red lines indicate allowed limits for pasteurised milk.

management during delivery to schools is a problematic combination when milk hygiene is considered.

3.3.1 Total plate count analysis

The plate count agar provided a general indication of the number of microorganisms in the sample, thereby revealing the hygienic status of the milk (Ltd, 2018). All the samples were positive for microbial growth with large numbers of colonies, yielding a hundred percent (100%), occurrence/prevalence rate. The samples from the dairy during both sample collection periods showed growth of colonies on the plate count agar as depicted in Fig. 3.2.

The TBC (Total Bacterial Count) ranged from 3.2×10^2 CFU ml⁻¹ to $> 9 \times 10^5$ CFU ml⁻¹. The findings corroborate with those of Knight-Jones *et al.* (2016), who noted a TBC of 4.25×10^2 CFU ml⁻¹ upon arrival and became more $> 6 \times 10^5$ 2 days. There is a threshold limit value (TLV) or a level of the pathogen present in milk that can be tolerated in

humans. The threshold limit represents the maximum exposure level to any substance, which humans can be safely subjected to without raising a potential of causing any adverse health effects. Therefore, a total bacterial count lower than 10^3 CFU ml⁻¹ in the pasteurised milk is of satisfactory quality (USPHS/FDA, 2017).

Pathogenic microorganisms equally have TLV, therefore, ingestion of a fewer number of bacterial counts may be safe, depending on each microbe because each pathogen has its own infectious dose (that is, the number cells, colony forming units that are responsible for a disease condition).

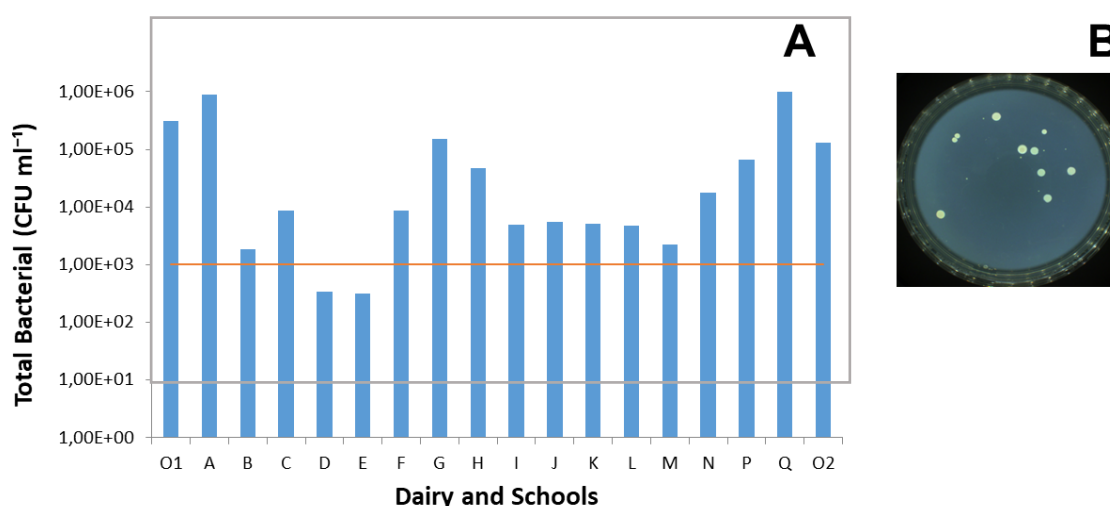


Figure 3. 3: (A) Total bacterial counts present in all the samples with 14 samples exceeding the threshold limit; (B) White colonies on plate count agar suggestive of the bacterial counted in the milk samples.

3.3.2 *Listeria* species analysis

Brilliance *Listeria* Agar uses the chromogen X-glucoside for presumptive identification of *Listeria* spp. S-glucosidase is common in all *Listeria* species and the chromogen is then cleaved by the glucosidase. Other organisms that possess this enzyme, such as *Enterococci*, were inhibited by the selective agents within the medium. The pathogens *Listeria ivanovii* and *Listeria monocytogenes* are then further differentiated by their ability to produce the phospholipase enzyme called lecithinase. The plates with light

blue colonies with an opaque white halo around the colony were suggestive of positive *Listeria monocytogenes*.

The light blue colonies appearing on BLA indicated the presence of *Listeria* species in a sample, thus suggesting a risk occurrence of pathogens; however, the level of the counts can be used to measure the effectiveness of the pasteurisation process and or recontamination (Bartsch *et al.*, 2018). The majority of the samples (77%) were negative, showing no *Listeria* colonies on the cultured plates. In other words, most of the samples from the dairy that were analysed contained no *Listeria spp.*, although 4 samples from different schools showed the presence of *Listeria* species, but it is not a cause for public health concern as the counts were extremely low. In detail the samples that tested positive for *Listeria*, schools A and F had 2 *Listeria* colonies while samples N and P had only one colony, each. It is apparent that a threshold level between 10 and 100 CFU ml⁻¹ of *Listeria spp.* is (Abusheliabi *et al.*, 2017), hence the milk investigated was satisfactory with less than 10 CFU ml⁻¹.

3.3.3 Yeast and mould analysis

Majority of the yeast and mould are obligate aerobes (requiring free oxygen for growth), their acid/alkaline requirement for growth is fairly broad, ranging from pH2 to above 9. Their temperature requirement, also occur in a broad range from 10 - 35°C, with a few species, capable of growing below or above this range. The growth of yeast and mould creates a high risk of spoilage in food industries; therefore, their growth is most undesirable.

When the milk is exposed to the environment, moulds spores from the air can navigate their way into the milk production chain. Pasteurised milk can harbour moulds provided the milk production area also produces fermented milk cheese and so on. Yeast and mould species may not cause spoilage of either raw or pasteurised milk, but their presence may act as a source of contamination. *Penicillium*, *Aspergillus*, *Candida* and *Mucor* species are the most prevalent yeast and mould responsible for milk spoilage (Martin *et al.*, 2020).

Air is viewed as one of the major sources of contamination and the dispersion of fungal spores in the dairy environment, affecting equipment and milk, itself. Heating

milk at the temperatures of +70-+80°C kills both the moulds and their spores. However, there is a risk that harmful mycotoxins will remain poisonous even after heat treatment. In this study, yeast and mould were present in all the 18 samples with counts, ranging from 1.43×10^2 to 9.3×10^3 CFU ml⁻¹, described as too numerous to count (TNTC). Swedish regulatory authority suggested the limit for the occurrence of fungi in water to be 1×10^2 CFU ml⁻¹, due to pasteurisation and that of fresh milk is set at 5×10^1 CFU ml⁻¹ (Radmehr *et al.*, 2020).

Most of the schools with high yeast and mould counts were in the second batch collection. Accordingly, Iqbal *et al.* (2015) indicated that yeast and mould spores are stable even in UHT, with a potential of rapid growth at optimum temperatures. The schools, P and E had the highest counts of yeast and mould, in addition to the sample that was collected at the dairy, that was collected in the second batch. These findings revealed two possibilities; that the yeast and mould were resistant to the heat treatment and, secondly, the milk might have been re-contaminated post the pasteurisation process.

Rose Bengal chloramphenicol is taken up intracellularly by the fungi, restricting the size and the spread of moulds and inhibited the overgrowth of other slow growing microorganisms. The neutral pH in combination with chloramphenicol suppressed the growth of most bacteria. The Rose Bengal dye was absorbed by the cells of yeast and mould, allowing orange colonies (as depicted in Fig. 3.5A below) to be visible on the petri dishes.

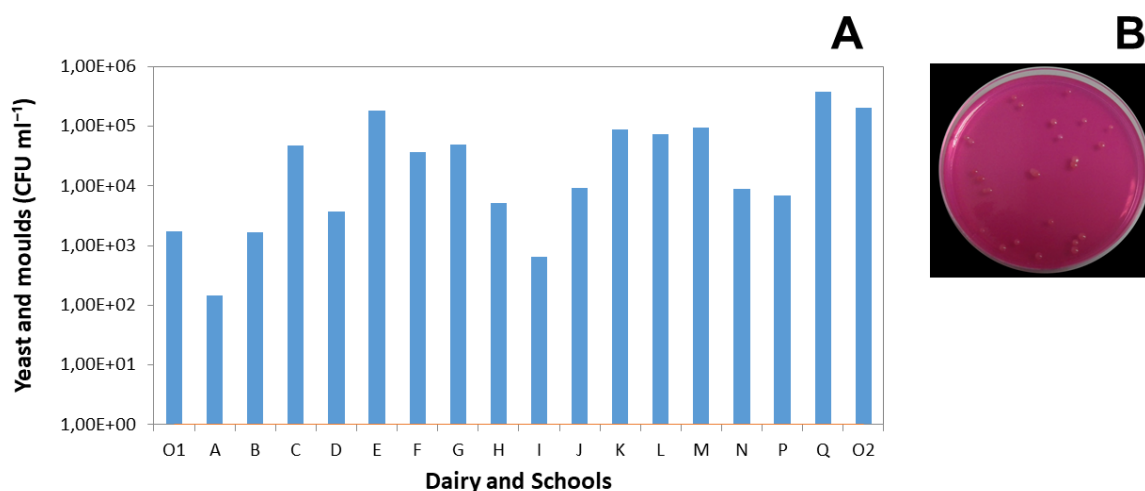


Figure 3.4: (A) Yeast and mould counts were suggestive in all samples, exceeding the set threshold limit of yeast and mould in pasteurised milk; (B) The light pink colonies on Rose Bengal Chloramphenicol agar are presumed to be yeast *spp.*

3.3.4 Enterococci analysis

Enterococci are the most common Gram-positive cocci capable of cellular respiration in both oxygen-rich and oxygen-poor environments. They are not spore forming and are tolerant of a wide range of environmental conditions such as extreme temperatures in the range of 5–65°C, pH of 4.5–10.0 and high sodium chloride concentrations. Therefore, *Enterococci* are reported to survive pasteurisation though the extent of their survival has not yet been fully explored (McAuley *et al.*, 2020). These organisms can be found in the bowels of both humans and other animals, thus, their presence in food indicates faecal contamination.

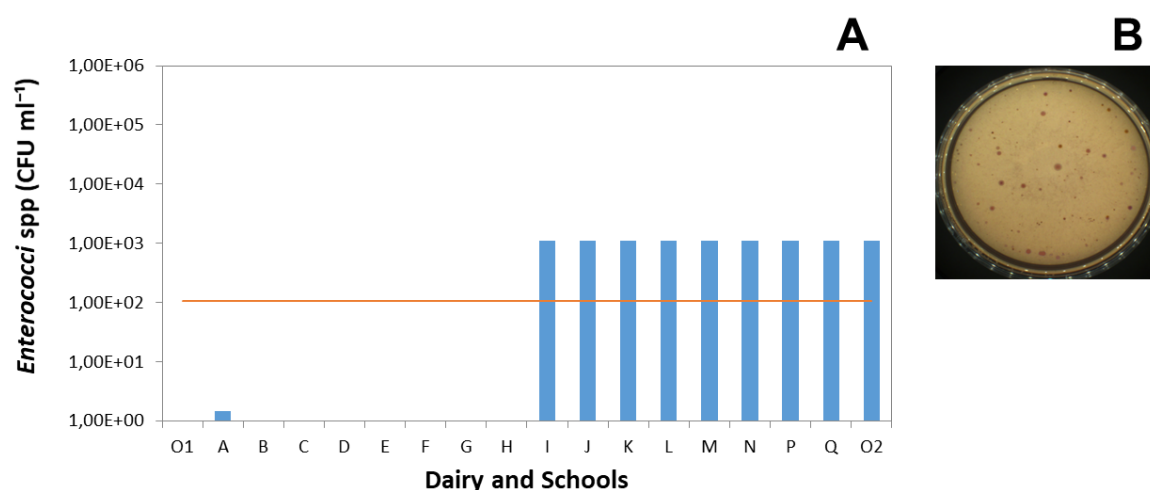


Figure 3.5: (A) *Enterococcus spp.* were detected in 63% of the samples, 56% of the samples exceeded the threshold limit. (B) Small red-maroon-pink colonies on Slanetz and Bartley agar indicative of presumptive *Enterococci* colonies in the milk samples.

Counts ranged from 1 – 1.1×10^3 CFU ml⁻¹ (Fig. 3.6). According to the Environmental Protection Agency (Terzić-Vidojević *et al.*, 2021) the threshold limit for *Enterococci* in pasteurised milk should not be more than 1.05×10^2 CFU ml⁻¹. The explanation for the observed counts could be that the cocci survived the UHT used during pasteurisation. The colonies appeared as small red-maroon-pink colonies in the petri dishes as illustrated in the Fig. 3.6B above.

3.4.5 Total coliforms and *Escherichia coli* analysis

Escherichia coli is a bacterium that is commonly found in the lower intestine of warm-blooded humans and animals. They are therefore released into the environment with the faecal matter. They are facultative anaerobes and can grow best at 37°C, with a survival temperature range of 4-45°C. The organism can survive refrigeration and freezing. Most *E. coli* strains are harmless, but some can cause serious food poisoning and other diseases. *Escherichia coli* is able to degrade milk proteins and ferment lactose, causing milk to be spoiled quickly (Risk, and Series, 2018).

At present, *E. coli* is the best indicator of faecal contamination, among the commonly used faecal-indicator organisms (Bragason *et al.*, 2020). In evaluating foods for safety, the presence of *E. coli* signifies a more positive assumption of hazard than the presence of other coliform bacteria (Yadav *et al.*, 2019). *Escherichia coli* counts detected ranged from 2×10^0 to 2.3×10^1 CFU ml⁻¹. The World Health Organization standardised *E. coli* limit to a zero count per 100 ml of water to be considered safe for drinking. The same microbial limit is applicable to pasteurised milk (WHO, 2017).

E. coli has many strains which can cause virulent and mild health effects if consumed, the bacteria can cause mild diarrhoea to fatal health complications (Owusu-Kwarteng *et al.*, 2020). 69% of the samples were positive for *E. coli* (Fig. 3.7). The process of pasteurisation destroys *E. coli*, therefore, the presence of the bacterium in both dairy samples indicates the possibility of post-production contamination of milk.

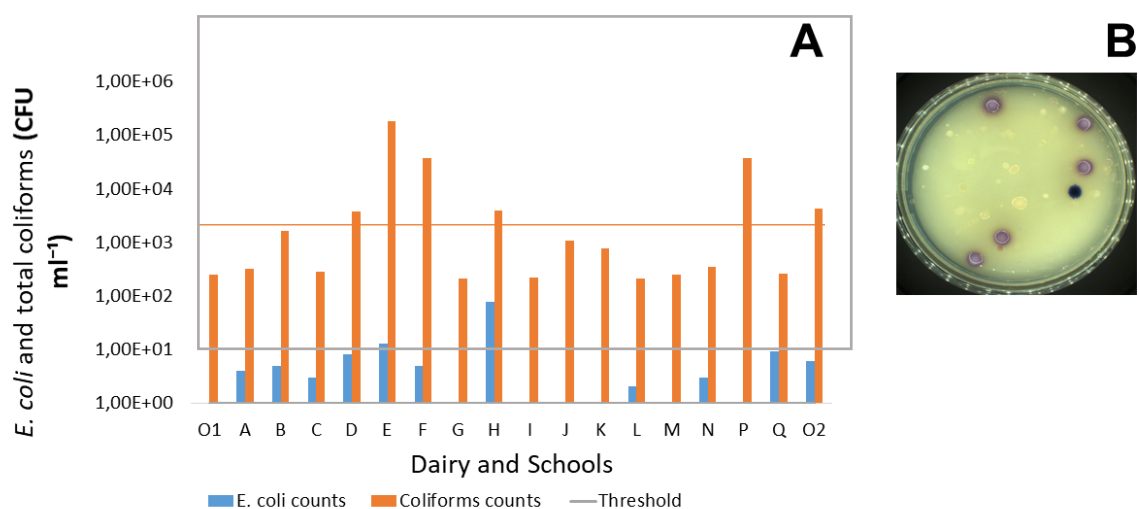


Figure 3.6: (A) Coliforms were present in all samples and *E. coli* in 69% of the samples from the schools and the dairy, exceeding the threshold limits (B) blue-green colonies are considered presumptive *E. coli* and salmon pink coliforms on Harlequin agar.

Coliform bacteria are Gram-negative, non-spore forming bacteria which can be motile or non-motile. They are always present in the digestive tracts of mammals and are therefore some are classified as faecal indicator organisms. These bacteria can ferment lactose producing acid and gas when incubated at 35-37°C (Cho *et al.*, 2018). The coliform counts ranged between 2×10^0 – 2.33×10^2 CFU ml⁻¹ colonies with samples E, F, P and O2 having the highest coliform counts; 100% of the samples contained coliforms (Fig. 3.7). The coliform counts must not exceed 1×10^3 CFU ml⁻¹ in pasteurised milk (USPHS/FDA, 2017).

The fact that these microorganisms cannot survive the heat treatment in pasteurisation, their presence in milk indicated contamination post pasteurisation; therefore, the hygienic status of the source in conjunction with that of the food handlers become questionable. Harlequin selective agar was used for culturing of both *E. coli* and coliforms in one plate; *E. coli* had blue-green colonies (Fig. 3.7B) while the colonies for coliforms were rose pink. Beige colonies were also evident on harlequin agar, which were suggestive of *Pseudomonas aeruginosa*, a rod-shaped encapsulated Gram-negative bacterium.

3.3.6 *Lactobacillus* analysis

Lactobacillus is a lactic acid bacterium, therefore, it can produce chemical changes that are desirable in the production of fermented dairy products (Hassouna, 2016). This bacterium occurs naturally in milk and is used for the desired culturing and the fermentation of some dairy products. Descriptively, it is a rod-shaped, Gram-positive, non-spore-forming bacterium (Bluma and Ciprovica, 2015) with an optimum growth temperature, ranging from 5°C to 53°C.

With reference, to the second collection of milk as presented in the Fig. 3.8, a marked difference can be observed with the presence of *Lactobacillus* species in contrast to the first batch results. A hundred percent (100 %) of the samples showed the presence of the bacterium, with counts ranging from 1.6×10^2 to 9.595×10^3 CFU ml⁻¹. The critical limit of mesophilic lactic acid bacteria 1×10^3 CFU ml⁻¹ in pasteurised milk (Radmehr *et al.*, 2020).

The bacteria should have been destroyed by the UHT during the pasteurisation process. *Lactobacillus* can occur as normal flora in the human intestinal tracts and be found in milk, naturally. Nevertheless, the presence of the bacteria after pasteurisation can be worrisome (Ortiz-Rivera *et al.*, 2017). The colonies appeared as small whitish spots on the clear MRS agar.

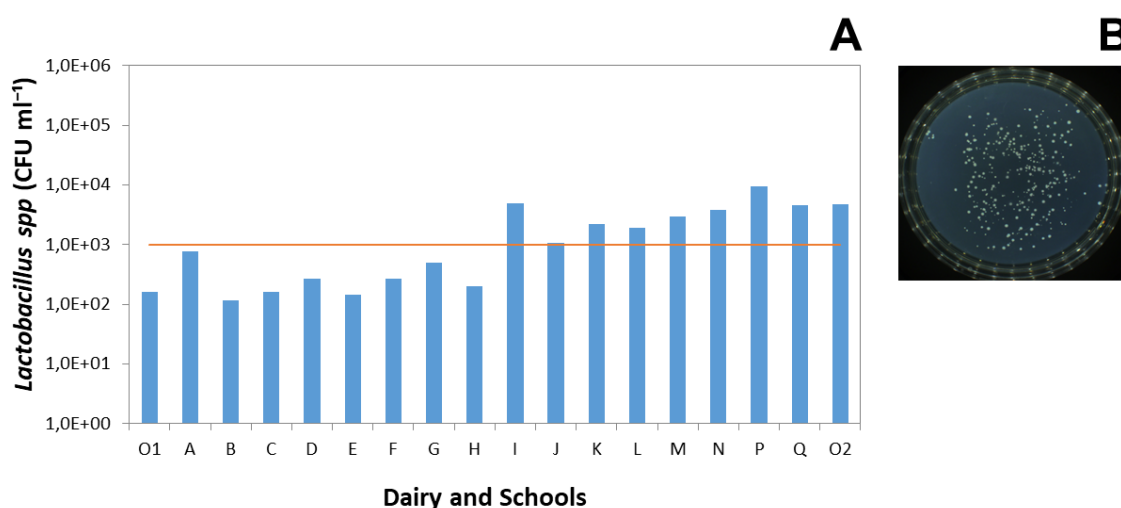


Figure 3.7: (A) *Lactobacillus* counts in all samples exceeding the threshold limit in 8 samples. (B) White small colonies in De Man Rogosa and Sharpe agar indicated positive *Lactobacilli* spp. in milk.

3.3.7 *Staphylococci* analysis

Staphylococci are Gram-positive, facultative anaerobic, non-spore-forming, round-shaped bacteria (Kadlec *et al.*, 2019). It thrives within the minimal temperature range of 37°C to 40°C (Aliyu *et al.*, 2020). The bacterium is frequently found within the upper respiratory tract and on the skin of humans (Goat *et al.*, 2019). *Staphylococci* spp. were detected in 100% of the samples, in the range 1×10^1 to 4.07×10^3 CFU ml⁻¹ (Fig. 3.9). *Staphylococcus* spp. must not exceed 1×10^3 CFU ml⁻¹ in pasteurised milk (USPHS/FDA, 2017).

Staphylococci are found on the skin and the nasal track of humans as a normal flora. Whenever food handlers do not observe appropriate personal hygiene, there are chances that *Staph* can be transferred into the milk (Goat *et al.*, 2019). During data collection of the knowledge, attitude and self-reported behaviour of the food handlers, it was observed that the food handlers do not fully understand that they can transmit microbes into the milk even when not sick.

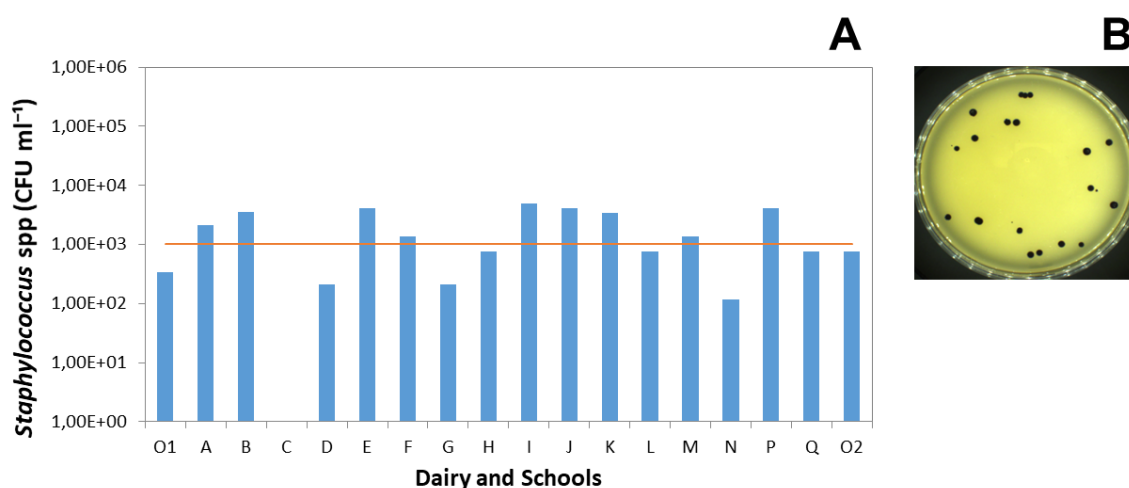


Figure 3.8: (A) *Staphylococcus* spp. counts in 15 samples, 9 exceeded the threshold limit. (B) Black colonies on Baird Parker agar suggestive of *Staphylococcus* spp. in milk

Both samples that were collected at the dairy during the two sampling periods demonstrated the presence of *Staphylococci*. Abusheliabi *et al.* (2017) studied the influence of temperature increase (10, 25, 37°C) on the growth inhibition profiles of

Staphylococci spp., *Listeria monocytogenes* and *E. coli* occurring in pasteurised bovine milk, raw bovine milk and pasteurised camel milk. The authors noted a rapid increase of all the 3 microorganisms with colonies ranging from 1.1×10^1 CFU ml⁻¹ $\geq 3 \times 10^2$ CFU ml⁻¹.

Therefore, the findings of our study are in accordance with those of Abusheliabi *et al.* (2017), highlighting that the temperature increase could have affected the proliferation of this microorganisms in the current study. The hygienic status of the schools added to the lack of maintenance of the cold chain during the transportation and the storage of milk, could have negatively affected the milk allowing the proliferation of microorganisms.

3.4 Conclusions

Milk is a safe and nutritious food that should be harvested, processed, stored, transported, and handled properly. Identifying the sources of contamination in a dairy industry is very imperative alongside, efficient, and effective implementation of any remedial mitigation processes. We anticipated that the milk samples from the dairy should be free of any form of microbial contamination because it was pasteurised, however, this was not the case in this regard. Failure to maintain the cold chain during transportation and before the milk could be served in various schools has also caused the proliferation of microorganisms in milk.

All seven investigated microorganisms were identified in some of the samples, but with varying number of colony forming units. However, some of the microorganisms were not prevalent such as *Listeria* species, which was only available in 22% of the overall samples, with the highest number of counts being 2×10^0 CFU ml⁻¹. The total counts are indicative of the bacterial population occurring in all the samples thus, highlighted the level of contamination. Apart from TBC, *Lactobacillus* spp. was the most prevalent microorganism in all the milk samples.

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CHAPTER 4

Knowledge, attitude and self-reported behaviour among the food handlers of a school feeding scheme in Maseru, Lesotho

4.1 Introduction

Gastrointestinal infections ascribed to waterborne or foodborne microorganisms are regarded as the primary causes of illness and mortalities in the under-developed, developing and developed countries (Krumkamp *et al.*, 2015). In developed countries, the gastrointestinal infections kill an estimation of one third of their populations (Bisholo *et al.*, 2018). The problem seems to be even more serious in the under-developed and developing countries, as an estimation of 1.9 million people die annually, across the globe due to these infections (Wen *et al.*, 2023).

Even in countries, where foodborne disease surveillance system is well in place, the true number of incidents of gastrointestinal infections in those countries may never be known and will never be reflected in literature (Rezaei *et al.*, 2015). Most of the times, the foodborne disease outbreaks are reported, but still at a lower level, while individual cases are not reported and investigated (Rakhshandeh *et al.*, 2017). In many cases, the gastrointestinal infection in primary school children is usually not reported hence, they are mostly resolved within a day or two. Parents and guardians usually ignore them.

Foodborne diseases adversely affect the social fabric of all countries (Ngivu, 2016). These illnesses are significantly more prevalent among the poor because of unsanitary surroundings, habitual and necessary reliance on foods that are sold on the streets from dubious origin and quality, and the lack of education, regarding safe handling of

foods (WHO, 2017). Similarly, the government owned primary schools face the same challenge in terms of unsanitary surroundings with minimal supervision of food handlers. Where food control system is available, it fails to adequately regulate, monitor and evaluate the food handling process at all stages; consequently, food that is unwholesome is served to the children (Bessy *et al.*, 2021).

Foodborne illnesses allow the poverty cycle to continue in populations that live below or at the poverty line (WHO, 2015). More than half (57%) of the population of Lesotho live below the poverty line of M138.00 per month; Lesotho is therefore at risk ('Lesotho country analysis working document final draft', 2017). Whenever the foodborne outbreaks occur, there is a high possibility of severe cases and mortalities, depending on the time of disease detection (Khera, 2017).

Food Safety appears to be one of the fundamentals of public health, hence it entails handling, preparation, transportation, and storage of food in the appropriate manner in order to reduce the risk of people getting in contact with the foodborne illnesses (Jomaa *et al.*, 2018). Food safety is currently a major global concern due to the burden of foodborne illnesses. There are three main risk factors affecting food safety and include, improper cooking and improper storage temperature of food, the use of contaminated equipment leading to cross contamination, and lastly, the preparation and use of foods from unsafe sources (Oloruntoba and Musah, 2014).

The engagement of competent food handlers can address all these factors, keeping them under control as well as assist in the production of safe food (Silva and Cruz, 2021). Food handler's knowledge and practice go together and are of equal importance, otherwise, the absence of any can result in foodborne illnesses (Quinlan, 2019). In addition, there must always be a proper training of all the people who are to handle food in combination with a necessary tool to assess if all the aspects of food safety had been grasped (Adane *et al.*, 2018).

The said trainings should be ongoing even when one had worked for a long period, as, there is always a possibility of emerging foodborne illnesses at all times (Quinlan, 2019). All food needs to be prepared safely, but that which is to be consumed by many people needs even more diligence, because many lives are involved (Webb *et al.*,

2018). School Feeding Programmes are of great concern, however, there is a proof of under reporting of illnesses affecting this group of people (Londonderry and Agency 2019).

It is still a key challenge in many developing countries to produce safe food for the children through SFPs (Jomaa *et al.*, 2018). The assurance of food safety in SFPs relies heavily on both the competency and the monitoring of the food handlers alongside the availability of resources, including infrastructure, equipment such as fridges, and potable water etc. (Uduku, 2011). The foodborne illnesses within the SFPs may cause acute infections, which may spread and affect children, eventually disrupting teaching and learning in schools (Khera, 2017). In addition, the absence of water within some of the schools participating in SFP has the upper hand in promoting the occurrence of food related diseases. According to Nnamani (2018) it is highlighted that the absence of clean portable water can lead to waterborne illnesses and transmission thereof.

On the other hand, WHO (2015) is encouraging food handlers to report any sickness to the management, immediately to curb the spread of disease should there be a change of spread. Nevertheless, community members have various reasons for not reporting gastrointestinal infections, consequently, it becomes difficult to know the number of people affected and also to have best practices to prevent and control future problems.

Based on the frequency and severity of the foodborne illness, especially among school aged children which can lead to hospitalisations and or death, it was the aim of the study to evaluate knowledge, attitude and self-reported behaviour of the food handlers among schools participating in school feeding scheme within Maseru, Lesotho.

4.2 Materials and methods

The methodological choice was channelled by the aim of the study. Hence the face-to-face structured interviews were used to assess the level of knowledge while interpreting the understanding of food handlers looking at the application of food safety measures deployed while handling milk at various primary schools (Sibanyoni, 2017;

Thomas, 2020). In cross-sectional study, one collects data from many different individuals at a single point in time, observes and describes variables without influencing them (Sibanyoni *et al.*, 2017). This research design was considered appropriate for this study to record information gathered of a sample population and offer a depiction of the population's characteristics at once.

4.2.1 The study area

The study population comprised of 16 primary schools, 48 food handlers from school participating in School Feeding Program in Maseru, Lesotho.

4.2.2 The Inclusion and exclusion criteria

Only the primary schools participating in the School Feeding Programme, supplied and served milk from the common source were included in this study. Primary Schools that happened to be too far from the dairy, but still supplied by the dairy plant got excluded, and the milk samples were analysed in the food laboratory in Bloemfontein on the same day of sample collection.

4.2.3 Research instrument

Each questionnaire comprised of 41 questions that were divided into 4 sections, including demographic information (with 7 inquiries), food safety knowledge (19 inquiries), attitude (8 inquiries) and self-reported behaviour (7 inquiries). The translated questionnaires were piloted in 4 primary schools, prior to the actual data collection, to assess both the comprehension and to establish the issues of time management. Knowledge, attitude and self-reported behaviour of the food handlers had proven to play an integral role in food safety (Fontannaz-Aujoulat *et al.*, 2019).

Therefore, the first section of the questionnaire composed of questions targeted to assess the knowledge and the behaviour of the respondents in relation to age, gender and educational level. Studies have indicated that there is a correlation between the three variables (Umza *et al.*, 2017). The second section was designed to evaluate the knowledge of the food handlers and the responses were either "yes" or "no". The third section had 3 alternative responses; "agree", "not sure" and "disagree" in order to determine the attitude of the respondents. Lastly, the self-reported behaviour, which

provided five options namely, “always”, “most times”, “sometimes”, “not often” and “never”.

The administration of the questionnaires assisted in assessing the respondents' knowledge in food safety and food hygiene, but particularly on personal hygiene, detrimental actions in food handling such as health problems that can have a direct impact on food safety, prevention of cross-contamination, importance of temperature control, as well as foodborne illnesses and their prevention and control.

All in all, the dairy had 21 primary schools to which milk had to be delivered, however, 5 schools were very remotely located thus, were not included in the sampling. Only one bakkie with a canopy was available to deliver the milk to all the 21 primary schools. The bakkie had no temperature control system insinuating that the milk was transported while the cold chain was not maintained.

4.3 Results and discussions

The study participants replied at a 100% rate and the entire population of the respondents were Lesotho nationals (100%), among which the vast majority were females (75%), which is usually indicated by most studies in food handling establishments in the age group, 44 - 60years (Zenbaba *et al.*, 2022). It is generally believed that women by nature have a better understanding of food handling (Williams, 2016). Only 21% of the study population had no elementary school-based knowledge.

This study showed that the educational level and the safe food handling course had different degrees of impact on food safety knowledge and attitudes of the food handlers (Table 4.1). It is interesting to note that those who had not received any formal education performed better than those who had received primary education. Nonetheless, it was eventually clear that all the food handlers must be provided with intensive regular training, though other trainings courses were just teachings to cover content. It must be taken into consideration that the food handlers have knowledge and skills during the trainings (Putri & Susanna, 2021).

Table 4.1: Demographic data of food handlers in SFP

Variables	Frequency	Occurrences (%)
Gender: Female	36	75
Male	12	25
Age: 35-45 years	5	10
46-55 years	30	63
56-65 years	3	6
Education Level:		
None	10	21
Primary level	19	40
High School level	18	38
Tertiary level	1	2

Table 4.2 below illustrates the findings during the assessment of the food handlers' knowledge of food hygiene. Proper food handling methods are vital in ensuring the production of safe food. Most studies indicated that with training, the knowledge of the food handlers can be improved, though that does not guarantee positive adjustments in food handling behaviour and attitude (Tuglo *et al.*, 2021). Less than 50% of the study population understood that cold milk meant safe milk. This explains the reason the food handlers were never disturbed by milk being transported while the cold chain was not observed.

Approximately, 44% of the participants had a poor perception about appreciating the quality of water in that they concluded whether the water was clean by mere looking at the water. This raised a suspicion that even the safety of milk can be determined by its appearance. Recent studies highlighted that most of the food handlers usually believe that food safety can be measured by the way food appears; this can consequently lead to occurrence of a number of foodborne outbreaks (Raji *et al.*, 2021). The use of water collected from a non-reliable source or that had been contaminated after being collected from a reliable source is one of the important causes of unsafe food (Meierhofer *et al.*, 2019). This is one of the most critical issues that must be addressed through regular trainings together with monitoring and evaluation.

Table 4.2: Food handlers' knowledge assessment results (n: 48)

Variables	Answer	Frequency	Occurrences (%)
Is washing hands with soap important?	Yes	47	98
	No	1	2
Can milk transmit any diseases?	Yes	42	88
	No	6	12
Does cold milk mean safe milk on delivery?	Yes	23	48
	No	25	52
Can milk be delivered with and other foods (e.g. meat and bread?	Yes	12	25
	No	36	75
Is timely delivery important?	Yes	37	77
	No	11	23
Can wiping cloths spread microorganisms?	Yes	40	83
	No	8	17
Can one come to work when sick e.g. with diarrhoea, vomiting?	Yes	8	17
	No	40	83
Can milk temperature be taken 20 minutes after delivery?	Yes	34	71
	No	14	29
Can pasteurised milk be left at room temperature overnight and be served the next day?	Yes	10	21
	No	38	79
Can refrigerating foods lower bacterial growth?	Yes	35	73
	No	13	27
Can safe water be identified by the way it looks?	Yes	21	44
	No	27	56
Can expired milk be consumed?	Yes	6	12
	No	42	88
Can raw food be stored separately from cooked food?	Yes	5	10
	No	43	90
Can thermometers be useful for ensuring food is thoroughly pasteurised?	Yes	39	81
	No	9	19

Although, all the food handlers agreed that hand washing must be done before handling food, and that food safety training courses are important as well as accepted, that clean working environment promotes good health; however, the information that the food handlers did acknowledge, especially on hand washing and clean working environments, was not implemented at all while they were observed carrying out their

routine activities. This is one imperative aspect that must always be taken into consideration because the hands of the food handlers could serve as vectors for food borne illnesses, following the presence of the microbial load presented in Chapter 3 (Tadele *et al.*, 2022).

The respondents seemed to know what is correct, though they did not demonstrate during the data collection period. About 13 % of the food handlers affirmed that milk that had been expired can be consumed, and even the majority that said milk must not be consumed when expired; did not check the expiry date of the milk at all (Ncube *et al.*, 2020). There is an old common practice in Lesotho, where milk that is spoiled can still be consumed and is called sour milk.

A much lower percentage (13%) of the population expressed a lack of knowledge in relation to the diseases that can be transmitted by contaminated milk. The common knowledge of the participants that were involved in the investigation, revealed that pasteurised milk cannot transmit diseases. Recent studies revealed that most food handlers have a common knowledge that whenever milk is pasteurised, it means it is sterile (da Vitória *et al.*, 2021). Additionally, they were without the knowledge of cross-contamination occurring after pasteurisation. It was further revealed that the food handlers were ignorant and lacking knowledge, particularly in the activities plus the actions that can contaminate milk, thereby, rendering it unfit for human consumption.

The pupils were provided with water to wash their hands before taking their meals, only in 3 of the 16 (19%) schools. Only 1 school (6%) did a proper hand washing as illustrated in picture 1B above. The hand washing technique was not carried out properly in the other 2 schools, as the inside of the hands and in-between the fingers were not given attention. The issue of proper hand washing has been reported to decrease the threat of food borne diseases significantly, therefore, the practice must be encouraged broadly, and the handwashing facilities must be there, in every place where food is prepared and served (Evans *et al.*, 2020).

A: Children washing hands with water only



B: Children washing hands with soap and water



Figure 4.1: Students washing hands before the meals are served

The attitude of the food handlers toward milk handling was assessed, and the results are stipulated in the Table 4.3 below. The assessment was done in such a way that it gave the participants 3 options, which alternated from “agree, disagree and not sure”. The answer “not sure” was interpreted as the respondent did not know the answer, since she/he could not give the precise response. The findings based on the attitude of the participants gave an elevated hope in comparison to the reality on the ground. Various studies indicated that the probabilities of having good food handling practice are usually 3.4 times higher among trained food handlers compared to those that are not trained (Legesse *et al.*, 2017; Azanaw *et al.*, 2019).

The majority of the questions were answered correctly, although the observation tools of the data collectors recorded the opposite. On average, 81 % of the overall questions were answered correctly. Should the correct knowledge be practiced while handling food, then the results of the attitude would then tally with the actions of the food handlers. In addition, 96 % of the respondents highlighted that keeping the kitchen

surfaces clean can reduce the risk of acquiring illness and that inspection of food is very important, which conforms with other studies (Teferi *et al.*, 2021).

In all the schools, the inspection of the milk on arrival was not done, and it was only in 4 schools where the surfaces were managed to be kept clean. Other studies mentioned that in various schools, the issue of clean surfaces is not a priority at all to the food handlers, rather they worry about availing the food at the right time to the children (Ali *et al.*, 2022). A preponderance of 79% agreed that sieving of milk can be salient, though none of the food handlers in the study implemented the idea. This aspect of milk sieving was proposed by the researcher. It was realised during the pilot that the milk was usually served from a third container, therefore, there was a possibility of introducing the extrinsic materials into the milk. Contrary to this, studies indicated that the issue of sieving milk can also be a contributing factor to milk contamination, if the sieve is not hygienically handled (Zenbaba *et al.*, 2022).

In addition, 77% of the food handlers established that milk must not be put out of the refrigerator for more than two hours, yet the milk was delivered before 8:30 a.m. In all the schools, but it was only served between 12 noon and 1:00 p.m. They knew that the milk was brought to them while the cold chain was not observed, yet they never had a problem with, using such milk.

All food handlers agreed that washing of hands before the handling of food and throwing away food that has expired is important. In all the 16 schools that were assessed, there were no hand washing facilities with running water, and the food handlers did not take an extra time for hand washing prior to the serving of meals. The findings of this study are in consistent with those reported by the study conducted in Ethiopia, where handwashing was a known practice but not well practiced (Young *et al.*, 2018; Admasu & Kelbessa, 2018). Furthermore, the expiry date of the milk was never checked, rather they were happy when the milk temperature was low. They had the impression that having cold milk meant that the milk was fresh.

Table 4.3: Food handlers' attitude assessment results

Variables	Frequency	Occurrences (%)
Does keeping kitchen surfaces clean reduce the risk of illness? (n=48)		
Agree	46	96
Disagree	2	4
Does keeping raw and cooked food separate help to prevent illnesses? (n=48)		
Agree	21	44
Disagree	19	40
Not sure	8	17
I think it is unsafe to leave cooked food out of the refrigerator for more than 2 hours (n=48)		
Agree	37	77
Disagree	6	13
Not sure	5	10
Inspecting food for freshness and wholesomeness is valuable? (n=48)		
Agree	46	96
Not sure	2	4
Does sieving the milk play an important role? (n=48)		
Agree	38	79
Disagree	4	8
Not sure	6	13
Can milk be put on direct sunlight? (n=48)		
Agree	15	31
Disagree	21	44
Not sure	12	25

Furthermore, the food handlers noted that milk must not be kept or be put in direct sunlight, yet the milk was kept in the wheelbarrows and at some serving points, it was kept in direct sunlight. Figure 4.2 below shows what was going on as the milk arrived and how it was fed to the pupils. Also, 96 % of the food handlers agreed that food must be inspected on arrival, to determine if it is fit for human consumption, however, none of the food handlers did this. Studies pointed out that the majority of food handlers know the right activities to undertake yet tend to focus only on the production of food (Labović *et al.*,2023).



Figure 4.2: Milk in plastic containers placed in sunlight

The most preferred temperature range for bacteria responsible for foodborne illnesses is 4°C-60°C, which is known as the danger zone, owing to the fact that the food spoilage bacteria grow very fast in this temperature range. Food that spoils easily must never be kept or stored at a temperature occurring in the danger zone for more than two hours. For reason that the microorganisms may grow rapidly, rendering the food not wholesome anymore. Several studies depicted that pasteurised milk is usually may still contain those microorganisms that can survive that high temperature treatment (Zanin *et al.*, 2017). Nonetheless, it is shocking to note that all the milk that was served through all the 16 schools was left in the danger zone for more than 2 hours.

The respondents were given five options to choose from when assessing the behaviour of the food handlers. Similarly, what the data collectors observed was far different from what the food handlers said. If they were to fill the questionnaires without talking to them; they would be having far different records. A Brazil study showed that all the researchers observe during any study is more valuable than the responses of the questionnaires. Hence, it is assumed that the respondents work on giving out positive feedback not the reality (Akabanda *et al.*, 2017). The food handlers did not get 100 % in any of the 8 questions that were asked to assess their behaviour. The 5 answers included “always”, “most times”, “sometimes”, “most often” and “never”.

During the data collection, it was evident that the food handlers did not wash their hands prior to handling the food. For those who cook pap within the school facilities, they usually started by making the fire and followed by cooking; they did not wash their hands frequently in between the activities. They moved from one point to another without making sure that personal hygiene is maintained, this occurs almost every time during food preparation in many food establishments, hence HACCP is always valuable (Bulto *et al.*, 2022). Figure 4.3 below illustrates one of the activities that the food handlers participated in, prior to serving the meals for the children.

Figure 4.3 below exemplifies the food handlers preparing pap for the pupils to eat at lunch. Some of the pap moved out of the pot while stirring. The small pieces of pap were taken back into the pot after stirring the content in the pot. This was done with the hands that, were not washed prior to the stirring of the pot nor using the clean cloth to wipe the surfaces that might be in contact with the pap. (as observed by the data collector). Such acts can serve as channels for transferring disease causing agents or microorganisms into the pap.



Figure 4.3: Food handlers preparing meals

A significant number of the respondents (64%) acknowledged that they mixed the left-over milk of the previous day with the freshly delivered milk for that day, even though the milk was not refrigerated for more than 2 hours. The issue of milk refrigeration was not important at all to the food handlers, in conjunction with the issue of maintaining cold chain from the manufacturer to the school. Besides that, 77% of them claimed

Table 4.4: Food handlers' behaviour assessment results

Variables	Frequency	Occurrences (%)
I wash my hands before and during food preparation. (n=48)		
Always	38	79
Most times	10	21
I clean surfaces and equipment used for food preparation before re-using on other food. (n=48)		
Always	35	73
Most times	13	28
I separate raw and cooked food during storage. (n=48)		
Always	36	75
Most times	5	10
Not often	1	2
Sometimes	6	13
I store any left-overs in a cool place within two hours. (n=48)		
Always	34	71
Most times	3	6
Never	3	6
Sometimes	8	17
I mix my left-over milk which was not refrigerated with the milk that has been newly delivered. (n=48)		
Always	15	32
Most times	15	32
Never	6	13
Not often	2	4
Sometimes	9	19
I check and throw away food beyond its expiry date. (n=48)		
Always	37	77
Most times	5	10
Never	2	4
Sometimes	4	8
I warm up the milk before serving it. (n=48)		
Always	2	4
Most times	1	2
Never	37	77
Not often	4	8
Sometimes	4	8

that they checked the expiry date of the milk upon arrival, but it was never checked at all. Rather, they estimated the temperature of the milk by touching the container, using the back of the palm and all concluded that if the milk was cold, it was safe. In many cases, when perishable foods appear cold, consumers together with food handlers concluded inappropriately, that the food is still in its good condition (Ratajczak *et al.*, 2021).

There were various aspects that the data collectors observed during the data collection activity; those findings are presented in the Table 4.5 below. A total of 20 elements was observed during the data collection without the knowledge of the food handlers except for those areas, where a question had to be posed in a bid to acquire the desired information. Observation is the most reliable data collection method and works well when the audience is not aware that data is being collected through observation (Fideles *et al.*, 2022). The observation tool had only “yes” or “no” alternative answers together with the space for comments, where necessary. Approximately, 40% of the good practices that were supposed to be there in the 16 schools were not found.

All the schools had no rodent or vector control systems in place and the milk from the dairy was poured into a plastic bucket prior to serving in all the 16 schools. This practice could be the main source of contamination of the milk. Not all the 16 schools had a kitchen from which to serve food, and those that had kitchens did not make use of them in serving the pupils. The floors, the walls and the ceiling were not in good conditions in all the schools and none of the schools had a fridge. Any facility used for serving food must reach certain standards to minimize any form of contamination to food (Raji *et al.*, 2021). Hence, the milk was kept at any convenient place awaiting the children to exit their classrooms for lunch.

Only 38% of the food handlers covered their hair while preparing and serving the food and 19% of the food handlers wore clean aprons. Very paramount to mention was that 31% of the toilets were closer to the classrooms, which were used to serve the pupils. Thus, houseflies were present in the vicinity during the serving of the food to the children. Houseflies can transmit the pathogens from one surface to another, carrying them with the hair on their feet and body or by sucking and vomiting on the food (Akabanda *et al.*, 2017).

Table 4.5: Data collectors' observations

Variables	Frequency	Occurrences (%)
Is the general appearance of the food handler good? (n=48)		
Yes	35	73
No	13	27
Are there any visible wounds on the food handlers hands (n=48)		
Yes	46	96
No	2	4
Are the nails cut short? (n=48)		
Yes	41	85
No	7	15
Is the hair properly covered? (n=48)		
Yes	18	38
No	30	63
Is the food handler wearing an apron? (n=48)		
Yes	9	19
No	39	81
Is the food served inside a room? (n=48)		
Yes	38	79
No	10	21
Is the milk pitcher made of plastic? (n=48)		
Yes	29	60
No	19	40
Are the children encouraged to wash their hands before eating? (n=48)		
Yes	28	58
No	20	42
Is the soap used for washing the hands? (n=48)		
Yes	8	17
No	40	83
Are there any signs of rodents and vectors? (n=16)		
Yes	9	56
No	7	44
Are the toilets close to the classrooms? (n=16)		
Yes	5	31
No	11	69

Also, 29% of the milk pitchers that were used to serve milk were made from plastic and most of them seemed to be in a good form, although, proper washing and handling demonstration prior to use could not be proven. Only 6% of the food handlers provided

the children with soap and running water to wash their hands before eating their meals. Most studies acknowledge too that hand washing is one of the best ways for disease prevention and control, even foodborne pathogens are not spread if the hands are thoroughly and frequently washed (Raji *et al.*, 2021).

A total of 96% of the food handlers had visible abrasions on their hands which they said were due to fire making; open wounds can harbour pathogens, which ultimately could be transmitted to the food hence, such food handlers must be prohibited to handle food until they are fully recovered. Lastly, it is very imperative for the food handlers to wear clean aprons to ensure proper hygiene and food safety. If aprons are worn, there will be no possibility of any contaminants falling off from the chefs' regular clothes as they can gather various pathogens. Only 19% of the food handlers had their aprons on (Ratajczak *et al.*, 2021).

4.4 Conclusion

Generally, the food handlers in this study seem to have knowledge on food safety issues, however, translation of that knowledge into attitude and self-reported behaviour into practice is very minimal. Therefore, there is need for further training of the food handlers and routinely monitoring and evaluation. The study assisted mostly in understanding the food handlers' point of view, their behaviour and also identified that there is a need for adequate and effective trainings to fill the identified gaps. The trainings must be structured and designed in such a way that they promote food safety and minimize the causative factors of foodborne diseases.

Food handlers that put their knowledge into practice at all times can impact the lives of those that they serve positively at all times. Over half of the respondents gave correct answers while filling the questionnaires, though the observational checklists recorded the opposite during practice. All food handlers at schools must have a superior body which randomly checks and corrects their attitude and behaviour at all costs. Furthermore, it must be the responsibility of the overseer to ensure that they transmit the link between the knowledge acquired during the trainings with the attitude and behaviour for food safety into practice.

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CHAPTER 5

Concluding remarks and recommendations

5.1 Introduction

It has been discussed previously that milk is an excellent high-quality food, providing major nutritional requirements to man at any age, but it is extremely susceptible to spoilage, ascribed to microbes (Bragason *et al.*, 2020). Furthermore, it had been deliberated that the introduction of various microorganisms via unhygienic production of milk, improper storage, inappropriate transportation, and unsanitary milk handling can cause early milk spoilage (Pan, 2017). The presence of organisms in pasteurised milk indicated that unhygienic practices have been conducted somewhere in the production chain (Lemma *et al.*, 2018).

The most leading challenges which remain in the School Feeding Programme are limited/improper knowledge and or self-reported behaviour and the attitude of the food handlers (Lessa *et al.*, 2017). They do not focus entirely on the production of safe food, rather, just to put food on the table for the children and to earn some money for living from the school feeding activity (Africa, 2019). Food handlers must possess certain documents and attributes to show before they can be permitted to handle food. Adequate trainings can positively contribute toward food safety hence proper care will be taken not to contaminate the food with various microbes even unknowingly (Ali *et al.*, 2022).

5.2 General conclusions

The study investigated the hygiene practices and quantified the microbiological quality of milk served to children attending some primary schools in Maseru, Lesotho. From the findings of this study, it is worth concluding, the knowledge, behaviour and attitude of food handlers toward storage and preparation of food in a hygienic manner is

seriously lacking (Knight-Jones *et al.*, 2016). Therefore, the skills and competencies on safety food principles and protocols must be taught to improve on the general and personal hygiene of both the food handlers at the primary schools and at the dairy plant. Other conclusions based on specific findings include the following.

5.2.1 Assessment of the predominance microorganisms in milk served to children through School Feeding Program

Firstly, the danger temperature zone of milk is between 4°C and 60°C. In all the schools, the milk was not refrigerated on arrival, yet it was not transported while the cold chain was maintained (Mukundan, 2016). It must be remembered that some of the microorganisms are able to thrive in and outside the milk danger zones (Garden-Robinson, 2020). We must also reiterate that the milk was not served on arrival in these schools, and the lowest and highest temperatures at which milk was served to the children were 8.3°C and 25.3°C, respectively. This was also of a concern, because the milk was put either in the kitchen, classrooms or just left outside in the sunlight on arrival until the serving time.

Secondly, considering the data on the prevalence of each microbiological parameter, it was observed that all the milk samples collected from all the schools were contaminated, including the milk from the dairy, except for *Listeria* species. Therefore, it can be concluded that the contamination began in the dairy either during production, processing, and handling; meaning it could be ascribed to the knowledge, attitude, and behaviour tool (Merwan *et al.*, 2018). Accordingly, Narwal (2017) emphasised that most frequently used food production sites neglect laboratory quality assurance of the food produced in their companies, which might lead to very serious health challenges in many cases (Boor *et al.*, 2017).

Foodborne illnesses cannot always be predicted or prevented rather, efficient food safety trainings with close inspections and monitoring can yield safer wholesome food (Kendall *et al.*, 2017). It is very unfortunate that children are amongst the groups that are counted to be more vulnerable to infections of the gastrointestinal tract due to their daily routines, in addition the maturity level of their immune system contributes negatively too.

There is quite a thin line between foodborne infections and waterborne infections. To differentiate the two, microbiological analysis food samples, vomits or stools are required (WHO, 2017). Hence, it is very crucial to have further studies, investigating both food and water to enable the conclusion on the microbial status of the food given to children via school feeding programmes. Foodborne illnesses are habitually ascribed to poor personal hygiene and improper food handling by the food handlers (Adane *et al.*, 2018). Similarly, food handlers play a primary role in the prevention and control of foodborne diseases.

5.2.2 Knowledge, attitude and self-reported behaviour of food handlers

Thirdly, forty-four percent (44%) of the study population (n=48) had hypothetically believed that the cleanliness of water can be measured by the naked eyes; the analogy made it clear that even milk safety can be assessed by its appearance. The majority of the study population (71%) further affirmed that the milk temperature can be taken even after 20 minutes upon arrival of the milk. This indicated a general lack of knowledge in terms of proliferation of microorganisms in food (Pricope-Ciolacu *et al.*, 2019); the reason for the microbial load demonstrated in the study.

5.3 Limitations to study

The study did not uncover the actual microbial population found in the milk samples. There was growth of a number of other microorganisms, which were different from the organisms of interest within the scope of the research. These organisms were found in various petri dishes, containing the media, Harlequin, Baird Parker and in Brilliance *Listeria* agar. Further isolation and identification of these microorganisms would add more value to the study if investigations would be continued hence there are lots of strains of microorganisms. Lastly, for further research, it will be very appropriate to sample even the utensils used, like the cup that was used to measure milk for each child.

The swab test is the most general technique used to determine microbial contamination on surfaces, including food handler's hands. The hand-swab samples

can isolate microorganisms that would be present in their hands. In this study, the swab tests are a missed opportunity to give a full insight of the food handler's hands.

5.4 Recommendations

Following the findings obtained from the study, we put forth the following recommendations:

- a) All dairy plants must be obliged to produce safe milk, by ensuring that the set legislation and SOPs are always followed together with setting up the GMPs and HACCP can improve on the quality of the produced milk and other dairy products (Singh *et al.*, 2018).
- b) All dairy plants should also conduct microbial analysis of milk every day, to monitor the quality of milk that is produced (Tibbo, 2016).
- c) It is of utmost significance to deploy food handlers able to portray a satisfactory level of food handling skills in relation to knowledge, self-reported behaviour and attitude. This knowledge will assist the food handlers to thoroughly understand all issues pertaining to the transportation, the storage and the handling of all sorts of food, either perishable or non-perishable.
- d) Routine training of food handlers must be conducted. The moments of hand washing and proper hand washing technique may come naturally following such training.
- e) Lastly, writing and validating set standard examination should be a prerequisite to allow food handlers to handle food at all commercial levels (Bessy, 2021).

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APPENDIXES

A: Ethical approval letter



LESOTHO

Ministry of Health
P.O. Box 514
Maseru 100

REF: ID66-2024

Date: March 05, 2024

To

Ms. Lizzy Sello

School of Nursing

Student Number: 20325363

Central University of Technology, Bloemfontein

Category of Review:

- ☒ Initial Review
- ☐ Continuing Annual Review
- ☐ Amendment/Modification
- ☐ Reactivation
- ☐ Serious Adverse Event
- ☐ Other _____

Dear Ms. Sello

**RE: MICROBIAL COMPOSITION OF MILK AND RELATED HYGIENE PRACTICES
ASSOCIATED WITH THE PRIMARY FEEDING SCHOOL PROGRAMME IN MASERU**

This is to inform you that the Ministry of Health Research and Ethics Committee reviewed and retrospectively **APPROVED** the above named study in the belief that the study was conducted according to the activities and population specified in the protocol.

This approval includes review of the following attachments:

☒ Research report dated March 2023

☒ Informed Consent form: Consent Form

☒ **Data Collection Tool:** Questionnaire

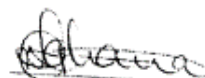
☒ Other materials: Letter of request for retrospective approval dated 29th February 2024

We look forward to receiving your progress reports and a final report at the end of the study. If you have any questions, please contact the Research and Ethics Committee at mohrcu@gmail.com (or) 59037919/58800246.

Sincerely,

DR. 'NYANE LETSIE

Director General Health Services



MRS. VERONICA LEHANA

Co-Chairperson National Health Institutional
Review Board (NH-IRB)

B: Observation tool

Observe/Actions	Yes	No	Comments
Are all the containers drip free?			
Is the general appearance of the food handler good?			
Are there any visible wounds on the food handlers' hands			
Are there any hand washing facilities in place?			
Are the nails cut short?			
Is the hair properly covered?			
Is the food handler wearing an apron?			
Is the milk served from its original container?			
Is there a third container used to serve the milk? E.g. cup?			
Is the food served inside a room?			
Is the milk pitcher made of plastic?			
Are the children encouraged to wash their hands before eating?			
Is the soap used for washing the hands?			
Are there any signs of rodents and vectors?			
Is there any rodent/vector control system in place?			
Are the toilets close to the classrooms?			
Is there any ceiling in the kitchen?			
Are the walls in good condition?			
Are the floors in good condition?			
Is there a fridge in place?			

C: Questionnaire translated into Sesotho

LIPOTSO TSA BAHLAHISI BA LEBESE

SELELEKELA

Ke thabela ho kopana le uena. Lebitso la ka ke ----- . Ke ntse ke etsa lipatlisiso ka pheto-phetoho ea lebese le mekhoha e amanang le bophelo bo botle. Ketso ena e etsoa e le karolo ea tlhahiso ea lebese Lesotho ho hlahloba hore na hona le tlhokahalo ea ho fetola mekhoha ea ho tšoarana le lebese. Thahasello ea lipatlisiso tsena ke ho phenya-phenya tsebo, maikutlo, boitšoaro le litloaelo malebana le lebese. Lipatlisiso tsena li tla etsoa likolong tsa 'muso tsa mathomo seterekeng sa Maseru. Litholoana tsa lipatlisiso tsena li tla fanoa ele tlatsetso lithupelong ka tšoaro ea lijo le tlhahiso ea lebese. Li ka boela tsa fanoa ele tlatsetso Lekaleng la Bophelo, Lefapheng la Toantso ea Mafu a hlahang lijong le mafapheng a mang. Litaba tse amanang le uena ka kotloloho li tla bolokoa ele lekunutu. Ke lumela hore u tla khahloa ke ho nka karolo lipatlisising tsena.

A. LITABA TSE AMANG UENA

1. Letsatsi _____
2. Lebitso la motšoare oa lijo _____
3. U lilemong tse lipakeng tsa _____
4. Boemo ba thuto:
☐ Ha kea kena sekolo ☐ Sekolo sa mathomo ☐ Sekolo se phahameng ☐ Sekolo se seholo
5. Lenane la bana ba feptjoang _____
6. Litšela-lebese tse sebelisitsoeng _____

TSEBO		
POTSO	E	CHE
Ana ho bohlokoa ho hlapa matsoho pele u tšoara lijo?		
Ana ho bohlokoa ho sebelisa sesepa ha u hlapa matsoho?		
Na lebese la ka fetisa mafu?		
Ana thupelo ea ho tšoara lijo e ea hlokahala?		
Na ho beha lebese sehatsetseng ho bolela ho fana ka lebese le batang?		
Na lebese le ka fanoa le lijo tse ling tse kang nama le bohobe?		
Ana phano (ea lebese) e nakong e bohlokoa?		
Ana malapi a hlakolang a ka baka 'mopo?		
Ana ho hloekisa libaka tse sebeletsang ho ka holisa bophelo bo botle?		
Ana motho ea nang le letšollo kapa lehlatsi joalo-joalo o lokela ho ea mosebetsing?		
Ana mocheso oa lebese o ka nkoa metsotso e mashome a mabeli kamorao hore lebese le hangoe?		
Ana lebese le ka bolokeha hantle tlasa mocheso o tloaelehileng?		
Ana lijo tse sa phehoang li ka se bolokoe le tse phehiloeng?		
Ana lebese le belisitsoeng le ka behoa mochesong o tloaelehileng bosiu kaofela la nto sebelisoa hoseng?		
Ana ho beha lijo sehatsetseng ho ka liehisa ho ata hoa 'mopo?		
Ana metsi a hloekileng a ka bonahala ka chebahalo feela?		
Ana nka eketsa ntho efe kapa efe lebeseng ho le etsa mafi kapa hona ho le tiisa?		
Ana lebese le feletsoeng ke nako le ka nna le jeoa?		
Ana lilekanya-mocheso li ka ba bohlokoa ho netefatsa hore lebese le belisitsoe?		

BOIKUTLO			
POTSO	E	HO HLOKA BONNETE	CHE
Ana ho hlapa matsoho khafetsa ha u lokisa lijo ho bohlokoa?			
Ana ho boloka sebaka sa ho phehela se hloekile ho ka fokotsa monyetla oa bokulo?			
Ana ho arola lijo tse phehiloeng ho tse sa phehoang ho thibela bokulo?			
Ke nahana hore ha hoa bolokeha ho siea lijo tse phehiloeng kante ho sehatsetse nako e fetang lihora tse peli?			
Ho bohlokoa ho hlahloba hore na lijo li ntse li le maamong a matle a hore li ka sebelisoa.			
Ke nahana hore ho bohlokoa ho qhala lijo tse feletsoeng ke nako.			
Ana ho sefa lebese ho bohlokoa?			
Na lebese le ka behoa letsatsing?			

BOIPOLELO BA BOITŠOARO					
POTSO	Kamehla	Khafetsa	Ka nako e 'ngoe	E seng khafetsa	Hohang
Ke hlapa matsoho pele le ha ke ntse ke lokisa lijo.					
Ke hloekisa sebaka sa ho lokisetsa lijo le lisebelisoa pele nka li sebelisa lijong tse ling hape.					
Ke arola lijo tse sa phehoang ho tse phehiloeng nakong eo ke li bolokang.					
Ke boloka lijo tsohle tse setseng sebakeng se pholileng nakong ea lihora tse peli.					
Nka kopanya lebese le setseng mme le sa ka la kengoa sehatsetseng le lee qetang ho hangoa.					
Ke hlahloba le ho qhala lijo tse feletsoeng ke nako.					
Ke futhumatsa lebese pele ke le sebelisa.					