HYGIENE AND NUTRITIONAL CONTENT OF THE NATIONAL SCHOOL NUTRITION PROGRAMME IN BLOEMFONTEIN, SOUTH AFRICA

by

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DECLARATION

I, the undersigned, hereby declare that the work contained in this dissertation is my own original work, except for assistance which is acknowledged. I declare further that I have not previously submitted this dissertation, in its entirety or partially, at any other tertiary institution in respect of a qualification.

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SUMMARY

Malnutrition and concomitant infections are major contributing factors to child morbidity and mortality in developing countries such as South Africa. Globally, children benefiting from school feeding programmes are generally from communities with low socio-economic statuses. The meals provided through feeding schemes, such as the National School Nutrition Programme (NSNP) in South Africa, are aimed at significantly supplementing the beneficiaries' daily energy and nutrient requirements. The possible nutrient deficiency of meals provided through such programmes compromises the nutritional well-being of children, promotes malnutrition and renders children more susceptible to infectious diseases. Furthermore, illness, particularly caused by diarrhoeal and infectious diseases, is a major factor contributing to child malnutrition as the human body is unable to efficiently digest foods and absorb nutrients during illness. Therefore, the microbiological safety of the foods served to children via feeding schemes is essential. In an effort to contribute towards the safety and wholesomeness of foodstuffs served through the NSNP, the present study was conducted with a view to assess the nutritional quality and safety of the foodstuffs. The knowledge, attitudes and practises (KAP) of food handlers and NSNP representatives/committee members at the schools were also investigated in order to assess origins of potential food contamination.

Data collected via nutritional analyses of meals served to school children were compared to the nutrient-based standards set by the United Kingdom as guidelines for an average school lunch. The carbohydrate, energy, calcium and zinc contents of the school meals were below the standards, the majority of the meals met the protein and iron standards and all meals complied with the standards for lipid and vitamin C contents. During the microbiological analysis study, preparation surfaces yielded higher counts of all detected organisms (total coliforms, *Escherichia coli*, *Staphylococcus aureus* and yeasts and moulds) compared to the hands of food handlers. Therefore possible sources of contamination may be foodstuffs, animal pests and environmental elements such as dust. However, significant differences of surface microbial counts could not be established ($P > 0.05$) and thus cross-contamination may have resulted among

surfaces, possibly augmented by shortfalls in cleaning regimes. The majority of the participants of the questionnaire survey reportedly washed their hands and cleaned all surfaces several times during the day with water and detergent. In addition, a disinfectant was used by some of the food preparers during cleaning. Furthermore, participants stated that their aprons were washed daily. These claims were in agreement with the findings of the surface microbial study with regards to the hands, however, they did not match the findings of the preparation surfaces which contained the highest counts of total coliforms, *E. coli* and *S. aureus* of the three surfaces analysed, and aprons responsible for the highest yeast and mould counts.

Improper storage and food preparation methods, such as the application of high temperatures, excessive exposure to UV light and oxygen, and high moisture conditions, may result in the deterioration of nutrients. Storage conditions which may permit pest infestation may also increase the risk of food-related illnesses and risk could be further elevated by application of improper cleaning and sanitation practices. In order for the NSNP to operate effectively, it is essential that the national and provincial Departments of Basic Education, which are responsible for the overall administration of the NSNP, and schools' personnel function in an integrated manner through support structures and effective communication. Infrastructural limitations (lack of proper kitchen facilities and ventilation) and shortage of resources while administering the NSNP were the main challenges observed during the present study. Due to these hurdles, adhering to food safety practices and maintaining nutritional quality of foods may be a challenge. Continuous training in personal and general hygiene is also a necessity in preserving food safety. Furthermore, nutritional quality of foodstuffs may be preserved through proper storage practices and application of preparation methods which minimize loss of nutrients.

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LIST OF ACRONYMS

ADHD	Attention deficit hyperactivity disorder
BCCDC	British Columbia Centre for Disease Control
BHT	Butylated hydroxytoluene
BPA	Baird parker agar
CCA	Chromocult coliform agar
CCPs	Critical Control Points
CDC	Centers for Disease Control and Prevention
CFU	Colony Forming Unit
DBE	Department of Basic Education
DoE	Department of Education
DoH	Department of Health
EFSA	European Food Safety Authority
FSA	Food Standards Agency
GHPs	Good hygiene practices
GMPs	Good manufacturing practices
HACCP	Hazard Analysis Critical Control Point
HUS	Haemolytic uraemic syndrome
HPLC	High-Performance Liquid Chromatography
ICP-OES	Inductively coupled plasma-optical emission spectrometry
INP	Integrated Nutrition Programme
KAP	Knowledge, attitudes and practices
MDGs	Millennium Development Goals
MEC	Member of the Executive Council
NSNP	National School Nutrition Programme
PCA	Plate count agar
PDA	Potato dextrose agar
PMG	Parliamentary Monitoring Group
PRPs	Pre-requisite programs
PSC	Public Service Commission
PSNP	Primary School Nutrition Programme

Q	Quintile
RI	Refractive index
SGB	School Governing Body
TNTC	Too numerous to count
TVC	Total viable count
VFHs	Volunteer Food Handlers
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION TO THE SOUTH AFRICAN NATIONAL SCHOOL NUTRITION PROGRAMME

The right to education is one of the basic human rights reserved in the Bill of Rights contained in the Constitution of South Africa (Currie and De Waal, 2005). However, due to poverty in communities across the country, the learning process in schools tends to be hindered by factors such as malnutrition and hunger (PSC, 2008). In an effort to avert these factors, the Integrated Nutrition Programme (INP) was developed from the recommendations of a nutrition committee appointed in 1994 by the residing Minister of Health to develop a nutrition strategy for South Africa. The committee recommended an integrated approach to nutrition as a replacement for the preceding fragmented food-based approach (Kloka, 2003).

The Primary School Nutrition Programme (PSNP), a school feeding scheme which formed part of the Department of Health's INP, was introduced nationwide in South Africa in September 1994. This followed former President Nelson Mandela's announcement in his State of the Nation Address on the 24th of May 1994 that such a nutritional feeding scheme would be implemented in every primary school where a need was identified (Kloka, 2003; Noe, 2005; Ntuli, 2009). The PSNP was primarily designed to improve active learning capacity by providing direct services to primary school learners to alleviate the effects of malnutrition and was aimed to improve educational outcomes by alleviating short-term hunger and improving school attendance and participation (Meaker, 2008; Ntuli, 2009). Since the programme was conceptualised to focus primarily on educational outcomes rather than on health issues and since the then Department of Education (DoE) had been tasked with the mandate of working directly with schools, responsibility for the programme was transferred from the Department of Health (DoH) to the former DoE in 2004 to improve its efficiency in schools (PSC, 2008).

Since its initiation, the PSNP catered for the most needy primary school learners, i.e., learners from communities with low socio-economic status. However, following the 2006 survey by the Fiscal and Finance Commission, it was confirmed that there was a need to expand the programme to secondary schools (DBE, 2009). Upon its extension to secondary schools, the PSNP was renamed the National School Nutrition Programme (NSNP). Ntuli (2009) quotes the former KwaZulu-Natal Member of the Executive Council (MEC) for education, Ms Ina Cronjé, as follows: "Our idea as the department is to provide meals for all the poor schools regardless whether it is a primary or secondary school. We want all the hungry learners to be fed in our schools". In April 2009, the NSNP was successfully extended for the first time to secondary schools (DBE, 2010a) and is currently administered by the Department of Basic Education (DBE).

The DBE (2009) classifies the NSNP as one of the essential components of the government's Programme of Action, which was specifically assigned the responsibility of addressing children's ability to learn by providing them with nutritious meals. The success thereof may contribute towards the country's realisation of the Millennium Development Goals (MDGs) which include reduction of child mortality, achieving universal primary education and eradication of extreme poverty and hunger by 2015 (PSC, 2008; Kimani-Murage *et al.*, 2011). The following are the objectives of the NSNP: to alleviate poverty and improve learning capacity of children through school feeding; to generate and promote sustainable food production and economic activities in school communities; to strengthen nutrition education in schools; to increase attendance of learners and to obliterate school dropout; to increase the pass rate; to reduce the unemployment rate, particularly among women; to reduce the incidents of child mortality, mobility and the morbidity rate; to empower poverty-stricken communities, particularly in the rural areas across all nine provinces in South Africa; and to increase the transfer of skills and self-reliance (PMG, 2007; Seoketsa, 2007; PSC, 2008). It is essential that this programme is managed in such a manner that its aims and objectives are met in order to abundantly benefit the learners served (Seoketsa, 2007).

The NSNP is funded through a provisional grant that is transferred to provinces according to the Division of Revenue Act and directives from the DBE and National

Treasury (Grant Framework 2010/11) (DBE, 2010a; DBE, 2011). The DBE coordinates and oversees the programme, ensuring adherence to policies and relevant legislation through monitoring. The Provincial Education Departments are tasked with the procurement of goods and services for the NSNP while adhering to conditions stipulated by the Grant Framework (DBE, 2010a; DBE, 2011). Ntuli (2009) explains that schools are funded according to a national system of ranking and funding of schools referred to as a quintile (Q). The DBE ranks schools within quintiles according to this system, taking into account the socio-economic circumstances, such as inequality and poverty, of learners and schools. For example, schools rated at the lowest quintiles (1 and 2) receive more funding based on the Norms and Standards for Funding Schools (Ntuli, 2009). The schools targeted are primary and secondary schools ranked in Q1 to Q3 (DBE, 2010a; DoE, 2009).

The provincial/district office and/or schools are allocated funds for the procurement of equipment, utensils and foodstuffs (DoE, 2009). Food items are delivered to schools by private contractors and further prepared on the school premises (Noe, 2005). At each participating school, the school principal is responsible for the overall management and success of the programme. Operational responsibility for the NSNP is assumed by an educator/administrator nominated by the school principal as a NSNP school coordinator. The school coordinator supervises the daily activities of the programme such as receiving and recording stock, maintaining and updating records of all invoices, meals served and number of learners fed per day. Each school has a nutrition committee comprising the NSNP school coordinator, school management team, a school governing body (SGB) member, a food handler, and/or a food gardener (DoE, 2009). The SGB provides support in addressing any additional requirements of the programme and ensuring that the programme is implemented effectively. He/she is also responsible for identifying unemployed community members to be recruited as volunteer food handlers (VFHs) who will be responsible for the preparation and serving of meals and for the maintenance of the preparation area (PSC, 2008; DoE, 2009). The VFHs are required to handle foodstuffs in a manner that preserves the safety and nutritional quality of foods (DBE, 2009). The NSNP is further facilitated by other government departments such as the Departments of Health and Agriculture, and a number of private companies nationwide, such as Massmart Holdings Limited (DBE, 2011).

DBE (2010a) indicates some achievements of the programme during the financial year 2009/10 as: supplying meals to approximately 7 million learners in over 20 thousand schools nationally; successful extension of the programme to Q1 secondary schools; improvement in the quality of meals (provincial menus included vegetables and fruits); providing learners with cooked meals five days a week; and the transfer of approximately R83 147 million to provincial departments to procure equipment in preparation to extend the programme to Q2 secondary schools in April 2010 (DBE, 2010a). Furthermore, the number of VFHs increased when compared to the previous financial year. Plans for the 2010/11 financial year included strengthening monitoring, research, programme advocacy and partnerships to ensure quality meals, and to prepare for the expansion of the programme to Q3 secondary schools in 2011 (DBE, 2010a).

The first issue of the NSNP Newsletter “Inside NSNP” reported that the programme provided daily nutritious meals to a significant number of school learners nationally. The DBE continues to encourage schools to promote healthy eating and food safety through training workshops. This is achieved through activities such as the NSNP Best School Awards, where the winning school and nominated schools receive prizes, and the NSNP Newsletter (DBE, 2010b).

1.2 NUTRITIONAL PROPERTIES OF THE NATIONAL SCHOOL NUTRITION PROGRAMME

According to Whitney and Rolfes (2008) and Insel *et al.* (2013), approximately 14% of the world’s population experiences persistent hunger and 60% of deaths of children globally may be attributed to poor nutrition. Furthermore, the prevalence is greater and the consequences more severe in developing countries with the primary cause being poverty. An estimated 1.3 billion people live in poverty in developing countries and of these approximately 798 million suffer from chronic hunger (Nnakwe, 2013).

Sound nutrition is a basic human right stipulated in South Africa's Constitution, through the Bill of Rights, and comprises more than simply the availability of food or the consumption of a certain amount of nutrients per day. According to Kloka (2003), nutrition security incorporates food security, health security and care security, where security refers to sustainability with food and good nutrition being provided on a continual basis. Furthermore, nutrition security entails physical and economic access to a balanced diet and safe drinking water to all people at all times (Panda, 2010). Nutrition security is particularly vital throughout the school attending period for providing children with opportunities to express their full innate potential in physical and mental development (Panda, 2010). Therefore, the DBE has an obligation to ensure that nutrition security is respected, protected, facilitated and provided to those it serves through the NSNP.

Twenty-four workshops on menu planning, meal preparation, food safety and hygiene were conducted by the DBE during the 2009/10 financial year to aid in improvement of meal quality (DBE, 2010a). The workshops were compulsory and were targeting provincial coordinators, VFHs and NSNP supervisors in six provinces namely Free State, KwaZulu-Natal, Limpopo, Mpumalanga, Northern Cape and North-West. Menus for the meals provided to learners follow the Food Based Dietary Guidelines, which provide for a variety of food items inclusive of vegetables and fruits (DBE, 2010a).

1.2.1. Malnutrition

Nutrition is defined as all the processes during which the body ingests, digests, absorbs, transports, utilizes and excretes food components (Marotz *et al.*, 1997). According to Blake *et al.* (2010) and Insel *et al.* (2013), nutrients are constituents of food that maintain these body processes which include providing building blocks to replace body cells as they perish. Nutrients also provide the body with energy to perform all body functions and processes which may involve any activities from maintaining a heartbeat to participating in classroom activities (Blake *et al.,* 2010). Since the majority of foodstuffs contain numerous nutrients, nutrient deficiencies are usually multiple; therefore a poor diet may affect the intake level of various nutrients (Brown, 2002). Nutrients are regarded as essential since the human body is unable to produce them or produce them in sufficient quantities to maintain body functions. They should therefore be obtained from the food ingested (Blake *et al.,* 2010).

Malnutrition is poor nutrition which results from both inadequate and excessive intake of nutrients in the body (Brown, 2002). Roday (2007) defines malnutrition as the significant deficiency (under-nutrition) or excess (over-nutrition) of a nutrient or energy over time, while under-nutrition is most prevalent in poverty stricken communities in developing countries. Chronic deficiency of a nutrient will impact the body's ability to function in the short-term and over time. Moreover, chronic deficiencies, excesses and imbalances will affect long-term health. A study conducted in Uganda by Acham *et al*. (2012) linked learning to the health and nutrition of school children. Results from this study suggested poor school achievements as an indicator of under-nutrition; in particular, school-aged children deficient in iodine and iron exhibited diminished learning capacity when compared to children replete with these minerals. The lack of nutrients encourages fortification of food with vitamins and minerals such as with the fortified maize meal served by the NSNP.

According to Wardlaw *et al.* (2004), children from low-income communities generally experience more nutritional deprivation and overall illnesses, and are more severely affected than children from less economically deprived communities. Poverty (the inability to secure the minimum consumption requirements for life and health efficiently) is therefore a major cause of hunger and malnutrition (Nnakwe, 2013). Additionally, illnesses constitute one of the major factors contributing to child malnutrition, particularly by causing diarrhoea and infectious diseases, as they interfere with the body's ability to utilize the nutrients consumed (Panda, 2010). Conversely, malnutrition makes a child more susceptible to infectious diseases, and the combination of malnutrition and infection is a major contributing factor to child morbidity and mortality in developing countries (Wardlaw *et al.*, 2004; Blake *et al.,* 2010). Figure 1.1 indicates the cyclical relationship between malnutrition and infection. With a deficiency of energy, the person may develop the symptoms of under-nutrition with an evident loss of body mass and becoming prone to infection and disease. With the deficiency of a nutrient, the person may experience skin rash, depression, hair loss, bleeding gums, muscle spasms, night blindness and/or other symptoms. Symptoms such as diarrhoea, skin rash and fatigue are easily overlooked as indicators of malnutrition because they resemble the symptoms of other diseases (Whitney and Rolfes, 2008). Nutrition, in general, plays an important role in preventing disease and promoting health.

Micronutrient deficiencies are prevalent in South Africa and are affecting especially vulnerable groups such as children and elderly people who are at a higher risk of becoming inadequately nourished (Brown, 2002; Kloka, 2003). There is no single food source which contains all the required nutrients. Adequate diets are achievable by including foods that are quality sources of numerous nutrients and should include fruits, vegetables, grains and dairy and meat products (Brown, 2002). In addition to poor nutritional status, knowledge of nutrition among South African communities is unsatisfactory and, even among those with relatively accurate knowledge, it is often not applied (Walsh, 1995). The NSNP is therefore a key strategic programme in decreasing the effects of malnutrition among school attending children in South Africa (DBE, 2010a).

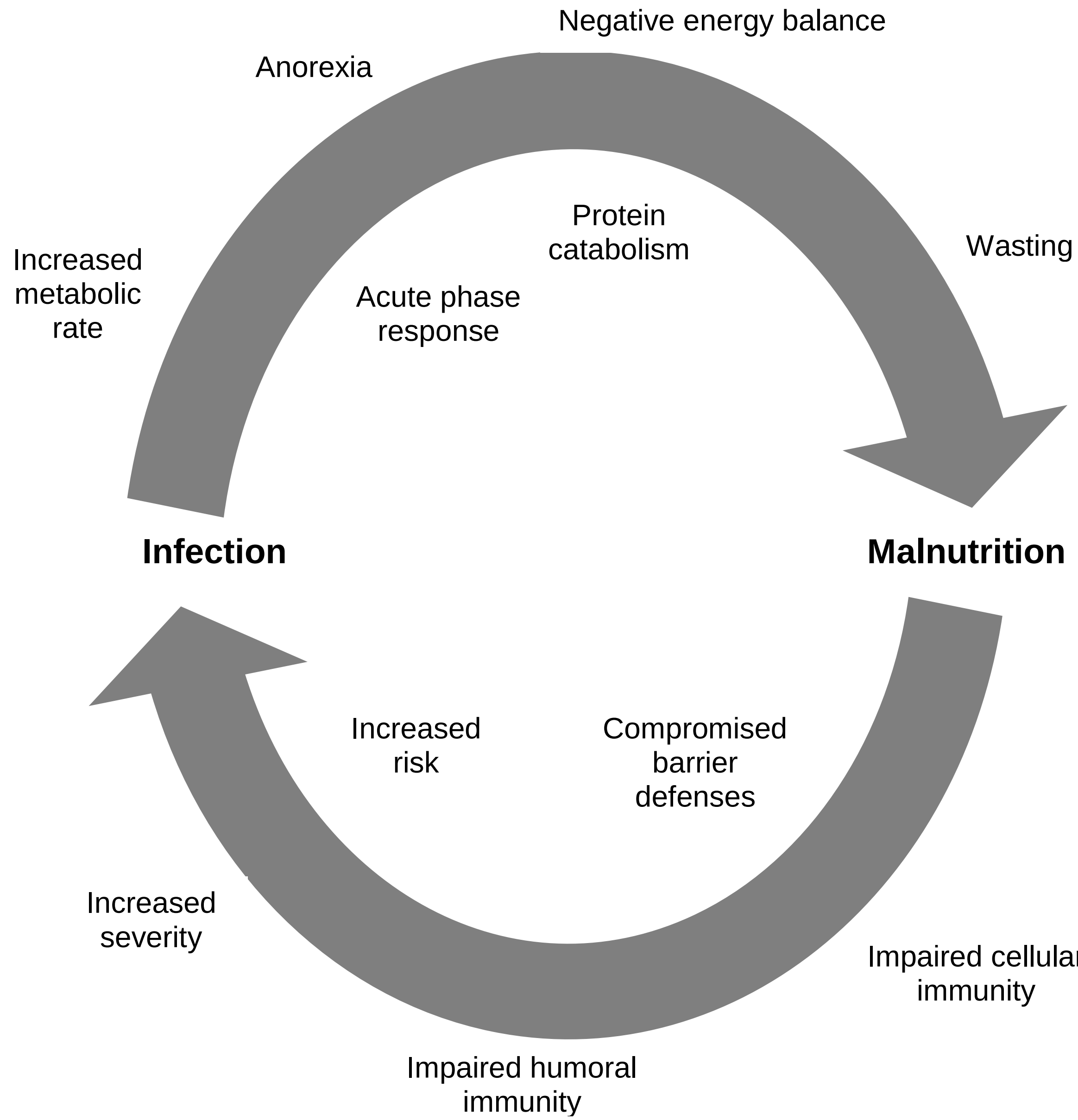

Figure 1.1. Cycle of infection and malnutrition (adapted from Macallan, 2009)

1.2.2. Nutrition during childhood and adolescence

Childhood and adolescence are periods in which the human body develops from infancy to adulthood. During these periods, the body changes significantly in terms of physical, hormonal, reproductive and emotional status (Eastwood, 1999). Due to the rapid growth and development of children, nutritional wellbeing is critical during childhood and adolescence. Furthermore, the nutritional state of an individual is dependent on total food intake, rate of growth and physical activity (Francis, 1986; Whitney and Rolfes, 2008). Carbohydrate intake, as a measure of percentage, for children beyond one year of age, should remain the same through the ages into adulthood (Whitney and Rolfes, 2008; Blake *et al.*, 2010; and Insel *et al.*, 2013). Fibre recommendations for younger children with low energy intakes are less than those for older ones with high energy intakes. In addition, the protein requirement declines slightly with age when the child's body weight is considered; however, total protein needs increase slightly with age, while the vitamin and mineral requirements of children increase with age. Energy and nutrient needs are greater during adolescence than at any other stage of life, except during pregnancy and lactation. Characteristically, nutrient needs rise throughout childhood, peak in adolescence and then level off or diminish as the adolescents become adults (Whitney and Rolfes, 2008; Insel *et al.*, 2013). It is noteworthy that all people throughout life need the same nutrients in varying quantities (Marotz *et al.*, 1997). Feeding and nutrition education programmes in schools, when adequately implemented, provide not only essential nutrients for the children, but they also provide the opportunity for children to learn to make responsible choices regarding dietary intake (Lucas, 1993).

When children do not receive regular meals, their behaviour and academic performance are affected (Simeon, 1998). Non-specific symptoms of malnutrition are frequently seen in children with nutritional imbalances. In the majority of the cases these are of a psychological nature and include: impulsive and difficult behaviour; perceptual and auditory disability; acting without considering the consequences of their actions; seldom finishing tasks that they have started; imperviousness to the feeling of others; stubbornness; displaying a negative attitude;

and bullying may be part of the syndrome (Serfontein, 2001). Under-nutrition during childhood may further weaken resistance to infection because immune function decreases when nutrients such as protein, vitamin A and zinc are inadequate in the diet (Figure 1.1) (Wardlaw *et al.*, 2004). Essential vitamins and minerals for young children (ages 2 to 8) include iron, zinc, vitamin E, and vitamin D and for adolescents (ages 9 to 19), micronutrient requirements include iron, calcium and vitamin A (Insel *et al.*, 2013). Nutrients most likely to be low or deficient in growing children are calcium, iron and vitamins A and C (Lucas, 1993). Deficiencies in vitamin A, zinc, iron and protein may result in illness, stunted growth, partial development and possibly permanent blindness. Whitney and Rolfes (2008) recommend that children's meals should include a variety of foods from each food group to provide all the required nutrients. Healthy, well-nourished children are usually alert in the classroom and energetic while performing physical activities.

1.3. FOOD SAFETY ASPECTS ASSOCIATED WITH THE NATIONAL SCHOOL NUTRITION PROGRAMME

Food-borne illness resulting from consumption of foods or beverages contaminated with pathogenic bacteria has been an important public health concern for several years (Caillet *et al*., 2009). In earlier years, investment in food safety interventions was not considered a priority in developing countries where the main concern was the sufficient supply of food (Käferstein, 2003). This tendency has altered over the years with the increase in food related diseases. Estimations indicate that each year approximately a million people suffer from a food-borne illness, about 20 000 people receive hospital treatment and that there are around 500 deaths caused by food-borne illness in the United Kingdom alone (FSA, 2011). Estimates in the United States indicate that roughly 48 million people become ill each year, 128 000 are hospitalized, and 3 000 die due to food-borne diseases (CDC, 2013). In addition, estimations by the World Health Organization (WHO) reveal that 70% of the diarrheal diseases in African children are due to consumption of contaminated complementary food, leading to an estimated 30 660 deaths of children per year in Africa (CDC, 2013). In South Africa records of food-borne illnesses are not efficiently documented and although food-borne disease outbreaks are common in the country, literature reporting this is insufficient (Benade, 1996; Karas *et al.*, 2001; Smith *et al.*, 2007). Figure 1.2 indicates that diarrhoeal related diseases accounted for an average of 4% deaths among children of all ages in South Africa during 2000, while deaths due to bacterial meningitis were in excess of 2%. One of the regulations of section 2(1)(b)(i) of the *Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act 54 of 1972)* of South Africa states that no foodstuffs should contain microorganisms at levels which may cause harm to humans upon consumption. Furthermore, the Regulations Relating to Foodstuffs for Infants, Young Children and Children (R.1130 of 1984) stipulate that these foods should be free from pathogenic microorganisms and/or their toxins (DoH, 2000).

Rovira *et al.* (2007) describe a biological risk as the probability of a biological hazard contaminating food during the food production process. Various microorganisms associated with foods are beneficial, however, some may exhibit pathogenic characteristics posing severe health risks (Rovira *et al.*, 2007). Although it may be essential to consume a wide variety of foodstuffs, it is equally important to be aware of the risks associate with pathogens which may be present in these foodstuffs. Food-borne pathogens such as *Shigella, Staphylococcus aureus, Bacillus cereus, Clostridium perfringens* and *Escherichia coli* are important causes of morbidity in the world (Wren, 2006). These bacteria cause severe gastrointestinal symptoms such as vomiting and diarrhoea and, in the case of botulism poisoning, may result in death (Blake *et al.*, 2010). Table 1.1 summarises the pathogenic bacteria commonly found in foods. Some prerequisites for the development of food-borne infections include the mismanagement of raw or prepared foods and possible opportunities for contamination and multiplication of microorganisms (Ziady and Small, 2004). Contamination may occur at any stage during the handling of food; however, food-borne illnesses are rarely traced to the food processing plants and the majority of incidences originate from food preparation environments such as restaurants (Brown, 2011). According to Brown (2011), outbreaks are caused by contaminated foods, failure of sanitization processes or contamination of foods after sanitization.

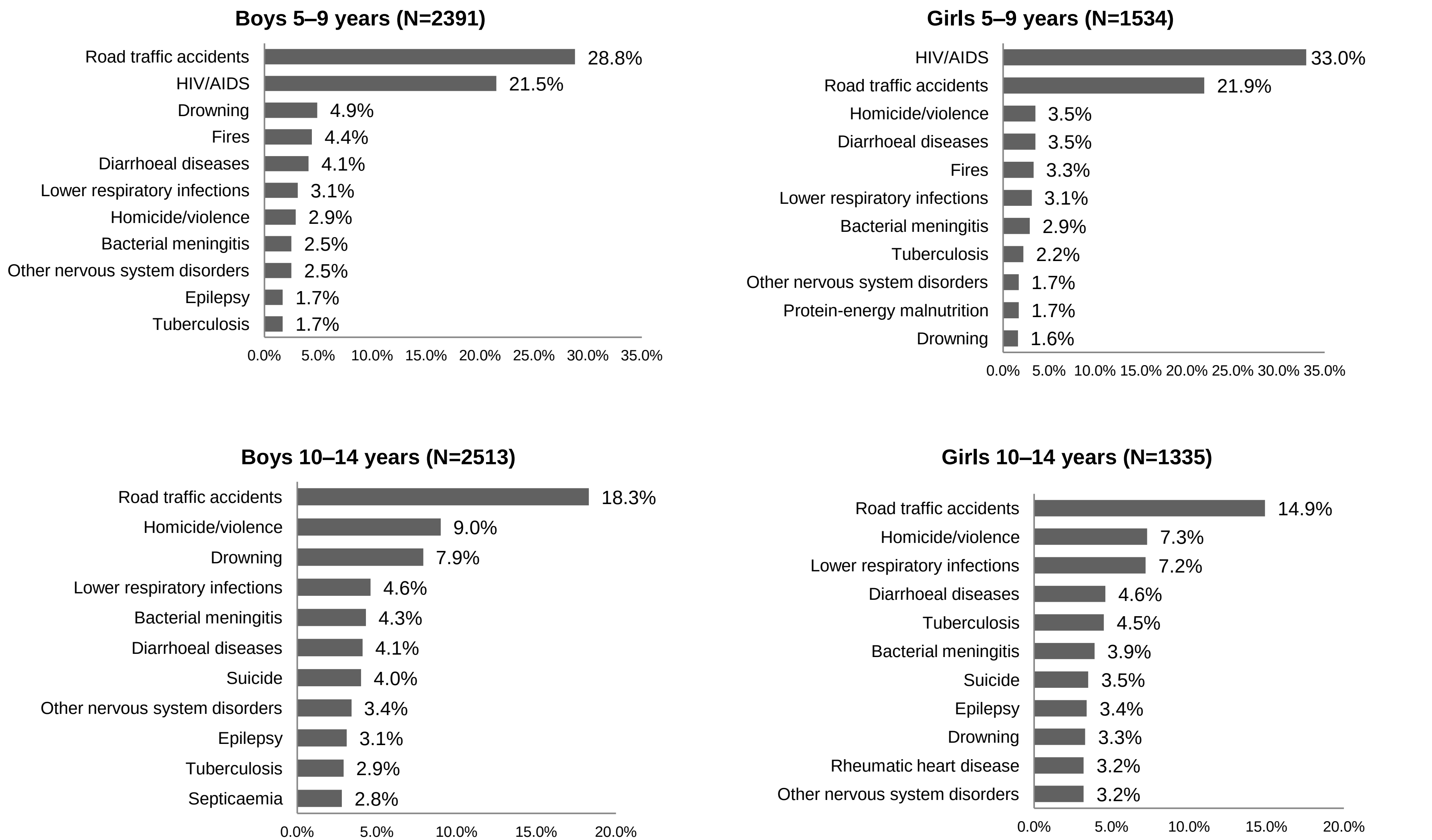

Figure 1.2. Leading causes of mortality among children aged 5–14 years, South Africa 2000 (adapted from Bradshaw *et al.*, 2003)

Table 1.1. Common food-borne pathogens and illnesses (adapted from Insel *et al.*, 2013)

Bacteria	**Sources**	**Diseases and symptoms**
Campylobacter jejuni	Raw poultry, meat and unpasteurised milk	Campylobacteriosis *Onset*: usually 2 to 5 days after eating *Symptoms*: diarrhoea, stomach cramps, fever, bloody stools - lasts 7 to 10 days
Clostridium botulinum (illness is caused by a toxin produced by this organism)	Improper canned foods such as corn, green beans, soups, beets, asparagus, mushrooms, tuna, and liver pate; also, luncheon meats, ham, sausage, garlic in oil, lobster, and smoked and salted fish	Botulism *Onset*: 18 to 36 hours after eating *Symptoms*: nerve dysfunction such as double vision, inability to swallow, speech difficulty, and progressive paralysis of respiration system. Can lead to death.
Escherichia coli O157:H7	Raw or undercooked meat, raw vegetables, unpasteurised milk, minimally processed ciders and juices, contaminated water	*E. coli* infection *Onset*: 2 to 5 days after eating *Symptoms*: watery and bloody diarrhoea, severe stomach cramps, dehydration, colitis, neurological symptoms, stroke, and haemolytic uremic syndrome (HUS), a particularly serious disease in young children that can cause kidney failure and death.
Listeria monocytogenes	Soft cheeses, unpasteurised milk, hot dogs, luncheon meat, cold cuts, other deli-style meat and poultry *Note*: resist salt, heat, nitrites, and acidity better than most microorganisms	Listeriosis *Onset*: 7 to 21 days after eating, but symptoms have been reported 9 to 48 hours after eating *Symptoms*: fever, headache, nausea, and vomiting; primarily affects pregnant women and their foetuses, newborns, older adults, and people with cancer and compromised immune systems. Can cause death in foetuses and babes.

Table 1.1. Common food-borne pathogens and illnesses (continued)

Bacteria	**Sources**	**Diseases and symptoms**
Salmonella	Raw or undercooked meats, poultry, eggs, raw milk and other dairy products; seafood; fresh produce, including raw sprouts; coconut; pasta; chocolate; foods containing raw eggs	Salmonellosis *Onset*: 1 to 3 days after eating *Symptoms*: nausea, abdominal cramps, diarrhoea, fever, and headache
Shigella	Undercooked liquids or moist food that has been handled by an infected person	Shigellosis (bacillary dysentery) *Onset*: 12 to 50 hours after eating *Symptoms*: stomach cramps; diarrhoea; fever; sometimes vomiting; and blood, pus, and mucus in stools
Staphylococcus aureus (illness is caused by a toxin produced by this organism)	Meat and poultry; egg products; tuna, potato, and macaroni salads; cream-filled pastries and other foods left unrefrigerated for long periods *Note*: S. aureus is frequently found in cuts on skin and nasal passages	Staphylococcal food poisoning *Onset*: 1 to 6 hours after eating *Symptoms*: diarrhoea, vomiting, nausea, stomach pain and cramps - lasts 1 to 2 days.
Vibrio vulnificus	Raw seafood, especially raw oysters	Vibrio infection *Onset*: 1 to 7 days after eating *Symptoms*: chills, fever, nausea and vomiting, and possibly death, especially in people with underlying heath problems

Additionally, the main factors associated with food-borne illness are poor personal hygiene, cross-contamination and incorrect time/temperature control. The general principle steering food safety is to provide food that will not cause harm when consumed. To prevent food-borne illness, food service personnel, food flow (such as purchasing, storage, preparation, cooking, holding, cooling, reheating and sanitation) and food safety programmes should be implemented and closely monitored (Brown, 2011). Furthermore, food safety is achievable by the application of a number of systems which include good manufacturing practices (GMPs), good hygiene practices (GHPs) and hazard analysis critical control point (HACCP) systems as well as pre-requisite programs (PRPs) which provide guidelines to minimize the risk of contamination (Blackburn, 2003; Brown, 2011).

1.4. RATIONALE

1.4.1. Problem delineation

Food poisoning contributes significantly to mortality and despite advances in hygiene, consumer knowledge, food treatment and food processing, food-borne pathogens represent a significant threat to human health worldwide (Wren, 2006). The South African food legislation further requires that surfaces and foodstuffs made available to the general public should be hygienic and free of harmful substances and organisms (R.1183 of 1990; R.918 of 1999). Although annual reports of the DBE indicate the success of the NSNP (DBE, 2009; DBE, 2010a; DBE, 2011), studies conducted in various areas in the country focusing on the efficacy of the programme revealed deficiencies. A study by Napier *et al.* (2009) indicated that malnutrition remains a persistent problem amongst school children even with the implementation of programmes such as the NSNP. Results of studies by Noe (2005) and Manyatsa (2007) indicated a lack of resources to support the daily operations of the programme in schools. Children catered for by feeding programmes are from poverty stricken communities and possibly attend schools without receiving decent meals and for majority of these children, the meals provided through the NSNP are their main, and in some cases their sole, sources of energy and nutrients. If these meals are nutrient deficient, the nutritional wellbeing of the recipients may be compromised and further promotes malnutrition. Feeding children at schools motivates them to attend classes and children learn more efficiently when they are fed. An improvement in school attendance was observed as a result of the intervention of a school feeding programme in Kenya (Vermeersch and Kremer, 2004). With education, these children may be able to discontinue the cycle of poverty in society.

As indicated in the first newsletter of the year 2010, the NSNP considers nutrition, food safety and food being served in a dignified manner a priority (DBE, 2010b). Previous studies conducted with regards to the programme were conducted before 2009 while it was still the PSNP (Noe, 2005; Manyatsa, 2007; Napier *et al.*, 2009). These studies therefore focused mainly on fortified biscuits, which was the main food item served by the programme during their studies. Since then two major changes have been implemented with regards to the programme: 1) it has currently expanded to secondary schools; and 2) a more diverse menu has been introduced. The wider food range on the menu offers the programme a nutritional advantage; however it further allows for a wider opportunity for microbial contamination. Additionally, with cases of food-borne illnesses on the increase, food safety should not be overlooked. Food safety is essential with regards to the NSNP because it caters for young, school-aged children. Young children are at greater risk of contracting food poisoning since their digestive and immune systems are not as fully developed as in adults. Food poisoning outbreaks are even more prevalent in settings, such as that of the NSNP, where food is served in large quantities, by a variety of people and to numerous individuals.

1.4.2. Aim and objectives

The overall aim of this study was to contribute towards the safety and wholesomeness of food served through the NSNP.

The objectives of this study are listed as follows:

- To evaluate the nutritional content of foodstuffs served through the NSNP;
- To determine the microorganism prevalence on various surfaces that may come into contact with food products as an indicator of general hygiene during the administering of the programme;
- To determine the knowledge, attitudes and practices (KAP) of the food handlers and NSNP representatives with regards to food safety; and
- To conclude on the inter-relationships and contribution of the empirical data to the overall problem and the identification of possible solutions.

It is envisaged that the findings and recommendations as reported in this dissertation will contribute to the body of knowledge of school feeding schemes. In addition, the findings and recommendations will be offered in an attempt to improve the effectiveness of the NSNP for its beneficiaries by making suggestions towards preserving the nutritional content of meals served and reducing the health risks associated with foodstuffs.

REFERENCES

Acham, H., Kikafunda, J.K., Malde, M.K., Oldewage-Theron, W.H. and Egal, A.A. (2012). Breakfast, midday meals and academic achievement in rural primary schools in Uganda: implications for education and school health policy. *Food & Nutrition Research*. 56, 1.

Benade, J.G. (1996). A massive outbreak of food poisoning – a reminder of the importance of proper toxic waste control. *South African Medical Journal*. 86, 551–552.

Blackburn, C. de W. (2003). Microbiological analysis and food safety management: GMP and HACCP systems. In *Detecting pathogens in food*. T.A. McMeekin (Ed). Cambridge: Woodhead Publishing Limited, pp. 3–17.

Blake, J.S., Munoz, K.D. and Volpe, S. (2010). *Nutrition: from science to you*. San Francisco: Pearson Benjamin Cummings.

Bradshaw, D., Bourne, D. and Nannan, N. (2003). *What are the leading causes of death among South African children?*. Cape Town: Burden of Disease Research Unit, Medical Research Council.

Brown, A. (2011). *Understanding food: principles and preparation*. 4th edition. Belmont: Wadsworth Publishing.

Brown, J.E. (2002). *Nutrition now.* 3rd edition. Belmont: Wadsworth Group.

Caillet, S., Ursachi, L., Shareck, F. and Lacroix, M. (2009). Effect of gamma radiation and oregano essential oil on murein and ATP concentration of *Staphylococcus aureus*. *Journal of Food Science*. 74, M499–M508.

Centers for Disease Control and Prevention (CDC). (2013). Estimates of foodborne illness in the United States. Available from: http://www.cdc.gov/foodborneburden/index.html. Date of access: 2013/02/04.

Currie, I. and De Waal, J. (2005). *The Bill of Rights handbook*. 5th edition. Claremont: Juta & Company Ltd.

Department of Basic Education (DBE). (2009). National School Nutrition Programme: 2008 Annual Report. Pretoria: Government Printers.

Department of Basic Education (DBE). (2010a). National School Nutrition Programme: Annual Report 2009/10. Pretoria: Government Printers.

Department of Basic Education (DBE). (2010b). *Inside NSNP*, Issue1, December 2010. Pretoria: Government Printers.

Department of Basic Education (DBE). (2011). National School Nutrition Programme: Annual Report 2010/11. Pretoria: Government Printers.

Department of Education (DoE). (2009). National School Nutrition Programme: a guide for secondary schools. Pretoria: Department of Education.

Department of Health (DoH). (2000). Guidelines for environmental health officers on the interpretation of microbiological analysis data of food. Pretoria: Directorate of Food Control, Government Printer.

Eastwood, M. (1999). *Principles of human nutrition*. Maryland: Aspen Publishers, Inc.

Food Standards Agency (FSA). (2011). Foodborne disease strategy 2010-15: an FSA programme for the reduction of foodborne disease in the UK. Available from: http://www.food.gov.uk/multimedia/pdfs/fds2015.pdf. Date of access: 2013/02/04.

Francis, E.M. (1986). *Nutrition for children*. London: Blackwell Scientific Publications.

Insel, P., Ross, D., McMahon, K. and Bernstein, M. (2013). *Discovering nutrition*. 4th edition. Burlington: Jones & Bartlett Learning.

Käferstein, F. (2003). Foodborne diseases in developing countries: aetiology, epidemiology and strategies for prevention. *International Journal of Environmental Health Research*. 13, S161–S168.

Karas, J.A., Nicol, M.P., Martinson, N. and Heubner, R. (2001). An outbreak of food poisoning among children attending an international sports event in Johannesburg. *South African Medical Journal*. 91, 417–421.

Kimani-Murage, E.W., Norris, S.A., Pettifor, J.M., Tollman, S.M., Klipstein-Grobusch, K., Gómez-Olivé, X.F., Dunger, D.B. and Kahn, K. (2011). Nutritional status and HIV in rural South African children. *BMC Pediatrics.* 11, 23.

Kloka, D. (2003). Integrated Nutrition Programme (INP). Background document for Cabinet briefing. Pretoria: Department of Health.

Lucas, B. (1993). Nutrition and the school-age child. In *Nutrition in Infancy and Childhood.* L.P. Pipes and C.M. Trahms (Eds). 5th edition. St. Louis: Mosby Year Book, Inc., pp142–164.

Macallan, D. (2009). Food security in Sub-Saharan Africa. *Medicine*. 37, 525–528.

Manyatsa, M.J. (2007). The influence of storage on vitamin degradation in fortified biscuits. M. Tech. Dissertation. Bloemfontein: Central University of Technology.

Marotz, L.R., Cross, M.Z. and Rush, J.M. (1997). *Health, safety, and nutrition for the young child*. 4th edition. Washington: Delmar Publishers.

Meaker, J. (2008). An observational cross-sectional investigation of food service management and general management practices in schools running the National School Nutrition Programme (NSNP) in the formal and informal urban areas of Pietermaritzburg, KwaZulu-Natal, South Africa. M.Sc. Dissertation. Stellenbosch: Stellenbosch University.

Napier, C., Oldewage-Theron, W. and Kearney, J. (2009). Comparison of three school feeding strategies for primary school children in an informal settlement in Gauteng, South Africa. *Journal of Interdisciplinary Health Sciences*. 14, 96–103.

Nnakwe, N.E. (2013). *Community nutrition: planning health promotion and disease prevention*. 2nd edition. Burlington: Jones & Bartlett Learning.

Noe, M.H. (2005). The influence of aerosolized microorganisms on the safety and quality of fortified biscuits. M. Tech. Dissertation. Bloemfontein: Central University of Technology.

Ntuli, S. (2009). South Africa: 400 high schools on the Government's Nutrition Programme. Available from: http://allafrica.com/stories/200904061262.html. Date of access: 2013/01/07.

Panda, S.C. (2010). *Sustainable food and nutrition security in national economy*. 1st edition. Jodhpur: Agrobios (India).

Parliamentary Monitoring Group (PMG). (2007). National School Nutrition Programme, conditional grants, life skills and HIV and AIDS conditional grant and learner transport. Available from:

http://www.pmg.org.za/minutes/20070514-national-school-nutrition-programme-conditional-grants-life-skills-hiv-aids-conditi. Date of access: 2013/01/07.

Public Service Commission (PSC). (2008). Report on the evaluation of the National School Nutrition Programme (NSNP). Pretoria: The Public Service Commission (PSC).

Republic of South Africa. (1990). Regulation No. R.1183 of 1 June 1990: Regulations relating to perishable foodstuffs, promulgated under the *Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act No. 54 of 1972*). Pretoria: Government Printer.

Republic of South Africa. (1999). Regulation No. R.918 of 30 July 1999: Regulations governing general hygiene requirements for food premises and the transport of food, promulgated under the *Health Act, 1977 (Act No. 63 of 1977)*. Pretoria: Government Printer.

Roday, S. (2007). *Food science and nutrition*. New Delhi: Oxford University Press.

Rovira, J., Cencic, A., Santos, E. and Jakobsen, M. (2007). Biological hazards. In *Safety in the agri-food chain*. P.A. Luning (Ed). Wageningen: Wageningen Academic Publishers, pp. 67–136.

Seoketsa, L.M. (2007). Management of school feeding scheme at Manamelong Primary in North West Province. M. Tech. Dissertation. Pretoria: Tshwane University of Technology.

Serfontein, W. (2001). *New nutrition: transform your life*. Cape Town: Tafelberg Publishers.

Simeon, D.T. (1998). School feeding in Jamaica: a review of its evaluation. *American Journal of Clinical Nutrition.* 67, 790S–794S.

Smith, A.M., Gouws, A.M., Hoyland, G., Sooka, A. and Keddy, K.H. (2007). Group for enteric, respiratory and meningeal disease surveillance in South Africa (GERMS-SA). Outbreaks of food-borne disease - a common occurrence but rarely reported. *South African Medical Journal*. 97, 1272.

Vermeersch, C. and Kremer, M. (2004). School meals, educational achievement, and school competition: evidence from a randomized evaluation. World Bank Policy Research working paper No. 3523. Washington, DC: World Bank.

Walsh, C.M. (1995). The effect of a nutrition education programme on the knowledge of nutrition and dietary practices of lower socio-economic Coloured communities. PhD Thesis. Bloemfontein: University of the Free State.

Wardlaw, G.M., Hampl, J.S. and DiSilvestro, R.A. (2004). *Perspectives in nutrition*. 6th edition. Boston: McGraw-Hill.

Whitney, E. and Rolfes, S.R. (2008). *Understanding nutrition*. 12th edition. Belmont: Cengage Learning.

Wren, B. (2006). How bacterial pathogens evolve. In *Emerging food-borne pathogens.* Y. Motarjemi and M. Adams (Eds). England: Woodhead Publishing Limited, pp. 3–19.

Ziady, L. and Small, N. (2004). *Prevent and control infection.* Cape Town: Juta & Company Ltd.

CHAPTER 2

ASSESSING THE QUALITY OF FOOD SERVED UNDER A SCHOOL FEEDING SCHEME: A NUTRITIONAL ANALYSIS

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2.1. ABSTRACT

Under-nutrition due to poverty is most prevalent in developing countries. Nutrients in food are essential to sustain normal body function, growth and development. Sound nutrition is, therefore, crucial for the wellbeing of children whereas stunted growth due to nutrient deficiencies hinders the development of children and the effects may continue into adulthood. Such effects of malnutrition may be prevented and reversed by implementing supplementary nutritional programmes. Thus school feeding schemes have been implemented in various schools across the globe to improve the nutritional wellbeing of learners. The purpose of this study was to identify possible nutritional benefits/deficiencies of foodstuffs served during the administration of the South African National School Nutrition Programme in the Bloemfontein area. Representative meal samples were collected from 10 randomly selected NSNP-beneficiary schools in the area and the nutrient contents of meals were determined. Results were measured against the United Kingdom's nutrient-based standards for an average school lunch for individuals aged 7–10 and 11–18 years. For both age groups, the meals did not meet the nutrient standards for carbohydrate and energy contents while the protein standards were met by 90% of meals for individuals aged 7–10 years and met by 40% of meals for those aged 11–18 years. Ten percent of the school meals met the standards for calcium (for the age group of 7–10 years; none for the age group of 11–18 years) and zinc (for both age groups) whereas for iron content, 80% and 30% met the nutrient standards for those aged 7–10 years and 11–18 years, respectively. The lipid and vitamin C contents were within standards for both age groups. The nutritional status of meals may be improved by including foodstuffs from various food groups. Moreover, the implementation of proper storage and food preparation procedures may significantly assist in preserving the quality of nutrients.

Keywords: National School Nutrition Programme, malnutrition, nutrients, chemical analysis, nutrient-based standards

2.2. INTRODUCTION

Food consists of a combination of essential chemicals (nutrients) which are required for normal bodily function, growth and development (Blake *et al.*, 2010). Additionally, these essential nutrients maintain cells and tissues while they also regulate the numerous metabolic processes which take place inside the body throughout each day (Insel *et al.*, 2013). The deficiency of nutrients results in the deterioration of health as the human body is unable to produce nutrients or it produces them in quantities that are insufficient to support health (Byrd-Bredbenner *et al.*, 2013). With prolonged deficiency, the damage may be permanent. However, should the nutrient be replaced in the diet, the effects may be reversed and health restored (Byrd-Bredbenner *et al.*, 2013; Insel *et al.*, 2013). For example, vitamin A supplements may reverse the effects of deficiency on the eyes; however, should the deficiency be prolonged, permanent blindness may result (Insel *et al.*, 2013).

Malnutrition is caused by continual consumption of foods that provide inaccurate levels of nutrients and/or energy to maintain the requirements of the human body (Nnakwe, 2013). According to Black *et al*. (2008) and Usfar *et al.* (2009), about a third of young children globally are stunted and the causes of their growth failure may be traced to poverty. Malnutrition and hunger account for nearly half of the death rate of preschool children worldwide with approximately 26% of undernourished children residing in Africa (World Hunger Education Service, 2011; Nnakwe, 2013). Twenty percent of the population in developing countries suffer from iodine deficiency, while approximately 25% of children are vitamin A deficient (Nnakwe, 2013). Other nutrients most likely to be deficient in children have been reported to be iron, zinc, calcium, folic acid and vitamin B_6 (Mabaya *et al*., 2010; Iversen *et al.*, 2011). Iversen *et al.* (2011) report that under-nutrition is a health concern in South Africa and posit that it particularly affects young children residing in rural areas. Furthermore, during a national food consumption and anthropometric survey among South African children, the Free State province was revealed to have high prevalence of nutritional disorders (Labadarios *et al.*, 2005).

Nutritional requirements during childhood and adolescence are high because of the demands for rapid growth (Weichselbaum and Buttriss, 2011). In addition to growth and development, nutrients also provide young children with fuel to perform physical and metabolic functions (Insel *et al.*, 2013). Therefore, adequate nutrition is vital during the school-age years since nutrition and health influence a child's ability to learn at school (Kallman, 2005; Nnakwe, 2013). Children who lack certain nutrients in their diet, iron and iodine in particular, and suffer from protein-energy malnutrition, persistent hunger, parasitic infections or other food-related diseases are likely to have a reduced potential for learning compared to healthy, well-nourished children. This may be attributed to the difficulty experienced by hungry learners to concentrate and perform complex tasks (Kallman, 2005). Nutrient deficiencies account for the inability of a child to achieve full mental and physical potential owing to stunted growth, low physical work capacity, reduced IQ and lower resistance to infection (Mabaya *et al*., 2010). A study by Usfar *et al.* (2009), which was conducted in rural villages of developing areas, indicated a more rapid growth in children who received supplementation while children without supplements were stunted and at risk of chronic infections even during adulthood.

Although supplementation may yield rapid results in preventing and reversing the effects of malnutrition, food fortification is considered a more cost-effective and sustainable solution to long-term malnutrition (Mabaya *et al*., 2010). These fortified foods may be highly beneficial to numerous children when served at schools. School feeding schemes provide access to various nutritious foodstuffs that promote learners' health and their capacity to perform academic tasks (Bevans *et al.*, 2011). Furthermore, schools are uniquely positioned to promote healthy eating behaviours and attitudes among children which may be a foundation for future dietary preferences and eating behaviour in adult life (Perez-Rodrigo and Aracenta, 2001; Weichselbaum and Buttriss, 2011). The United Kingdom government established food-based standards (to increase intake of healthier foods such as fruit, vegetables and oily fish) and nutrient-based standards (to promote an increased provision of foodstuffs containing essential nutrients) as guidelines for school lunches. The standards are aimed to address concerns regarding the poor quality of school meals and to improve the quality and nutritional balance of meals served to school children (School Food Trust, 2008; Haroun *et al.*, 2011; Department of Education, UK, 2012). During the present study, the constituents of the six classes of nutrients in food (moisture, carbohydrates, proteins, lipids, vitamins and minerals) were determined with the application of chemical analysis of the meals served during the administration of the National School Nutrition Programme (NSNP) in Bloemfontein, South Africa. The study aimed to cast light on possible nutritional benefits and deficiencies of the school meals.

2.3. MATERIALS AND METHODS

2.3.1. Sampling procedure

Representative food samples were collected from 10 randomly selected schools which were beneficiaries of the NSNP in Bloemfontein, South Africa. The school sample included primary, intermediate, combined and special schools, categorized under the three quintiles, namely Q1, Q2 and Q3. This sample also represented an even distribution of schools in the urban and rural areas of the region. The NSNP representative or school principal was notified prior to the visit and arrangements were made to collect food samples which were collected during serving times (between 10:30 and 12:00) during the summer season. This notification was necessary because schools were found not to always adhere to the serving time stipulated by the Department of Basic Education (DBE) as they operate differently in terms of the duration of classes and general attendance (DBE, 2013). The samples consisted of representative portions of food that were served to children under normal serving practises. In an attempt to collect a variety of food and obtain a wider perspective on the nutritional benefits of the meals, the samples were collected on specific days with guidance of menus provided by the schools.

Meal samples of between 267 g and 477 g were collected using latex gloves and placed in sterile polythene bags. Schools were alphabetically labelled to maintain confidentiality. Samples consisted of the following from each of the schools: A: maize porridge and cabbage with potatoes; B: maize porridge and soup with beans and cabbage; C: maize rice and soya mince stew with potatoes and carrots; D: maize rice and beef stew with carrots and potatoes; E: rice and cabbage with potatoes and carrots; F: maize porridge and cabbage with tinned fish; G: samp (a South African staple food made from broken, dried corn kernels) and soya mince stew with potatoes and pumpkin; H: maize porridge and milk; I: maize rice and soya mince stew with potatoes and carrots; and J: rice and tinned fish (pilchards in tomato sauce) stew. Onion, cooking oil, salt and spices were included during the preparation of all meals except for the meal served by school H. The food handlers followed recommendations of the DBE in preparing the meals with some modifications according to availability of ingredients (DBE, 2013). All meals had been prepared on the day they were sampled. The samples were transported to the laboratory on ice and homogenized upon arrival at the laboratory. Sampling and analyses were performed in triplicate.

2.3.2. Gravimetric determination of moisture content

Samples were dried in an oven at 105 ± 5°C for 24 hours and the moisture content was expressed as the percentage of moisture in the fresh sample upon determining the difference in weights between the fresh sample and dry matter (Moreno-Rojas *et al.*, 2010).

2.3.3. Analysis of soluble sugars by HPLC

Analysis of soluble sugars using HPLC-RI

The HPLC system consisted of a Shimadzu Prominence high-performance liquid chromatography apparatus (Shimadzu Corporation, Nakagyo-ku, Kyoto, Japan) equipped with a pump (LC-20AD), a solvent degasser (DGU-20A3), an autosampler (SIL-20AC, 230V), a refractive index (RI) detector, a CBM-20A controller and an integrator running DataApex Clarity Chromatography Software. For separation, a Phenomenex Luna NH_2 250 × 4.60 mm reverse-phase column (5 µm particle size)

(Phenomenex, Torrance, California, US) was used with the oven temperature at 40°C. An isocratic elution was employed with 75% acetonitrile (HPLC grade from Merck, Wadeville, Gauteng, SA) in nanopure water at a flow rate of 1.25 $ml.min^{-1}$ and the injection volume was 10 µl. A carbohydrate kit (Sigma-Aldrich, Aston Manor, Gauteng, SA) was used to identify and quantify individual sugars by comparing the relative retention times of sample peaks with standards using calibration curves. The calibration was carried out using the external standard method and four sets of calibration standards at concentrations of 0.4, 0.8, 1.8 and 3.2 $g.l^{-1}$ were prepared for each reference sugar. The standard material was weighted, the appropriate volume of nanopure water was added and the mixture was vortexed for 30 sec. The resultant solutions were filtered using syringe filters and analyzed by HPLC.

Extraction of soluble sugars

The sugars were extracted from the various food samples using a modified method as proposed by Barreira *et al.* (2010). Approximately 10 g of the homogenized samples were extracted with 40 ml of 80% aqueous ethanol (Merck, SA) at 70°C for 30 minutes. After cooling to room temperature the samples were centrifuged at 3000 rpm for 15 min. The ethanol in the supernatant was evaporated and the extract was diluted to a final volume of 10 ml in nanopure water, filtered at 0.45 µm and injected for HPLC analysis.

2.3.4. Total carbohydrate determination

Total carbohydrate content of food samples was calculated using the following formula as described by Charrondiere *et al.* (2004): total carbohydrate (g) = 100 g – (moisture + protein + lipid + ash) grams.

2.3.5. Total lipid determination and fatty acids analysis by GC-FID

With minor adaptation, the method proposed by Gressler *et al.* (2010) was applied for the identification and quantification of lipids and fatty acids. Five grams of each homogenized food sample were weighted to which 250 mg of pyrogalic acid (Sigma-

Aldrich, SA) (to minimize fatty acid degradation) and 5 ml ethanol were added. For acid hydrolysis, 25 ml of 32% HCl (Merck, SA) were added and shaken for 40 min at 70–80°C followed, by vortexing for approximately 10 min. The lipids were extracted (at room temperature) with ethyl ether (60 ml mixed in vortex for 1 min) and petroleum ether (60 ml mixed in vortex for 1 min) (both were purchased from Merck, SA). The samples were centrifuged (4000 rpm × 5 min) and the ether phase was evaporated to dryness under nitrogen gas. The residue was gravimetrically determined as total lipid content.

The fatty acids in the extracted lipid were methylated to fatty acid methyl esters (FAMEs) with boron trifluoride/methanol complex (5 ml of 20% BF_3/MeOH reagent) (Merck, SA) followed by heating in 2.5 ml toluene (Merck, SA) at 100°C for 45 min under gentle mix. At room temperature, nanopure water (12.5 ml) was added and the FAMEs were extracted with 5 ml of hexane (Merck, SA). The hexane fraction was dried in nitrogen gas, suspended in 500 µl hexane and the solution was filtered prior to analysis. The fatty acids were analysed using Finnigan Focus GC (Thermo Fisher Scientific, Waltham, Massachusetts, US) with flame ionization detector and a 25 m x 0.32 mm ID SGE capillary column BPX70, 0.25 µm film (SGE, Melbourne, Victoria, Australia). The temperature conditions were 100°C for 5 min, 100–240°C at a rate of 3°C.min^{-1} and at 240°C for 20 min. The samples were injected at 225°C and detected at 285°C with helium (linear flow of 20 cm.s^{-1}) as the carrier gas and split ratio of 1:50. A 37-Component FAME mixture (Sigma-Aldrich, SA) was used to identify the fatty acids.

2.3.6. Protein content determination

The Dumas combustion method was used to determine the nitrogen content of food samples as described by Jung *et al.* (2003). The protein content was determined by means of a nitrogen conversion factor of 6.25.

2.3.7. Analysis of Vitamins A and E

HPLC-UV conditions

With minor variations, the HPLC system used was the same as described earlier for the analysis of soluble sugars. For vitamin separation, a Phenomenex Luna C18 (2) 5 µm 150 × 4.60 mm reverse-phase column (Phenomenex, US) was used and the analyses were performed under isocratic mode (mobile phase of acetonitrile) at a flow rate of 2.0 $ml.min^{-1}$ with the oven temperature at 40°C. The injection volume was 10 µl and a UV detector was set at 325 nm for vitamin A (retinyl acetate purchased from Sigma-Aldrich, SA) and 290 nm for vitamin E (δ-tocopherol, α-tocopherol and α-tocopherol acetate purchased from Sigma-Aldrich, SA) to monitored column effluents. The retention times, peak areas/heights and the spectra of the standard compounds were used for vitamin identification. For standard solutions, a stock solution of each vitamin was prepared by dissolving 3 mg of the vitamin standard in 100 ml ethanol containing 3 mg of antioxidant butylated hydroxytoluene (BHT) (Sigma-Aldrich, SA) as a protection reagent.

Saponification and extraction of vitamins

With minor adaptations, the method proposed by Salo-Väänänen *et al.* (2000) was applied to identify vitamin A and E contents of the homogenized samples. For saponification, samples of approximately 2 g were weighed into flasks after which pyrogallol (Sigma-Aldrich, SA) of 20 ml (15 $g.l^{-1}$, dissolved in absolute ethanol) and 10 ml KOH saponification solution (which consisted of 100 g of KOH pellets – purchased from NT Laboratory Suppliers Excom, Johannesburg, SA – dissolved in 100 ml of nanopure water) were added. Taka diastase (0.01 g) (Sigma-Aldrich, SA) was added to digest starch and prevent formation of lumps. The flasks were heated at 60°C for 30 min and cooled to room temperature for about 15 min. To avoid emulsion formation, 10 ml of 10% NaCl (Merck, SA) were added.

After saponification, the vitamins were extracted using three portions of 20 ml *n*-hexane-petroleum ether (80:20) (*n*-hexane was obtained from Merck, SA). With each portion, the flask was vortexed for about 30 sec and centrifuged (4200 rpm × 5 min). The phases were allowed to separate, and the organic layers were washed with 20 ml of 5% NaCl and evaporated. Five millilitres of ethanol and 5 ml of *n*-hexane were added to the flask and the solution was evaporated to dryness with nitrogen gas. The residue was dissolved in 1 ml of *n*-hexane (containing 5 mg of BHT) and filtered (Whatman, 0.45 µm) prior to HPLC analyses. Exposure to high temperature and bright light were eliminated throughout the process to prevent the loss of vitamins.

2.3.8. Vitamin C analysis

Total vitamin C content was determined according to AOAC Method 984.26 as proposed by Moses *et al.* (2009).

2.3.9. Determination of total ash and mineral content

The total mineral content was determined by a dry ashing method during which the dried food samples were ashed at 525°C overnight in a muffle furnace (McCleary *et al.*, 2010). The resultant ash was determined gravimetrically while individual minerals (calcium, iron and zinc) were identified and quantified using inductively coupled plasma-optical emission spectrometry (ICP-OES) as per the method proposed by Zhou *et al.* (2013).

2.3.10. Energy calculation

Energy was determined using the following formula as described by Charrondiere *et al.* (2004): energy (kJ) = (total carbohydrate grams ×17 kJ) + (protein grams ×17 kJ) + (lipids grams × 37 kJ).

2.3.11. Analyses of data

As far as was determined during the current study, there are no South African nutritional standards for school meals, thus the results of this study were analysed according to the United Kingdom’s nutrient-based standards (NBS) for an average school lunch as summarized in Appendix 1 (School Food Trust, 2008). It was deemed necessary to compare schools that served the same meal in order to explore preparation methods as possibly having an impact on nutritional quality of foodstuffs. The results were expressed as grams per day and milligrams per day for macro- and micronutrients, respectively, and as kilojoules per day for energy. All descriptive and inferential statistical analyses were performed using SigmaPlot 10.0.1, Systat software. In the cases of determination of significance, the *t*-test was used with a significance level of 0.05 (P). Means of triplicates values ± standard deviations and percentages were used to present the results.

2.4. RESULTS AND DISCUSSION

According to the menus received from schools and the one which had been designed by the DBE, balanced and wholesome meals should alternate the inclusion of a green and yellow vegetable along with the starch and protein portions. However, the only measurable vegetables served during sampling were cabbage (served by schools A, B, C, E and F) and pumpkin (served by schools G and J). In addition, the cabbage was served as a replacement for or in combination with the protein portion of the meals. To further supplement the nutrient intake, it was expected that a fruit would be provided to each child per week; however, it was observed that only one school adhered to this regulation during the course of this study.

2.4.1. Carbohydrates

The soluble sugars (glucose, fructose and sucrose) were quantified and the mono- and disaccharide contents are listed in Table 2.1. Soluble sugar contents ranged between 0.06 ± 0.03 and 1.01 ± 0.40 $g.d^{-1}$ for glucose, 0.11 ± 0.00 and 1.20 ± 0.72 $g.d^{-1}$ for fructose and 0.07 ± 0.00 and 1.02 ± 0.26 $g.d^{-1}$ for sucrose with calibration curves as indicated in Appendix 2. The low sugar contents were reflected in the results of a study by Menezes *et al.* (2004), who found that the contents were below 0.5% of fresh weight for all foods and ranged between 3.07 and 38.42 $mg.100g^{-1}$ for glucose, 3.77 and 55.90 $mg.100g^{-1}$ for fructose and 9.39 and 368.27 $mg.100g^{-1}$ for

Table 2.1. Macronutrient content and energy values of various school meals

School	Meal description*	Glucose (g.d^{-1})	Fructose (g.d^{-1})	Sucrose (g.d^{-1})	Total carbohydrate (g.d^{-1})	Lipid (g.d^{-1})	Protein (g.d^{-1})	Energy (kJ.d^{-1})
A	Maize porridge; cabbage with potatoes	0.61 ± 0.24	0.57 ± 0.14	0.24 ± 0.03	37.75 ± 0.40	9.42 ± 1.88	9.12 ± 1.12	1142.71 ± 43.54
B	Maize rice; beef stew with potatoes and carrots	0.26 ± 0.29	0.23 ± 0.26	0.19 ± 0.06	39.12 ± 3.25	6.42 ± 3.59	30.86 ± 0.62	1488.76 ± 52.66
C	Maize porridge; soup with beans and cabbage	0.54 ± 0.47	1.11 ± 0.20	0.23 ± 0.17	49.93 ± 0.87	5.96 ± 1.71	9.38 ± 0.40	1242.12 ± 62.76
D	Maize rice; soya mince stew with potatoes and carrots	0.36 ± 0.00	0.52 ± 0.29	0.16 ± 0.16	20.29 ± 0.76	4.97 ± 1.00	6.83 ± 0.18	663.86 ± 7.79
E	Rice; cabbage with potatoes and carrots	1.01 ± 0.40	1.20 ± 0.72	0.61 ± 0.40	55.33 ± 0.52	2.99 ± 0.81	10.15 ± 1.00	1240.33 ± 40.41
F	Maize porridge; cabbage with tinned fish (pilchards in tomato sauce)	0.07 ± 0.05	0.23 ± 0.14	0.07 ± 0.00	35.09 ± 8.67	6.03 ± 1.38	9.12 ± 0.31	974.63 ± 69.78
G	Samp; soya mince stew with potatoes; pumpkin	0.32 ± 0.07	0.11 ± 0.00	0.07 ± 0.07	40.92 ± 5.94	3.01 ± 0.42	9.10 ± 0.22	964.63 ± 115.50
H	Maize porridge; milk	0.81 ± 0.26	0.19 ± 0.05	0.43 ± 0.19	59.41 ± 0.10	5.05 ± 2.88	14.32 ± 0.20	1430.16 ± 149.80
I	Maize rice; soya mince stew with potatoes and carrots	0.46 ± 0.07	0.39 ± 0.07	1.02 ± 0.26	25.30 ± 8.91	16.49 ± 12.42	18.67 ± 1.55	1097.47 ± 8.27
J	Rice; tinned fish stew; pumpkin	0.06 ± 0.03	ND	0.03 ± 0.00	41.12 ± 9.22	6.98 ± 0.84	14.23 ± 1.09	1213.61 ± 167.81

Mean of values ± s.d. (standard deviation), (n = 3).
ND: non-detected using the current method.
*Onion, cooking oil, salt and spices were included during the preparation of all protein portions of meals except for school H.

sucrose. These results were attributed to the high starch content of the foodstuffs. Carbohydrates (in the form of glucose) are the main source of energy in the human diet and consist of a diverse family of compounds namely mono-, oligo- and polysaccharides (Molnar-Perl, 2000; Muir *et al.*, 2009; Insel *et al.*, 2013). Further illustrated in Table 2.1 are the total carbohydrate contents of meals which ranged between 20.29 ± 0.76 and 59.41 ± 0.10 $g.d^{-1}$. These data were significantly ($P \leq 0.05$) below the NBS minima of 70.6 and 86.1 g (Figure 2.1) for pupils aged 7–10 and 11–18 years, respectively. Similar results were observed from a study by Nicholas *et al.* (2013) during which the school meals were below the standard (≥ 86.1 g) required for carbohydrates and had a content of 73.2 ± 35.6 g. During a study by Pearce *et al.* (2012), however, the school lunches yielded a carbohydrate content which was above the standard at 89.2 ± 38.9 g.

2.4.2. Lipids and fatty acids

The values for the total lipid content ranged between 2.99 ± 0.81 and 16.49 ± 12.42 $g.d^{-1}$ (Table 2.1) and were within the NBS of below 20.6 and 25.1 g for individuals aged between 7–10 and 11–18 years respectively (Figure 2.1). A study by Haroun *et al.* (2011) indicated that the majority of the school lunches also met the standard for total fat content. Lipids, particularly fats, are dense sources of energy and facilitate the absorption of fat-soluble dietary components such as vitamins. Lipids also aid in regulating blood pressure and nerve transmissions (Gallagher, 2008; EFSA, 2010; Medeiros and Wildman, 2012; Byrd-Bredbenner *et al.*, 2013). While fat intake should be kept minimal, intake below 25% of total energy had been associated with low vitamin levels in young children (EFSA, 2010). Lipid intake further depends on the composition of fatty acids and the health effects of various lipid components (saturated, unsaturated and trans-fatty acids) (Gallagher, 2008). Table 2.2 lists the fatty acids identified in the various samples analysed in this study. It is apparent that saturated fatty acids were dominant in the majority of the meals. A high content of saturated fatty acids in school lunches was also observed in the study by Pearce *et al.* (2012). Saturated and monounsaturated fatty acids are synthesised by the human body and are thus not required in the diet, whereas polyunsaturated fatty

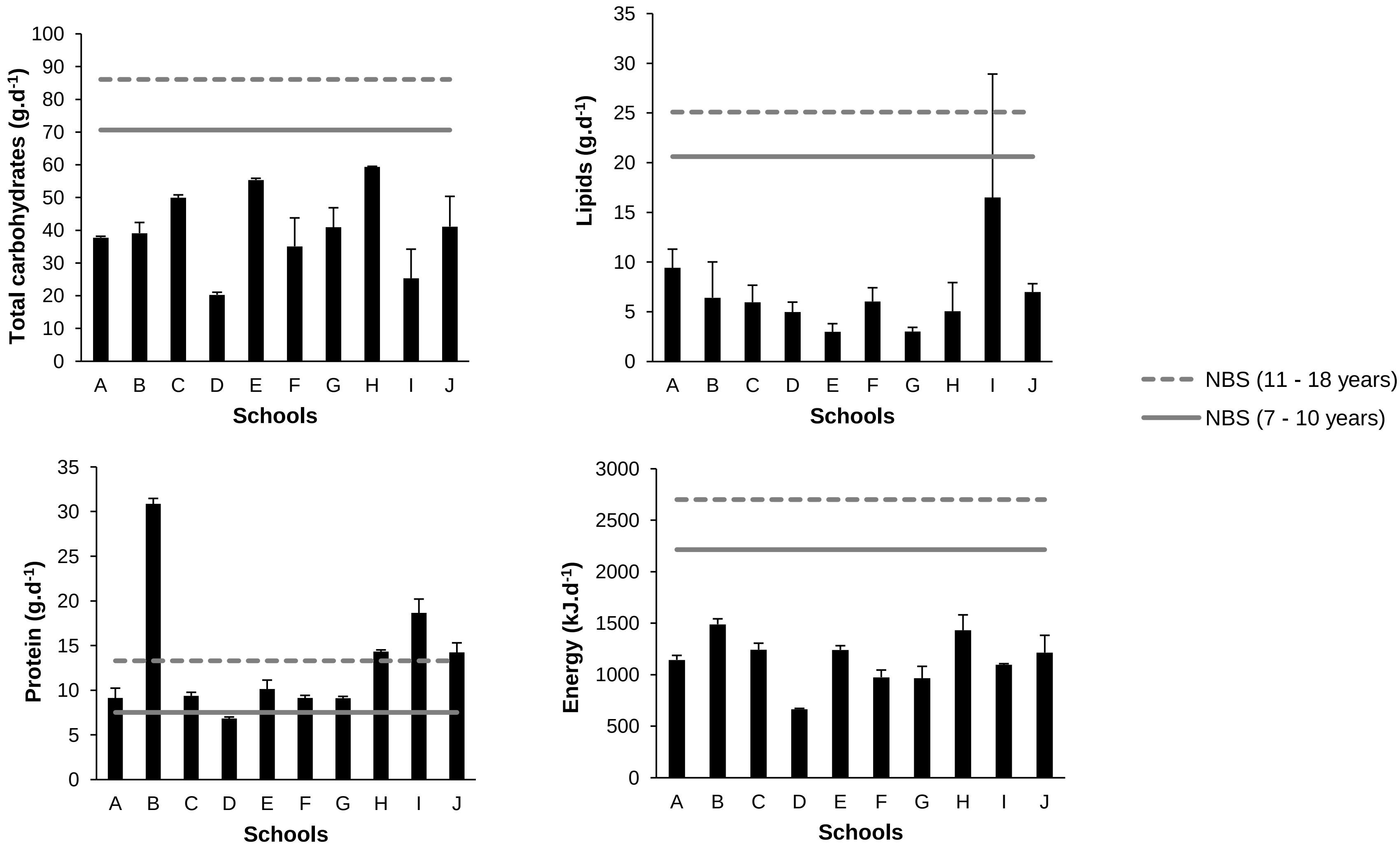


Figure 2.1. Mean macronutrient values of meals sampled at various NSNP-participating schools (Each data point represents triplicate values. The standard deviation was used as the error-bar)

Table 2.2. Fatty acid compositions of meals served by various NSNP-benefiting schools in Bloemfontein

School	A	B	C	D	E	F	G	H	I	J
Fatty acids	C4:0 C6:0 C8:0 C10:0 C12:0 C14:0 C16:1 C18:0 C18:1n9c C20:0 C21:0 C20:2 C22:2 C24:0 C20:5n3	C4:0 C8:0 C10:0 C13:0 C15:0 C17:0 C17:1 C18:3n3 C21:0 C20:3n6 C22:1n9 C20:3n3 C23:0 C22:2 C22:6n3	C4:0 C8:0 C10:0 C14:0 C16:1 C18:0 C18:1n9 C18:3n6 C21:0 C20:2 C22:0 C24:0 C20:5n3	C4:0 C16:0 C18:0 C18:1n6cC 20:2 C22:2 C24:0	C4:0 C8:0 C10:0 C11:1 C12:0 C13:0 C15:0 C17:0 C21:0 C22:1n9 C20:3n3 C22:2 C20:5n3 C22:6n3	C4:0 C6:0 C10:0 C12:0 C13:0 C14:0 C15:0 C16:0 C16:1 C17:0 C18:0 C18:1n9t C18:2n6tC 18:1n6c C20:0 C18:3n6 C20:1 C18:3n3 C20:2 C22:0 C20:3n3 C22:2 C24:0 C20:5n3 C24:1 C22:6n3	C4:0 C10:0 C14:0 C16:0 C18:0 C18:1n9t C18:1n9c C18:1n6c C21:0 C20:2 C24:0 C20:5n3	C4:0 C8:0 C10:0 C12:0 C14:0 C15:0 C16:0 C16:1 C17:0 C18:0 C18:1n9c C18:2n6t C18:1n6c C18:3n6 C20:1 C21:0 C20:2 C20:3n3 C23:0 C24:0	C4:0 C8:0 C16:0 C18:1n9t C18:1n9c C18:2n6t C18:1n6c C18:3n6 C20:2 C22:0 C24:0 C20:5n3	C4:0 C6:0 C10:0 C12:0 C14:0 C15:0 C16:1 C17:1 C18:1n9t C18:1n9c C20:0 C18:3n6 C20:1 C18:3n3 C21:0 C20:2 C20:3n6 C20:3n3 C24:0 C24:1 C22:6n3

acids, such as omega-3 and -6, are essential fats which should be obtained from the diet (EFSA, 2010). School B's meal contained omega-3 (C18:3n3) fatty acids while meals from schools C, H and I contained omega-6 (C18:3n6) fatty acids. Meals which excluded foodstuffs of animal origin (schools D, E and G) were deficient of essential fats, whereas the meal from school F had the highest fatty acid composition and, along with that of school J, had both omega-3 and omega-6 essential fatty acids (Table 2.2). Schools F and J served tinned fish (pilchards) and it is a recognized fact that essential fats are abundant in fish oil (Chan and Cho, 2009). Prior and Galduróz (2012) elaborate that these essential fats occupy one-third of the central nervous system while approximately 20% of the human brain consists of omega-3 fatty acids. This occupation of essential fatty acids in the brain was found to reduce attention deficit hyperactivity disorder (ADHD) symptoms in children during a study by Johnson *et al.* (2009).

2.4.3. Protein

As illustrated in Table 2.1, protein quantities ranged between 6.83 ± 0.18 and 30.86 ± 0.62 $g.d^{-1}$ and only one meal (school D) did not contain the protein required in a school lunch (minimum of 7.5 g) for children aged 7–10 years. For pupils aged from 11 to 18 years, only four school meals (B, H, I and J) met the nutrient standard of a minimum of 13.3 g, whereas the remaining six schools were significantly ($P \leq 0.05$) below the standard as indicated in Figure 2.1. School meals analysed during the studies by Pearce *et al.* (2012) and Nicholas *et al.* (2013) for nutritional quality met the standards for protein requirements. As indicated in Table 2.1 and Figure 2.1, the meal served by school B had noticeably higher protein content than those sampled from the other schools. This was due to the meal being the only one that included meat (beef), which is a primary source of protein. Proteins are nitrogen-containing compounds with amino acids as building blocks. These compounds mainly provide structure for the body and are major components of bone, muscle, blood, cell membranes, enzymes and immune factors (Hoffman and Falvo, 2004). Additionally, proteins may be a source of energy; however, the body does not rely on protein for daily energy requirements (Byrd-Bredbenner *et al.*, 2013). The quality of protein in food is dependent on the composition of essential amino acids which bind together to form proteins such as in hormone formation (Hoffman and Falvo, 2004; Gallagher, 2008). The human body is unable to synthesize the 8 to 9 essential amino acids; namely lysine, tryptophan, methionine, valine, phenylalanine, leucine, isoleucine, threonine and, for infants, histidine; and these should be obtained from the diet (Medeiros and Wildman, 2012).

2.4.4. Energy

The energy values of the analysed meals provided to school children ranged between 663.86 ± 7.79 and 1488.76 ± 52.66 $kJ.d^{-1}$ (Table 2.1), which were significantly ($P \leq 0.05$) below the minimum required values for an average school lunch (≥ 2215 kJ for individuals aged between 7–10 years and ≥ 2700 kJ for those aged between 11–18 years) as described in Figure 2.1. According to the School Food Trust (2008), a minimum of 50% of energy from food should be obtained from carbohydrates, less than 35% should be from fats, and a portion (quantity not specified) should be supplied by proteins. Data obtained from the current study indicated that meals from the majority of the schools contributed the required amount of total carbohydrates to the energy values and did not exceed the standard for lipids. This finding is similar to that of a study by Charrondiere *et al.* (2004), regarding numerous food items from various countries, during which the total carbohydrate content supplied 50–80% of energy and 7–11% of energy was from protein). However, the meal from school B supplied approximately 47%, 17% and 37% of energy from carbohydrates, lipids and protein, respectively, and therefore relied on protein for energy. Whereas the meal from school I contributed approximately 31%, 45% and 23% to the energy value from carbohydrates, lipids and protein, respectively (data not shown) indicating fats as the main source of energy. In an ideal diet, carbohydrates should be the main source of energy and the body should avoid reliance on protein for energy (Lucas and Feucht, 2008; Byrd-Bredbenner *et al.*, 2013). Similar results of low energy provided by school meals were observed during a study by Nicholas *et al.* (2013); however, the meals generally met the standards for percentage of energy from carbohydrates and fats, but not from non-milk extrinsic sugars (sugars that are not contained within the cellular structure of food). A study by

Burgess and Bunker (2002) regarding school lunches found that the energy values of meals were above the minimum standard, although neither of the percentages of energy from carbohydrates, fats and non-milk extrinsic sugars were within the standards. Energy intake of children should be sufficient to ensure growth and meals consumed by children should provide all the required nutrients without the addition excessive energy sources to the diet (McGuire and Beerman, 2013).

2.4.5. Vitamins A and E

The analysis for vitamins A and E in the present study yielded undetectable results for both vitamins. The chromatographs of the standards are presented in Appendix 3. Depending on the cooking method and composition of food, variable losses of vitamins may occur as a result of processing and cooking conditions (Lešková *et al*., 2006). Kuyper (2000) reported an average loss of 53% of vitamin A during the preparation of maize meal. The results obtained from a study by Pretorius and Schönfeldt (2012) indicated that fortification contributed to the improvement of the overall vitamin A status of children aged 1–9 years, whereas foodstuffs that were not fortified did not yield results. Vitamins enable numerous chemical reactions to occur in the body which may aid with the release of energy from carbohydrates, lipids and proteins (Byrd-Bredbenner *et al.*, 2013). The important roles that fat-soluble vitamins play in several functions of the human body include vision (Vitamin A), calcium absorption (Vitamin D) and antioxidative protection in cell membranes (Vitamin E) (Heudi *et al.*, 2004).

2.4.6. Vitamin C

Ascorbic acid values ranged between 14.41 ± 0.46 and 42.30 ± 0.69 $mg.d^{-1}$, with meals from schools I and D containing the lowest and highest levels respectively (Table 2.3). Meals from all the schools met the vitamin C requirements for pupils of all ages as stipulated for an average school lunch (Figure 2.2). Similar results were observed in the studies by Pearce *et al.* (2012) and Nicholas *et al.* (2013). Both groups of researchers reported that the vitamin C contents of the school meals they analysed met the required standards. The study by Fontannaz *et al.* (2006) revealed that soya-based food

Table 2.3. Micronutrient content of meals sampled from various schools

School	Vitamin C ($mg.d^{-1}$)	Iron ($mg.d^{-1}$)	Zinc ($mg.d^{-1}$)	Calcium ($mg.d^{-1}$)	% Ash (dry weight)
A	28.38 ± 0.96	4.83 ± 0.05	1.20 ± 0.04	73.65 ± 1.42	3.87
B	16.57 ± 0.46	3.11 ± 0.39	5.04 ± 0.05	50.36 ± 0.92	3.47
C	18.76 ± 0.71	5.96 ± 0.07	2.38 ± 0.08	52.25 ± 1.66	5.5
D	42.30 ± 0.69	1.98 ± 0.15	0.54 ± 0.02	45.88 ± 0.00	4.18
E	17.09 ± 1.32	1.60 ± 0.10	0.64 ± 0.06	90.78 ± 2.64	2.5
F	16.61 ± 2.32	4.35 ± 0.00	2.04 ± 0.06	115.08 ± 1.16	4.73
G	36.40 ± 0.25	4.90 ± 0.00	1.52 ± 0.04	58.80 ± 0.99	4.05
H	37.24 ± 2.36	6.02 ± 0.11	2.30 ± 0.04	189.07 ± 3.71	3.45
I	14.41 ± 0.46	6.03 ± 0.39	0.87 ± 0.06	75.33 ± 0.46	6.22
J	18.22 ± 1.01	3.70 ± 0.26	1.08 ± 0.05	243.63 ± 7.45	3.72

Mean of values ± s.d. (standard deviation), (n = 3).

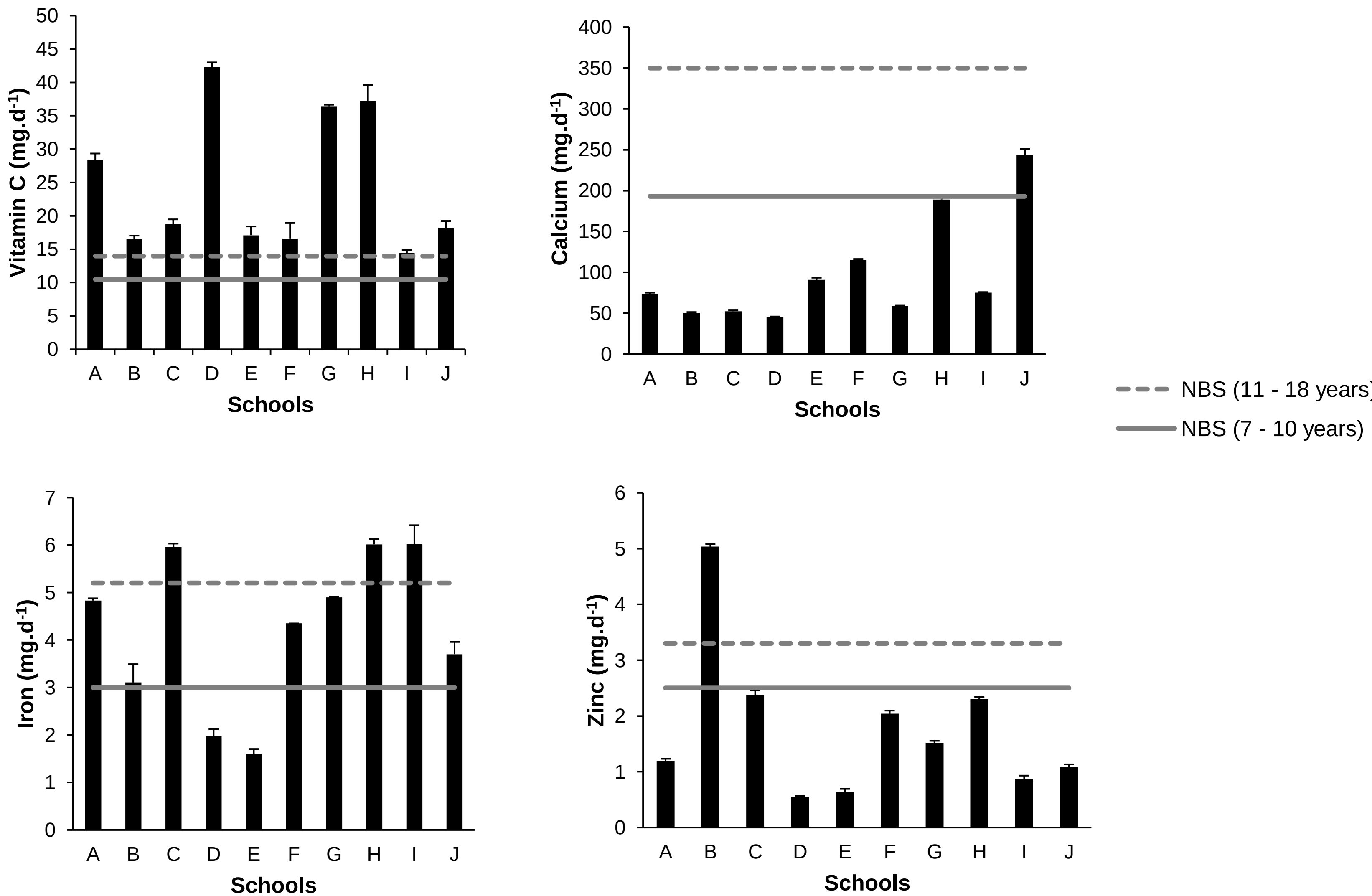


Figure 2.2. Mean micronutrient values of meals sampled at various NSNP-participating schools (Each data point represents triplicate values. The standard deviation was used as the error-bar)

contained higher vitamin C levels than meat-based food. This trend was also observed in the meals analysed in the current study as the food provided by schools D and G, which included soya mince, contained higher vitamin C levels than the meals of school B (which included beef) and school H (which included milk). Vitamin C is essential for growth and repair of tissues in the body (Grindberg and Williams, 2010). In addition, ascorbic acid acts as a cellular antioxidant and facilitates intestinal absorption of iron and maintenance of plasma iron (Tarrago-Trani *et al.*, 2012). Interestingly, meals collected from schools D and I were prepared using similar ingredients, however the meal from school I produced higher counts of all quantified nutrients, except for vitamin C (Figure 2.3). The *t*-test indicated that the meal from school D had a significantly higher ($P \leq 0.05$) ascorbic acid content than that of school I. This finding may be due to vitamin C being water-soluble and school D's meal had a higher moisture content (86%) than that of school I (78%). Furthermore a moderate positive correlation between moisture and vitamin C was observed (Figure 2.4).

2.4.7. Ash and mineral content

The ash content of all the meals analysed ranged between 2.5% and 6.22%. Ash content is regarded as an index of mineral content in biological mass (Effiong and Udo, 2010). The iron, zinc and calcium values ranged between 1.60 ± 0.10 and 6.03 ± 0.39 $mg.d^{-1}$, 0.54 ± 0.02 and 5.04 ± 0.05 $mg.d^{-1}$, and 45.88 ± 0.00 and 243.63 ± 7.45 $mg.d^{-1}$, respectively (Table 2.3). As illustrated in Figure 2.2, for iron content, only two school meals did not comply with the nutrient standard (≥ 3.0 mg) for pupils aged 7–10 years while seven schools did not comply with the standard (≥ 5.2 mg) for those aged 11–18 years. In addition, meals of schools C, H and I had iron levels that were above the NBS for both age groups and the standard for the zinc content of school lunches was met by one meal (school B) for both age groups (Figure 2.2). Furthermore, for the 11–18 years age group, the calcium standard (≥ 350 mg) was not met by any of the meals analysed while only one sample (school J) met the standard for individuals aged 7–10 years (≥ 193 mg).

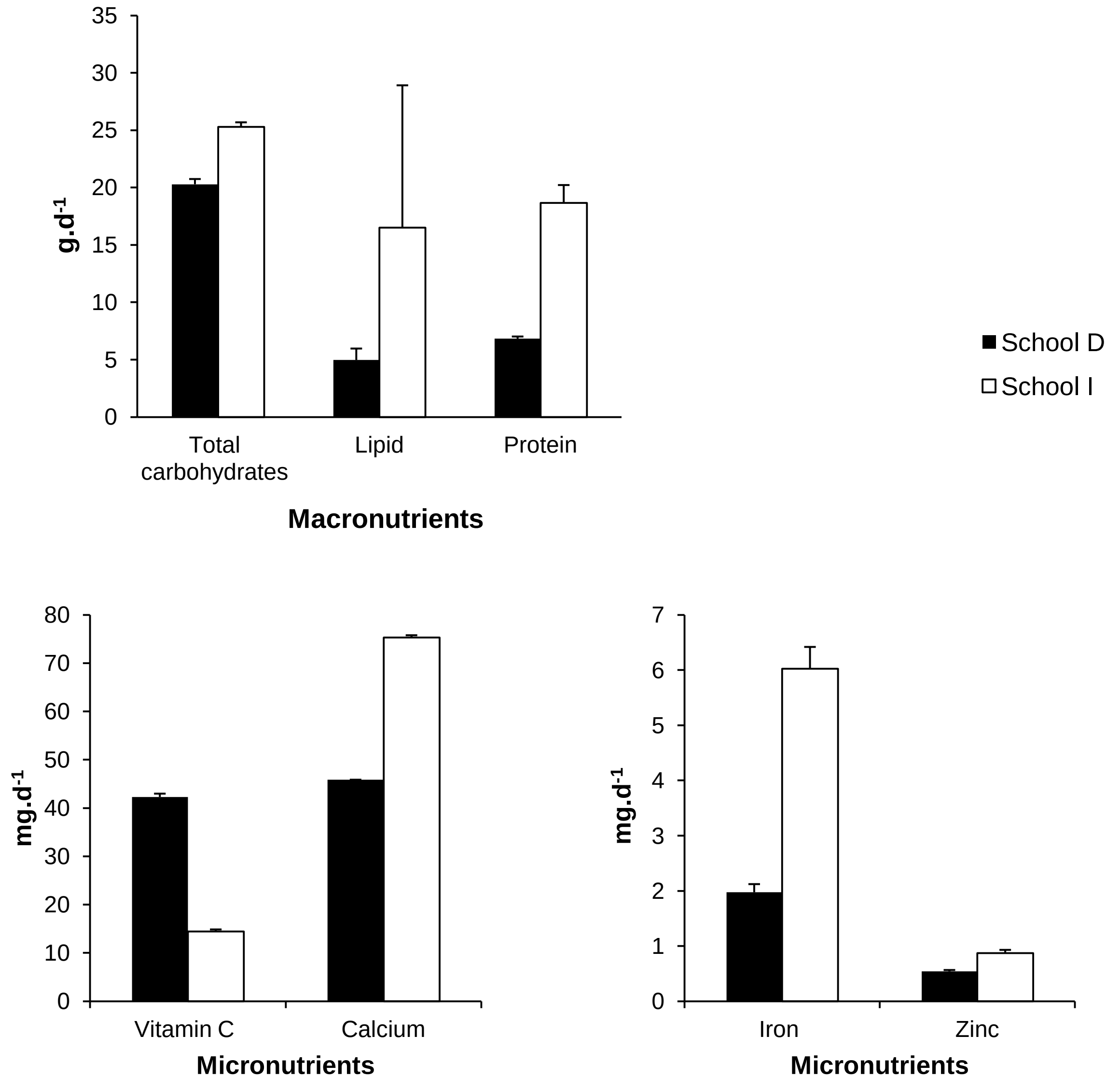


Figure 2.3. Variation in nutrient contents of similar meals served by schools D and I (Each data point represents triplicate values. The standard deviation was used as the error-bar)

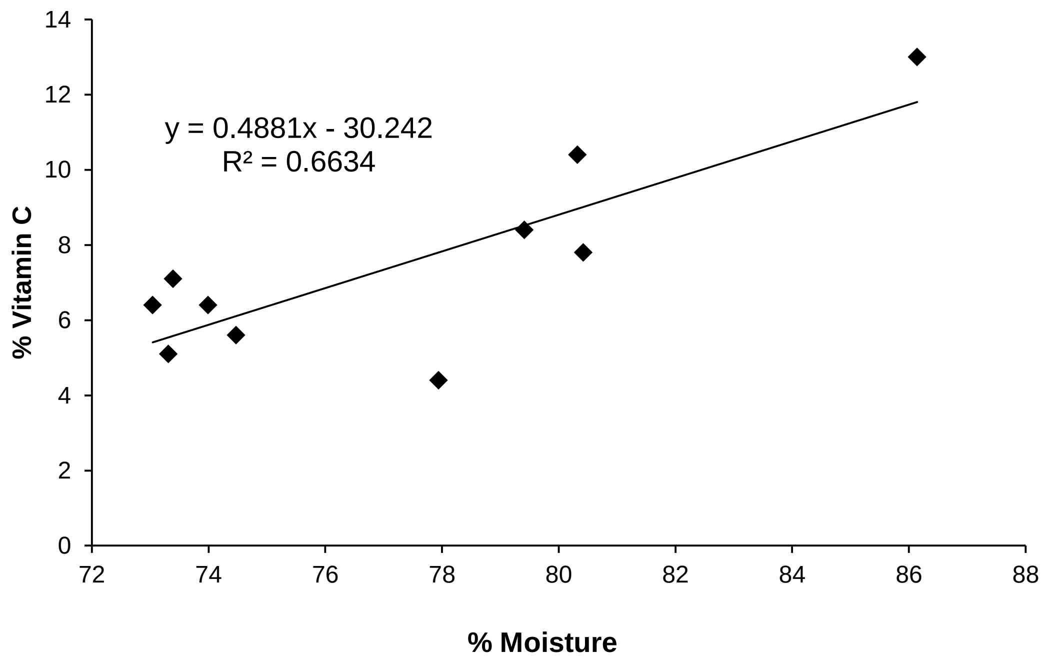


Figure 2.4. Relationship between moisture and vitamin C contents of meals served at various schools

Llorent-Martínez *et al.* (2012) observed significantly higher levels of minor nutritional elements (copper, iron and manganese) in soya products than in products of animal origin; however, the authors found that zinc levels were higher in foodstuffs of animal origin than of soya. A similar observation was made during the present study with the meal from school B presenting the highest level of zinc, which may be attributed to the inclusion of beef, and lower levels of the other micronutrients. The results of the studies by Pearce *et al.* (2012) and Nicholas *et al.* (2013) indicated school meal values that were below standards for calcium, iron and zinc. A below standard calcium content and an above standard iron content were reported in the results of a study by Burgess and Bunker (2002). Iron is critical for the transport and storage of oxygen in the body and children are at risk of developing iron deficiency anaemia should the nutrient be deficient (Lucas and Feucht, 2008). Children require calcium for mineralization and to maintain their growing bones. The primary sources of calcium are milk and dairy products (Lucas and Feucht, 2008) hence a calcium content of above the NBS was expected from school H’s meal (which consisted of milk). Zinc in children is essential for growth and healing of wounds with the major sources being meat and seafood.

The matter of storage conditions and preparation methods as well as their influences on the different nutritional categories emanated as a notable observation in this study. According to Yuan *et al.* (2009), food preparation methods induce significant changes in the chemical composition of foodstuffs. In addition, literature suggests that high temperatures used in cooking methods have an effect on the contents of nutrient and health-promoting food constituents such as vitamins (Vallejo *et al*., 2002; Lin and Chang, 2005; Cieslik *et al*., 2007; Sikora *et al*., 2008). Yuan *et al.* (2009) reported that various cooking treatments caused major losses of total soluble proteins, soluble sugars and vitamin C in broccoli due to the application of heat for prolonged periods during their study. The authors also identified the use of excessive liquid as reducing the nutritional content of foods via leaching of water-soluble components into the liquid. Components of the meals sampled in the present study were prepared using high volumes of liquid with the possible aim of supplementing the foodstuffs. However, this practice may compromise the nutrient content of food since water-soluble nutrients (such as vitamin C and soluble proteins and sugars) may be lost by leaching into surrounding liquid medium (Rickman *et al*., 2007). Further deterioration and loss of nutrients (particularly vitamins) may occur due to excessive exposure of foodstuffs to UV light and oxygen, the pH of the solvent or combinations of various conditions (Severi *et al*., 1997; Rickman *et al*., 2007). Moreover, a study by Vinha *et al.* (2013) revealed that in all the studied parameters, temperature and storage duration caused statistically significant differences in the nutritional values of each food sample analysed. Macronutrients are relatively stable under various storage conditions; however, the length of storage considerably affects the retention of micronutrients with high losses observed due to prolonged periods of storage (Severi *et al*., 1997; Rickman *et al*., 2007). It is therefore essential that NSNP-benefiting schools adhere to the first-in-first-out principle for storage conduct.

2.5. CONCLUSIONS

According to the data of the present study, meal samples from the various schools did not meet the NBS for carbohydrates and energy whereas the total carbohydrate content of the majority of the meals emerged as the main contributor to the energy value. Children aged between 7 and 10 years were provided with the required protein in their school meals while only four schools met the standard for those aged 11–18 years. The vitamin C and lipid requirements were satisfied for both age groups with 50% of the meals containing an essential fatty acid. The majority of the school meals provided did not satisfy the standards for zinc and calcium for both age groups while the majority met the NBS for the iron content of school meals for those aged from 7 to 10 years. The lower content of some nutrients as compared to the standards may be attributed to the possible shortage of variety in ingredients of the meals served. In this regard, a study by Snelling and Yezek (2012) indicated that using nutrient standards to guide the selection of foods offered in schools may positively affect the intake of energy and nutrients. Therefore, to improve the macro- and micronutrient quantities of meals, NSNP-participating schools may serve meals that include a variety of whole grains, meat/meat alternatives, fruits, vegetables and dairy options (Bevans *et al.*, 2011). Food handling methods, especially during storage and preparation, may also have a significant influence on the nutritional quality of foods. This was observed in the present study with the wide variation in nutrient levels of meals containing similar components. Moreover, it may have been possible that vitamin C leached into surrounding media because meals with high moisture content yielded higher values for this vitamin. It is further postulated that the undetected contents of vitamins A and E may be attributed to deterioration during handling of foodstuffs. Therefore, proper storage practices should be maintained to minimize loss of nutrients caused by exposing foodstuffs to surrounding elements and meals should be prepared in a manner that preserves the quality of nutrients.

REFERENCES

Barreira, J.C.M., Pereira, J.A., Oliveira, M.B.P.P. and Ferreira, I.C.F.R. (2010). Sugar profiles of different chestnut (Castaneasativa Mill.) and almond (Prunusdulcis) cultivars by HPLC-RI. *Plant Foods for Human Nutrition.* 65, 38–43.

Bevans, K.B., Sanchez, B., Teneralli, R. and Forrest, C.B. (2011). Children's eating behaviour: the importance of nutrition standards for foods in schools. *Journal of School Health*. 81, 424–429.

Black, R.E., Allen, L.H., Bhutta, Z.A., Caulfield, L.E., de Onis, M., Ezzati, M., Mathers, C. and Rivera, J. (2008). Maternal and child undernutrition: global and regional exposures and health consequences. *The Lancet*. 371, 243–260.

Blake, J.S., Munoz, K.D. and Volpe, S. (2010). *Nutrition: from science to you*. San Francisco: Pearson Benjamin Cummings.

Burgess, A.L. and Bunker, V.W. (2002). An investigation of school meals eaten by primary school children*. British Food Journal*. 104, 705–712.

Byrd-Bredbenner, C., Moe, G., Beshgetoor, D. and Berning, J. (2013). *Wardlaw's perspectives in nutrition*. 9th edition. New York: The McGraw-Hill Companies.

Cieslik, E., Leszczynska, T., Filipiak-Florkiewicz, A., Sikora, E. and Pisulewski, P.M. (2007). Effects of some technological processes on glucosinolate contents in cruciferous vegetables. *Food Chemistry.* 105, 976–981.

Chan, E.J. and Cho, L. (2009). What can we expect from omega-3 fatty acids?. *Cleveland Clinic Journal of Medicine*. 76, 245–251.

Charrondiere, U.R., Chevassus-Agnes, S., Marroni, S. and Burlingame, B. (2004). Impact of different macronutrient definitions and energy conversion factors on energy supply estimations. *Journal of Food Composition and Analysis*. 17, 339–360.

Department of Basic Education (DBE). (2013). Mnandi 4 sure: A recipe book for the National School Nutrition Programme. Available from: http://www.education.gov.za/LinkClick.aspx?fileticket=%2fBa%2fsZsQZvc%3d&tabid=440&mid=1911. Date of access: 2013/08/06.

Department of Education, United Kingdom. (2012). Nutritional standards. Available from: http://www.deni.gov.uk/index/support-and-development2/5schools_meals/nutritional-standards.htm. Date of access: 2013/06/27.

Effiong, G.S. and Udo, I.F. (2010). Nutritive values of four indigenous wild fruits in south eastern Nigeria. *Electronic Journal of Environmental, Agricultural and Food Chemistry*. 9, 1168–1176.

European Food Safety Authority (EFSA). (2010). Scientific opinion on dietary reference values for fats, including saturated fatty acids, polyunsaturated fatty acids, monounsaturated fatty acids, *trans* fatty acids, and cholesterol. *EFSA Journal*. 8, 1461.

Fontannaz, P., Kilinc, T. and Heudi, O. (2006). HPLC-UV determination of total vitamin C in a wide range of fortified food products. *Food Chemistry*. 94, 626–631.

Gallagher, M.L. (2008). The nutrients and their metabolism. In *Krause's Food & Nutrition Therapy*. L.K. Mahan and S.E. Stump (Eds). 12th edition. St. Louis: Saunders Elsevier., pp 39–143.

Gressler, V., Yokoya, N.S., Fujii, M.T., Colepicolo, P., Filho, J.M., Torres, R.P. and Pinto, E. (2010). Lipid, fatty acid, protein, amino acid and ash contents in four Brazilian red algae species. *Food Chemistry*. 120, 585–590.

Grindberg, T. and Williams, K. (2010). Vitamin C quantification using reversed-phase ion-pairing HPLC. *Concordia College Journal of Analytical Chemistry.*1, 19–23.

Haroun, D., Wood, L., Harper, C. and Nelson, M. (2011). Nutrient-based standards for school lunches complement food-based standards and improve pupils' nutrient intake profile. *British Journal of Nutrition.* 106, 472–474.

Heudi, O., Trisconi, M.J. and Blake, C.J. (2004). Simultaneous quantification of Vitamins A, D3 and E in fortified infant formulae by liquid chromatography–mass spectrometry. *Journal of Chromatography A*.1022, 115–123.

Hoffman, J.R. and Falvo, M.J. (2004). Protein – which is best?. *Journal of Sports Science and Medicine.* 3, 118–130.

Insel, P., Ross, D., McMahon, K. and Bernstein, M. (2013). *Discovering nutrition*. 4th edition. Burlington: Jones & Bartlett Learning.

Iversen, P.O., du Plessis, L., Marais, D., Morseth, M., Høisæther, E.A. and Herselman, M. (2011). Nutritional health of young children in South Africa over the first 16 years of democracy. *South African Journal of Child Health*. 5, 72–77.

Johnson, M., Östlund, S., Fransson, G., Kadesjö, B. and Gillberg, C. (2009). Omega-3/omega-6 fatty acids for attention deficit hyperactivity disorder: a randomized placebo-controlled trial in children and adolescents. *Journal of Attention Disorders*. 12, 394–401.

Jung, S., Rickert, D.A., Deak, N.A., Aldin, E.D., Recknor, J., Johnson, L.A. and Murphy, P.A. (2003). Comparison of Kjeldahl and Dumas methods for determining protein contents of soybean products. *Journal of the American Oil Chemists' Society*. 80, 1169–1173.

Kallman, K. (2005)**.** Food for thought: a review of the National School Nutrition Programme. Children's Institute. Cape Town: University of Cape Town.

Kuyper, L. (2000). Stability tests and sensory evaluation of fortified food vehicles for the national food fortification programme. Pretoria: Council for Scientific and Industrial Research (CSIR).

Labadarios, D., Steyn, N.P., Maunder, E., MacIntryre, U., Gericke, G., Swart, R., Huskisson, J., Dannhauser, A., Vorster, H.H., Nesmvuni, A.E. and Nel, J.H. (2005). The National Food Consumption Survey (NFCS): South Africa, 1999. *Public Health Nutrition*. 8, 533–543.

Lešková, E., Kubíová, J., Kováčiková, E., Košická, M., Porubská, J. and Holčíová, K. (2006). Vitamin losses: retention during heat treatment and continual changes expressed by mathematical models. *Journal of Food Composition and Analysis*. 19, 252−276.

Lin, C.H. and Chang, C.Y. (2005). Textural change and antioxidant properties of broccoli under different cooking treatments. *Food Chemistry.* 90, 9−15.

Llorent-Martínez, E.J., Fernández de Córdova, M.L., Ruiz-Medina, A. and Ortega-Barrales, P. (2012). Analysis of 20 trace and minor elements in soy and dairy yogurts by ICP-MS. *Microchemical Journal*. 102, 23–27.

Lucas, B.T. and Feucht, S.A. (2008). Nutrition in childhood. In *Krause's Food & Nutrition Therapy*. L.K. Mahan and S.E. Stump (Eds). 12th edition. St. Louis: Saunders Elsevier., pp 222–243.

Mabaya, E., Jordaan, D., Malope, P., Monkhei, M. and Jackson, J. (2010). Attribute preferences and willingness to pay for fortified cereal foods in Botswana. *Agricultural Economics Research, Policy and Practice in Southern Africa*. 49, 459-483.

McCleary, B.V., DeVries, J.W., Rader J.I., Cohen, G., Prosky, L., Mugford, D.C., Champ, H. and Okuma, K. (2010). Determination of total dietary fiber (CODEX definition) by enzymatic-gravimetric method and liquid chromatography: collaborative study. *Journal of AOAC International*. 93, 221–232.

McGuire, M.K. and Beerman, K.A. (2013). *Nutr*. Belmont: Cengage Learning.

Medeiros, D.M. and Wildman, R.E.C. (2012). *Advanced human nutrition*. 2nd edition. Sudbury: Jones & Bartlett Learning.

Menezes, E.W., de Melo, A.T., Lima, G.H. and Lajolo, F.M. (2004). Measurement of carbohydrate components and their impact on energy value of foods. *Journal of Food Composition and Analysis*.17, 331–338.

Molnar-Perl, I. (2000). Role of chromatography in the analysis of sugars, carboxylic acids and amino acids in food. *Journal of Chromatography A*. 891, 1–32.

Moreno-Rojas, R., Sánchez-Segarra, P. J., Cámara-Martos, F. and Amaro-López, M. A. (2010). Multivariate analysis techniques as tools for categorization of Southern Spanish cheeses: nutritional composition and mineral content. *European Food Research and Technology*. 231, 841–851.

Moses, **S.K.**, Whiting, A.V., Muir, D.C.G., Wang, X. and O'Hara, T.M. (2009). Organic nutrients and contaminants in subsistence species of Alaska: Concentrations and relationship to food preparation method. *International Journal of Circumpolar Health*. 68, 354–371.

Muir, J.G., Rose, R., Rosella, Q., Liels, K., Barrett, J.S., Shepherd, S.J. and Gibson P.R. (2009). Measurement of short-chain carbohydrates in common Australian vegetables and fruits by high-performance liquid chromatography (HPLC). *Journal of the Science of Food and Agriculture*. 57, 554–565.

Nicholas, J., Wood, L., Harper, C. and Nelson, M. (2013). The impact of the food-based and nutrient-based standards on lunchtime food and drink provision and consumption in secondary schools in England. *Public Health Nutrition*. 16, 1052–1065.

Nnakwe, N.E. (2013). *Community nutrition: planning health promotion and disease prevention*. 2nd edition. Burlington: Jones & Barlett Learning.

Pearce, J., Wood, L. and Nelson, M. (2012). Lunchtime food and nutrient intakes of secondary-school pupils; a comparison of school lunches and packed lunches following the introduction of mandatory food-based standards for school lunch. *Public Health Nutrition*. 16, 1126–1131.

Perez-Rodrigo, C. and Aracenta, J. (2001). School-based nutrition education: lessons learned and new perspectives. *Public Health Nutrition.* 4, 131–139.

Pretorius, B. and Schönfeldt, H.C. (2012).Vitamin A content of fortified maize meal and porridge as purchased and consumed in South Africa. *Food Research International.* 47, 128–133.

Prior, P.L. and Galduróz, J.C.F. (2012). (N-3) Fatty acids: molecular role and clinical uses in psychiatric disorders. *Advances in Nutrition*. 3, 257–265.

Rickman, J.C., Barrett, D.M. and Bruhn, C.M. (2007). Nutritional comparison of fresh, frozen and canned fruits and vegetables. Part 1. Vitamins C and B and phenolic compounds. *Journal of the Science of Food and Agriculture*. 87, 930–944.

Salo-Väänänen, P., Ollilainen, V., Mattila, P., Lehikoinen, K., Salmela-Mölsä, E. and Piironen, V. (2000). Simultaneous HPLC analysis of fat-soluble vitamins in selected animal products after small-scale extraction. *Food Chemistry*. 71, 535–543.

School Food Trust. (2008). A guide to introducing the government's food-based and nutrient-based standards for school lunches. Sheffield, UK: School Food

Trust: Eat better Do better. Available from: http://www.salisbury.anglican.org/resources-library/schools/schools-every-child-matters/be-healthy-school-food-trust-guide-to-government-lunch-standards. Date of access: 2013/06/27.

Severi, S., Bedogni, G., Manzieri, A.M., Poli, M. and Battistini, N. (1997). Effects of cooking and storage methods on the micronutrient content of foods. *European Journal of Cancer Prevention.* 6, 521–524

Sikora, E., Cieslik, E., Leszczynska, T., Filipiak-Florkiewicz, A. and Pisulewski, P.M. (2008). The antioxidant activity of selected cruciferous vegetables subjected to aquathermal processing. *Food Chemistry.* 107, 55–59.

Snelling, A.M. and Yezek, J. (2012). The effect of nutrient-based standards on competitive foods in 3 schools: potential savings in kilocalories and grams of fat. *Journal of School Health*. 82, 91–96.

Tarrago-Trani, M.T., Phillips, K.M. and Cotty, M. (2012). Matrix-specific method validation for quantitative analysis of vitamin C in diverse foods. *Journal of Food Composition and Analysis*. 26, 12–25.

Usfar, A.A., Achadi, E.L., Martorell, R., Hadi, H., Thaha, R., Jus'at, I., Atmarita, Martianto, D., Ridwan, H. and Soekirman. (2009). Expert meeting on child growth and micronutrient deficiencies - new initiatives for developing countries to achieve millennium development goals: executive summary report. *Asia Pacific Journal of Clinical Nutrition*. 18, 462–469.

Vallejo, F., Tomas-Barberan, F.A. and Garcia-Viguera, C. (2002). Glucosinolates and vitamin C content in edible parts of broccoli florets after domestic cooking. *European Food Research and Technology*. 215, 310–316.

Vinha, A.F., Barreira, S.V.P., Castro, A., Costa, A. and Oliveira, M.B.P.P. (2013). Influence of the storage conditions on the physicochemical properties, antioxidant activity and microbial flora of different tomato (Lycopersicon esculentum L.) cultivars. *Journal of Agricultural Science*. 5, 118–128.

Weichselbaum, E. and Buttriss, J. (2011). Nutrition, health and schoolchildren. *Nutrition Bulletin*, 36, 295–355.

World Hunger Education Service. (2011). 2012 World hunger and poverty facts and statistics. Available from: http://www.worldhunger.org/articles/Learn/world%20hunger%20facts%202002.htm#Number_of_hungry_people_in_the_world. Date of access: 2013/04/28.

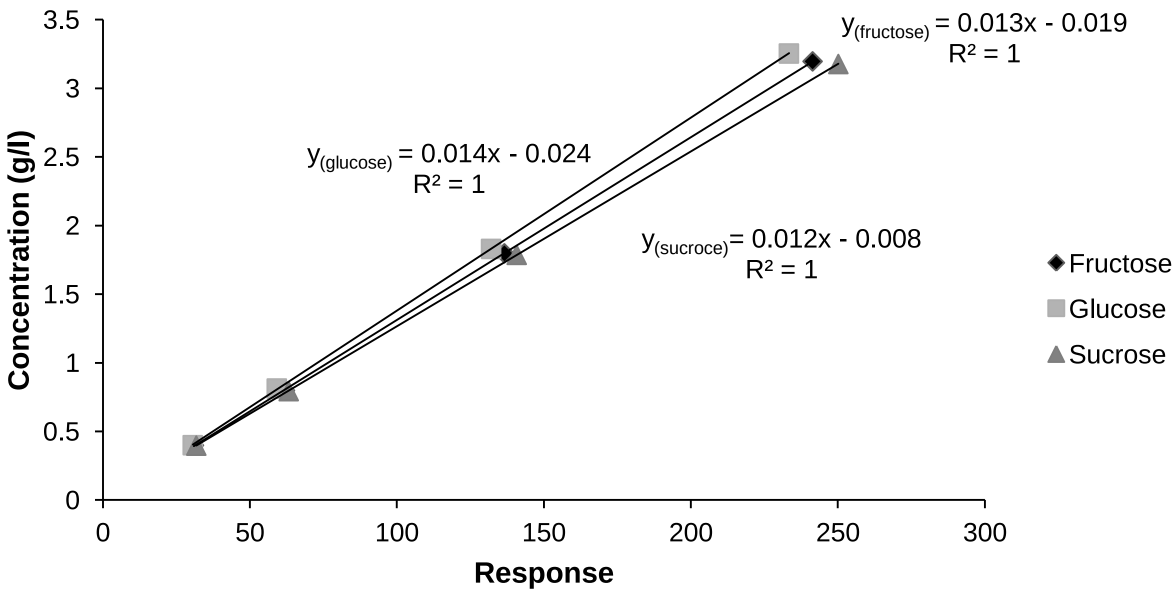
Yuan, G., Sun, B., Yuan, J. and Wang, Q. (2009). Effects of different cooking methods on health-promoting compounds of broccoli. *Journal of Zhejiang University SCIENCE B*.10, 580–588.

Zhou, J., Suo, Z., Zhao, P., Cheng, N., Gao, H., Zhao, J. and Cao, W. (2013). Jujube honey from China: physicochemical characteristics and mineral contents. *Journal of Food Science*. 78, C387–C394.

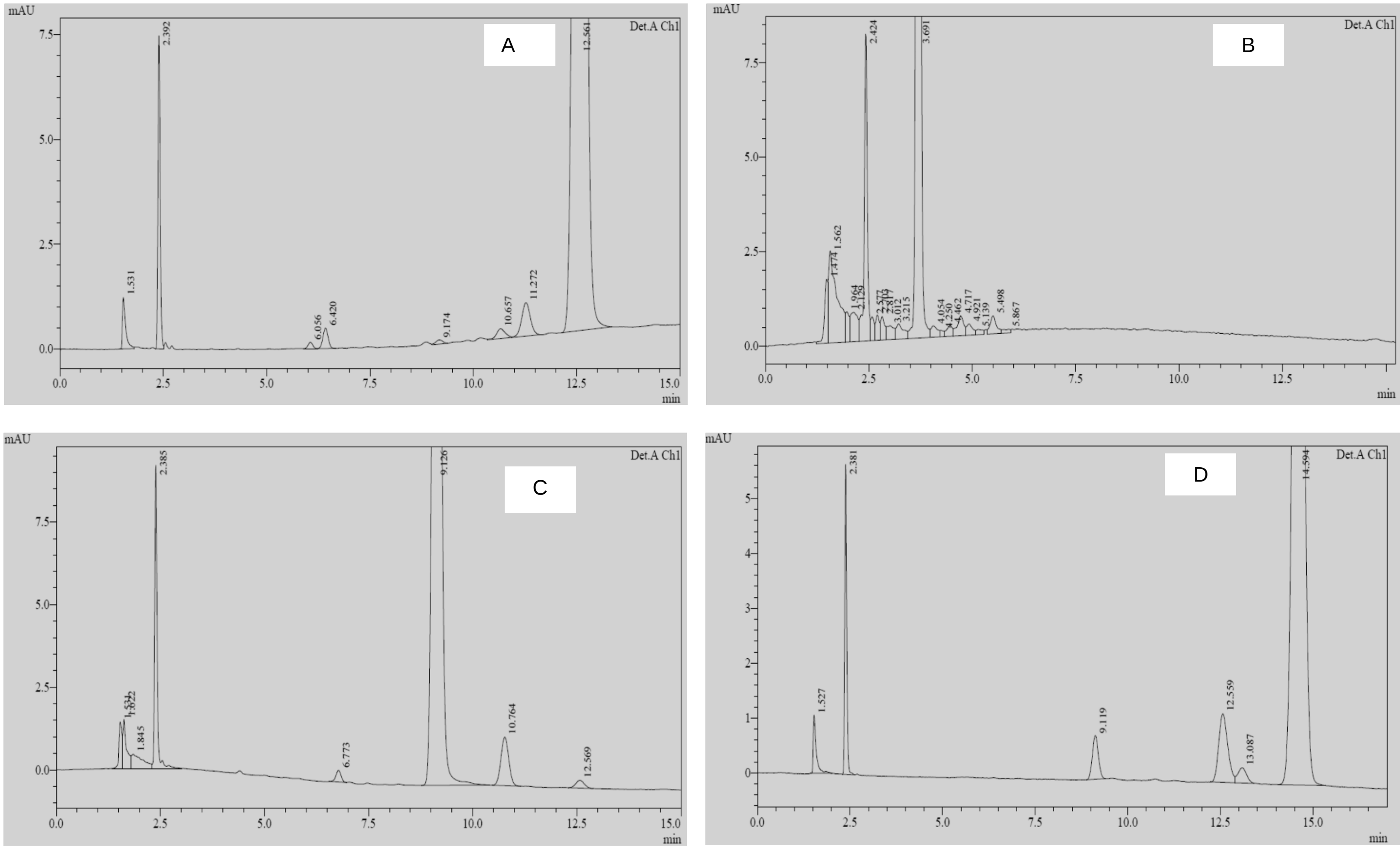
APPENDICES

Appendix 1. Nutrient-based standards for an average school lunch (adapted from School Food Trust, 2008)

Nutrient	**Maximum or Minimum**	**7–10 years**	**11–18 years**
Energy (kJ)	Min	2215 ± 111	2700 ± 135
Carbohydrate (g)	Min	70.6	86.1
Fat (g)	Max	20.6	25.1
Protein (g)	Min	7.5	13.3
Vitamin A (µg)	Min	175	245
Vitamin C (mg)	Min	10.5	14.0
Calcium (mg)	Min	193	350
Iron (mg)	Min	3.0	5.2
Zinc (mg)	Min	2.5	3.3



Appendix 2. Calibration curve regression of mono- and disaccharides over a calibration range of 0.4–3.2 $g.l^{-1}$



Appendix 3. Chromatograms of vitamins A and E standards (A: retinyl acetate; B: δ-tocopherol; C: α-tocopherol; D: α-tocopherol acetate)

CHAPTER 3

THE PREVALENCE OF MICROBIOTA ON FOOD CONTACT SURFACES ASSOCIATED WITH A SOUTH AFRICAN SCHOOL FEEDING SCHEME

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3.1. ABSTRACT

The prominence of disease transmission between individuals in confined environments is a concern particularly in educational environments. These environments primarily facilitate educational activities and are not conducive for catering purposes. With respect to school feeding schemes food contact surfaces may act as a potential source of cross-contamination of pathogens. The aim of this study was to assess the contamination levels of surfaces that came into contact with food provided to children during the administration of the National School Nutrition Programme in central South Africa. In each school under study, microbiological samples were collected from the preparation surfaces and the dominant hands and aprons of food handlers. The samples were analysed for total viable counts, total coliforms, *Escherichia coli*, *Staphylococcus aureus* and yeast and moulds. The criteria specified in the British Columbia Centre for Disease Control Guide for Environmental Health Officers were used to evaluate the results. Total viable counts produced colonies that were too numerous to count (over 100 colonies per plate) for the majority of the surfaces. When compared to the guide, approximately 7% of all surfaces produced unsatisfactory enumeration of *S. aureus* and *E. coli* whereas approximately 10% and 37% of the counts were unsatisfactory for total coliforms and yeast and mould, respectively. Statistically differences could not be established amongst microbial counts of the surfaces which suggest cross-contamination may have occurred. Contamination may be attributed to foodstuffs and animals (particularly rodents) in the vicinity of the preparation area rather than to the food handlers since the hands had the lowest counts of enumerated organisms amongst the analysed surfaces.

Keywords: National School Nutrition Programme, cross-contamination, microbiological testing, food contact surfaces

3.2. INTRODUCTION

Direct transmission of diseases among individuals has been shown to be prominent in confined environments such as schools (Mbithi *et al.*, 1992; Clay *et al*., 2006). School environments are particularly prone to epidemiological outbreaks due to the nature of inter-personal dynamics. The risk is augmented with the introduction of an additional variable which supports microbial proliferation, such as food. Food, water and surfaces may be contaminated with considerable quantities of pathogenic microorganisms during food preparation and consumption, which may result in illnesses (Taulo *et al.*, 2009). Young children are particularly vulnerable to pathogenic bacteria and are at risk of developing pathological conditions upon being infected with pathogens such as *Escherichia coli*, *Staphylococcus aureus* and some opportunistic pathogens upon consumption of contaminated foods (Gerba, 2009; Lee and Greiga, 2010; Adams, 2012). In children, *E. coli* infection may be associated with diarrhoea and haemolytic uraemic syndrome (HUS) (particularly in children under five years of age) which may result in fatality (Bell and Kyriakides, 1998; Scannell, 2012). Possible outbreaks amongst school children are of concern since illnesses from pathogenic bacteria may persist for a maximum of three to five days (Gerba, 2009; Scannell, 2012) and therefore promote absenteeism. The main factors that lead to food-borne illnesses have been shown to be improper time/temperature control, poor personal hygiene of the food preparer and cross-contamination (Collins, 1997; FDA, 2004; Brannon *et al.*, 2009). Blackburn (2003) describes food contact surfaces and food handlers' hands as significant potential vehicles of pathogens. Cross-contamination via the hands of food handlers and food contact surfaces, particularly chopping boards, is a major concern in the transmission of food-borne pathogens. These surfaces have been found to have a significant contribution to cross-infection and pose an elevated risk of microbial transfer (Bloomfield and Scott, 1997; Cogan *et al*., 1999; Gorman *et al*., 2002). Food-borne pathogens may be introduced by the unwashed hands of food handlers who themselves are infected while remaining operational in food preparation environments. Microbiota may further be transferred amongst foodstuffs by the use of utensil or cutting board without proper sanitation (CDC, 2013).

Since food contact surfaces are particularly important vectors in the dispersal of food-borne pathogens, their cleaning and sanitization is of importance in reducing the number and type of potential pathogens (Knechtges, 2012). Frequent sanitation is reportedly the most effective control measure in ensuring the microbiological safety of foodstuffs (Changani *et al.*, 1997; Blackburn, 2003). It is also critical to ensure that cleaning is achieved to a measure that substantially reduces cross-contamination and ensures the integrity of the food (Stephan *et al*., 2004; Jackson *et al*., 2008). Furthermore, the majority of food-related diseases are transmitted via the faecal-oral route, therefore reducing sources of faecal contamination is fundamental in achieving food sanitation (Gerba, 2009). In addition to cleaning and sanitizing, the application and evaluation of monitoring methods is necessary for ensuring the efficiency of sanitation procedures in the food processing environment (Gilbert, 1970). According to Moore and Griffith (2002), various methods of detecting microbiota and enumerating microbial surface contamination may be integrated. Microbiological testing plays an important role in identifying potential threats and their sources as well as evaluating their effects on the final product. Assessments may further assist in developing and implementing preventative measures (Blackburn, 2003) and may promote food safety while administering school feeding schemes such as the South African National School Nutrition Programme (NSNP). The NSNP was introduced to serve food to pupils across the country, mainly among poverty-stricken communities. However, since the programme is rolled out at schools that are primarily deficient of proper catering facilities, the maintenance of hygiene may be questionable during the administration of the programme. It was envisaged that the current study would provide information on the general hygiene of surfaces in contact with foodstuffs during the administration of the NSNP at participating schools in Bloemfontein, South Africa, through the use of microbiological methods.

3.3. MATERIALS AND METHODS

3.3.1. Sampling protocol

Ten schools were randomly selected from amongst beneficiaries of the NSNP in the Bloemfontein area. The sample represented schools in quintiles 1, 2 and 3 categories and included primary, intermediate, combined and special schools from the rural and urban regions. Schools are categorized (by the Department of Basic Education) in quintiles according to the socio-economic statuses of the communities with the lowest being quintile 1. For the purpose of this study, schools were alphabetically labelled to maintain confidentiality. From each school, representative samples were collected from three previously cleaned surfaces that came into contact with foodstuffs, namely the preparation surface, and the hand (thumb, forefinger, middle finger and palm of dominant hand) and the apron of the food handler. In total, 120 surface samples were collected. All samples were transported on ice to the laboratory where investigations were conducted without delay. All analyses were performed in triplicate.

3.3.2. Microbial analysis

Microbial samples were collected and quantified using 65 mm Rodac plates (Lasec, Ndabeni, Cape Town, SA). The media were prepared according to the manufactures' instructions, followed by preparation of the contact plates according to the method proposed by Bruch and Smith (1968) and Ness (1994). The selected agar media were used to investigate total viable counts, total coliforms, *E. coli*, *S. aureus* and yeasts and moulds on the dominant hand of each food preparer. Four samples were also collected from exposed areas of the aprons and cutting surfaces using the Rodac plates containing agar media to investigate the mentioned organisms.

Total viable counts

Plate count agar (PCA) (Merck, Wadeville, Gauteng, SA) was used for the enumeration and detection of TVC and plates were incubated at 36°C for 24 to 48 hours (Lues and van Tonder, 2007).

Total coliforms and Escherichia coli

Total coliforms and presumptive *E. coli* were enumerated using Chromocult coliform agar (CCA) (Merck, SA) and incubated at 36°C for 24 to 48 hours. Typical coliforms were salmon pink to red in colour, whilst *E. coli* produced typical dark-blue to violet colonies (González *et al.*, 2003).

Staphylococcus aureus

Baird-Parker agar (BPA) (Merck, SA) supplemented with egg yolk telluride emulsion was used for the enumeration of presumptive *S. aureus* and plates were incubated at 36°C for 24 to 48 hours. Grey-black shiny colonies with white margins surrounded by clear zones were identified as *S. aureus* colonies (Baird & Lee, 1995).

Yeasts and moulds

Potato dextrose agar (PDA) (Merck, SA) plates were incubated at 25°C for 3 to 5 days for the enumeration of yeasts and moulds (Beuchat, 1992). Typically, yeasts exhibited creamy to white colonies and moulds appeared as filamentous colonies of various colours.

Analysis of data

Upon differentiation of microbial colonies on appearance and colour, they were counted using a Symbiosis aCOLade colony counter (Vacutec, Randburg, Gauteng, SA) and expressed as CFU.cm^{-2}. All results were evaluated according to the British Columbia Centre for Disease Control (BCCDC) Guide for Environmental Health Officers using the following criteria: satisfactory: < 5 CFU.cm^{-2}; acceptable: 5 CFU.cm^{-2} to 10 CFU.cm^{-2}; and unsatisfactory: > 10 CFU.cm^{-2} (BC Centre for Disease Control, 2010). This guideline was used as it is considered authoritative

(Skowronski *et al.*, 2012) as well as related to the South African environmental health systems. In addition, the guideline provided by the BCCDC guide articulates well with the units and best described assumptions used in this study. Additionally the BCCDC guide was found to cover significantly more categories when compared to the South African R.918 of 1999 which offers only the guideline of 100 $CFU.cm^{-2}$ on surfaces. For the purpose of this study, counts of above 100 colonies as determined by the probable number of volumes which produced a matrix of growth rather than individual countable colonies were labelled as too numerous to count (TNTC). The significance defined was at the p-value of 0.05.

3.4. RESULTS AND DISCUSSION

As shown in Table 3.1, in terms of TVC, 80% of all the surfaces sampled had counts that were TNTC. For total coliforms, 60% of the counts obtained from hands were satisfactory while 20% were acceptable and 20% were not detectable. For preparation surfaces, 40% of coliform counts were satisfactory and 20% were acceptable, whereas 30% were unsatisfactory and 10% were not detectable when compared to the BCCDC guide. Furthermore, 80% of the apron counts were satisfactory, 10% were acceptable and 10% were not detectable for total coliforms. *E. coli* counts ranged between 0.50 and 2.63 $CFU.cm^{-2}$ for the hands, 0.60 $CFU.cm^{-2}$ and TNTC for preparation surfaces, and 0.29 and 2.44 $CFU.cm^{-2}$ for aprons (Table 3.1). Fifty percent and 90% of the *E. coli* counts were satisfactory for the hands and aprons, respectively, and the remaining counts of both surfaces were not detectable. Additionally, 60% of the counts for the preparation surfaces were satisfactory, 10% were acceptable. 20% were unsatisfactory and 10% were not detectable for *E. coli*. *S. aureus* counts ranged between 0.40 and 5.57 $CFU.cm^{-2}$ for the hands, 0.60 $CFU.cm^{-2}$ and TNTC for preparation surfaces, and 0.70 and 4.17 $CFU.cm^{-2}$ for aprons. For the hands, 80% of the *S. aureus* counts were satisfactory, 10% were acceptable and 10% were not detectable; while 60% were satisfactory for preparation surfaces, 20% were acceptable and 20% were unsatisfactory whereas all detectable counts (90%) were satisfactory for aprons. Of the three surfaces analysed, preparation surfaces enumerated the highest counts of total coliforms, *E.*

Table 3.1. Counts of various organisms from food contact surfaces of schools participating in the NSNP, Bloemfontein

School Nr	Surface	Bacterial counts ($CFU.cm^{-2}$)				
		TVC	**Total coliforms**	***E. coli***	***S. aureus***	**Yeasts & moulds**
A	Hands	TNTC	2.50	0.50	0.50	1.33
	Table	TNTC	9.88	4.13	1.47	3.31
	Apron	12.50	3.17	1.00	1.57	2.73
B	Hands	TNTC	0.40	ND	4.00	0.50
	Tray	TNTC	ND	ND	1.00	1.00
	Apron	TNTC	1.44	0.88	0.70	TNTC
C	Hands	TNTC	1.00	0.50	0.40	TNTC
	Sink	TNTC	1.17	1.25	0.60	TNTC
	Apron	TNTC	1.44	0.60	ND	TNTC
D	Hands	TNTC	1.00	0.50	3.67	7.00
	Table	TNTC	TNTC	7.00	12.19	TNTC
	Apron	TNTC	9.19	2.44	2.60	TNTC
E	Hands	TNTC	7.93	2.62	4.80	2.25
	Tray	TNTC	4.75	4.56	5.88	3.94
	Apron	TNTC	1.42	0.29	2.38	TNTC
F	Hands	TNTC	4.00	2.63	1.25	2.33
	Table	TNTC	13.75	11.88	4.31	TNTC
	Apron	TNTC	2.00	1.00	1.33	0.78
G	Hands	TNTC	1.50	ND	2.20	3.71
	Tray	TNTC	TNTC	TNTC	TNTC	TNTC
	Apron	4.06	1.70	1.40	2.77	TNTC
H	Hands	0.83	ND	ND	1.00	0.50
	Table	TNTC	2.75	1.00	1.20	ND
	Apron	TNTC	1.10	1.00	3.57	1.80
I	Hands	0.17	ND	ND	ND	ND
	Table	TNTC	6.13	1.00	1.13	17.19
	Apron	1.00	ND	ND	0.86	0.88
J	Hands	3.80	5.17	ND	5.57	5.75
	Table	TNTC	2.69	1.25	5.14	5.75
	Apron	TNTC	2.00	1.43	4.17	TNTC

TNTC: Too numerous to count (>100 colonies).
ND: Not detectable using the current method.

coli and *S. aureus*. Yeast and mould counts ranged between 0.50 $CFU.cm^{-2}$ and TNTC for the hands, 1.00 $CFU.cm^{-2}$ and TNTC for preparation surfaces, 0.78 $CFU.cm^{-2}$ and TNTC for the aprons (Table 3.1). According to BCCDC guide, for the hands, 60% of the counts of yeasts and moulds were satisfactory, 20% were acceptable, 10% were unsatisfactory and 10% were not detectable, while 40% were satisfactory, 50% were unsatisfactory and 10% were not detectable for the preparation surfaces, and 40% of the counts were satisfactory and 60% were unsatisfactory for the aprons. Aprons yielded the highest counts of yeast and moulds while hands had the lowest counts of these organisms.

The objective of TVC is to provide a general indication of the number of organisms present in the sample, thereby indicating the general hygiene status of the sample (Bell *et al.*, 2005) while the presence of coliforms indicates a risk in occurrence of pathogens and is therefore a measure of the effectiveness of sanitation programmes (Frank *et al.*, 1990; Buchanan, 2000). In addition, coliforms, including *E. coli*, form part of the natural microbiota in the intestinal tracts of warm-blooded humans and animals. Their presence generally indicates faecal contamination (Bell and Kyriakides, 1998; Lues and van Tonder, 2007; Pepper and Gerba, 2009). Pathogens may be present in faeces in concentrations of between 10^4 and $10^{11}.g^{-1}$ indicating that even a tenth of a milligram of faeces on the skin may contain up to a million infectious bacterial cells (Lee and Greiga, 2010). A higher contamination of food by hands than that by surfaces was observed during a study by Taulo *et al.* (2009), which found that the transfer of *S. aureus* was significantly higher than that of *E. coli*. The authors postulated that although the traditional cooking of thick porridge inactivated *S. aureus* and *E. coli*, the porridge could have been contaminated with the bacteria by hands and wooden ladles during serving. During this study, however, the hands of food handlers yielded lower counts of all enumerated organisms (total coliforms, *E. coli*, *S. aureus* and yeasts and moulds) than preparation surfaces. This finding suggests that the sources of contamination are more likely to result from the foodstuffs and animals (rodents particularly in the rural areas) in the vicinity of the preparation area rather than from the food handlers themselves.

Although some visual differences were observed among the contamination levels of hands, preparation surfaces and aprons, a significant deference regarding the microbial counts among these food contact surfaces could not be established ($P > 0.05$). Thus it appears that considerable cross-contamination resulted among the surfaces with no evident differences in, for example, cleaning regimes. Additionally, this observation points to a lack of practices that isolates these surfaces from one another so as to hinder cross-contamination. Other factors which may be attributed to contamination of surfaces include the use of contaminated water and there may have been shortcomings in surface sanitation methods, such as incorrect detergent to water dilution ratios and the minimum contact time for disinfectants (Samadi *et al.*, 2009; Taulo *et al.*, 2009). A study of Mosupye and von Holy (2000), during which facilities of street food vendors in Johannesburg, South Africa, were assessed, illustrated high aerobic plate and coliform counts from surface samples collected from a vendor who did not clean the food preparation surface during preparation whereas fewer counts were observed from a vendor who constantly cleaned the surface using a dishcloth. With regards to yeasts and moulds, the main source of contamination is the environment, particularly the air (Kure *et al*., 2004). Preparation areas of the majority of the schools were predisposed to becoming dusty due to a lack of proper kitchen facilities and ventilation which may contribute to contamination of surfaces and foodstuffs.

Illness-causing bacteria may survive on various surfaces around the kitchen, including hands, utensils, and cutting boards. The CDC (2013) recommends that hands be washed for 20 seconds with soap and running water, followed by scrubbing at the back, between fingers and under the nails. Furthermore, for utensils and cutting boards to be sufficiently sanitized, hot water with detergent and a sanitising (bleach) solution should be used. Although not sufficient, hand-washing alone significantly reduces levels of bacteria load. Due to a lack of resources and because of infrastructure limitations, the majority of the schools participating in the NSNP were not provided with hand-washing facilities within the food preparation areas and nor did they have readily available hot water. The water taps, particularly at schools located in rural areas, were located outside and were not in the vicinity of the food preparation areas. A study by Snyder (2004) found a significant reduction of *E.coli* by rinsing hands in a bucket of acetic acid solution prepared with tap water (at room temperature) and distilled vinegar (5% acetic acid). The solution proved to maintain effectiveness after several hand rinses (i.e., less than 1 CFU.10ml^{-1} was observed in the solution after 24 hours).

In addition to cleaning practices, the nature of the contact surfaces may have an impact on contamination levels of foods with microorganisms. According to the South African Health Regulations (R.918 of 1999), the surface which comes into direct contact with food should be made of smooth, rust-proof, non-toxic and non-absorbent material that is free of open joints, chips or cracks. Generally, smooth surfaces are easier to clean than irregular surfaces. Surfaces which may crack, splinter, scratch and distort provide harbourage for microorganisms and prevent proper cleaning and sanitizing (Knechtges, 2012). Additionally, organic material from food residues may reduce the effectiveness of disinfectant by either reacting chemically with the disinfectant or inhibiting the physical access of the disinfectant to the targeted microbiota (Entis, 2007; Meyer *et al.*, 2010). The high levels of organic material likely to be present on food contact surfaces increase the hydrophilicity of the surfaces, and bacteria attach more readily to hydrophilic surfaces, but struggle to remain attached to hydrophobic surfaces (Zottola and Sasahara, 1994; Dickinson *et al*., 1997; Abban *et al.*, 2012). The majority of the schools sampled during the current study (60%) prepared food on wooden table tops while the other 40% used plastic surfaces (data not shown). According to Abban *et al.* (2012), stainless steel is the material of choice in the food processing environment. However, plastic cutting boards may also contribute greatly to cleanliness and minimize cross-contamination (Knechtges, 2012). According to Entis (2007), the cutting board is the most susceptible to contamination of all the kitchen utensils and the porous nature of wood leads to concerns regarding the potential for cross-contamination. The wooden food preparation surfaces employed by schools during the administration of the NSNP were irregular and hydrophilic with distinct flaws, thus creating a favourable habitat onto which microorganisms could attach and grow. Conversely, it is noteworthy that the preparation surface used by school G (which was made of plastic) had counts that were TNTC for all enumerated organisms which indicates that in some instances the method of sanitation may have a greater impact on the hygiene of surfaces than the nature of material from which the surface is made.

3.5. CONCLUSIONS

Generally, the present study indicated that preparation surfaces had the highest counts of the detected pathogens, whereas hands had the lowest counts of microorganisms. However, a significant difference in the microbial loads amongst the food contact surfaces could not be established. These findings suggest that although the surfaces may have not been sources of contamination, opportunity for the occurrence of cross-contamination among surfaces may be due to lack of surface isolation and shortcomings in the cleaning regimes. To prevent cross-contamination, all equipment and working surfaces must be thoroughly washed with hot water and detergent after being used to prepare raw foods. In this regard, sanitation programmes have proved to be cost effective, simple to implement and to significantly reduce microbial contamination (Stretch and Southgate, 1991; Blackburn, 2003). According to DeVere and Purchase (2007), the traditional two-step detergent and rinse cleaning method has been substituted with various antibacterial products that have been developed to provide fast and effective cleaning to food preparation areas. Household bleach (sodium hypochlorite) is an inexpensive and readily available agent for sanitizing preparation surfaces (Entis, 2007). Individuals carry thousands of bacteria on the surface of their skin (such as *S. aureus* and *Salmonella* bacteria) and are usually not aware they may be carriers of food pathogens (Stretch and Southgate, 1991). The importance of washing hands, particularly after using the toilet, should not be overlooked. With the various opportunities for food to become contaminated during production and preparation, monitoring procedures which include microbial analyses may contribute to ensuring the safety of foodstuffs.

REFERENCES

Abban, S., Jakobsen, M. and Jespersen, L. (2012). Attachment behaviour of *Escherichia coli* K12 and *Salmonella Typhimurium* P6 on food contact surfaces for food transportation. *Food Microbiology*. 31, 139–147.

Adams, M. (2012). Introduction to food microbiology. In *Handbook of food safety engineering.* D. Sun (Ed). Chichester: Wiley-Blackwell, pp. 3–17.

Baird, R.M. and Lee, W.H. (1995). Media used in the detection and enumeration of *Staphylococcus aureus*. *International Journal of Food Microbiology*. 26, 15–24.

BC Centre for Disease Control. (2010). Environmental hygiene monitoring: a guide for environmental health officers. Available from: http://www.bccdc.ca/NR/rdonlyres/EF1461BE-0301-4A59-8843-420072412721/0/EnvMonitoringHygieneGuideforEHOs.pdf. Date of access: 2012/05/28.

Bell, C. and Kyriakides, A. (1998). *E. coli: a practical approach to the organism and its control in food*. 1st edition. London: Blackie Academic & Professional.

Bell, C., Neaves, P. and Williams, A.P. (2005). *Food microbiology and laboratory practice.* Oxford: Blackwell Publishing.

Beuchat, L.R. (1992). Media for detecting and enumerating yeasts and moulds. *International Journal of Food Microbiology.* 17, 145–158.

Blackburn, C. de W. (2003). Microbiological analysis and food safety management: GMP and HACCP systems. In *Detecting pathogens in food*. T.A. McMeekin (Ed). Cambridge: Woodhead Publishing Limited, pp. 3–17.

Bloomfield, S.F. and Scott, E. (1997). Cross-contamination and infection in the domestic environment and the role of chemical disinfectants. *Journal of Applied Microbiology*. 83, 1–9.

Brannon, L.A., York, V.K., Roberts, K.R., Shanklin, C.W. and Howells, A.D. (2009). Appreciation of food safety practices based on level of experience. *Journal of Foodservice Business Research.* 12, 134–154.

Bruch, M.K. and Smith F.W. (1968). Improved method for pouring rodac plates. *Applied Microbiology*. 16, 1427–1428.

Buchanan, R.L. (2000). Acquisition of microbiological data to enhance food safety. *Journal of Food Protection*. 63, 832–838.

Centers for Disease Control and Prevention (CDC). (2013). Food safety. Available from: http://www.cdc.gov/foodsafety/, Date of access: 2013/02/21.

Changani, S.D., Belmar-Beiny, M.T. and Fryer, P.J. (1997). Engineering and chemical factors associated with fouling and cleaning in milk processing. *Experimental Thermal and Fluid Science.*14, 392–406.

Clay, S., Maherchandani, S., Malik, Y.S. and Goyal, S.M. (2006). Survival on uncommon fomites of feline calicivirus, a surrogate of norovirus. *American Journal of Infection Control*. 34, 41–43.

Cogan, T.A., Bloomfield, S.F. and Humphrey, T.J. (1999). The effectiveness of hygiene procedures for the prevention of cross-contamination from chicken carcasses in the domestic kitchen. *Letters in Applied Microbiology*. 29, 354–358.

Collins, J.E. (1997). Impact of changing lifestyles on the emergence/re-emergence of foodborne pathogens. *Emerging Infectious Diseases*. 3, 471–479.

DeVere, E. and Purchase, D. (2007). Effectiveness of domestic antibacterial products in decontaminating food contact surfaces. *Food Microbiology*. 24, 425–430.

Dickinson, R.B., Nagel, J.A., Proctor, R.A. and Cooper, S.L. (1997). Quantitative comparison of shear-dependent *Staphylococcus aureus* adhesion to three polyurethane ionomer analogs with distinct surface properties. *Journal of Biomedical Materials Research*. 36, 152–162.

Entis, P. (2007). *Food safety: old habits, new perspectives*. Washington, DC: ASM Press.

Food and Drug Administration (FDA). (2004). FDA report on the occurrence of foodborne illness risk factors in selected institutional foodservice, restaurant, and retail food store facility types. Available from: http://www.fda.gov/Food/FoodSafety/RetailFoodProtection/FoodborneIllnessandRiskFactorReduction/RetailFoodRiskFactorstudies/ucm089696.htm. Date of access: 2012/07/03.

Frank, J.F., Gillett, R.A.N. and Ware, G.O. (1990). Association of *Listeria spp.* contamination in the dairy processing plant environment with the presence of *Staphylococci*. *Journal of Food Protection*. 53, 928–932.

Gerba, C.P. (2009). Environmentally transmitted pathogens. In *Environmental microbiology*. 2nd edition. R.M. Maier, I.L. Pepper and C.P. Gerba (Eds). Burlington: Elsevier, pp. 445–484.

Gilbert, R.J. (1970). Comparison of materials used for cleaning equipment in retail food premises, and of two methods for the enumeration of bacteria on cleaned equipment and work surfaces. *The Journal of Hygiene*. 68, 221–232.

González, R.D., Tamagnini, L.M., Olmos, P.D. and de Sousa, G.B. (2003). Evaluation of a chromogenic medium for total coliforms and *Escherichia coli* determination in ready-to-eat foods. Food Microbiology. 20, 601–604.

Gorman, R., Bloomfield, S. and Adley, C.C. (2002). A study of cross-contamination of food-borne pathogens in the domestic kitchen in the Republic of Ireland. *International Journal of Food Microbiology*. 76, 143–150.

Jackson, L.S., Al-Taher, F.M., Moorman, M., DeVries, J.W., Tippett, R., Swanson, K.M.J., Fu, T.J., Salter, R., Dunaif, G., Estes, S., Albillos, S. and Gendel, S.M. (2008). Cleaning and other control and validation strategies to prevent allergen cross-contact in food-processing operations. *Journal of Food Protection.* 71, 445–448.

Knechtges, P.L. (2012). *Food safety: theory and practice*. Burlington: Jones & Bartlett Learning.

Kure, F.C., Skaar, I. and Brendehaug, J. (2004). Mould contamination in production of semi-hard cheese. *International Journal of Food Microbiology*. 93, 41–49.

Lee, M.B. and Greiga, J.D. (2010). A review of gastrointestinal outbreaks in schools: effective infection control interventions. *Journal of School Health*. 80, 588–598.

Lues, J.F.R. and van Tonder, I. (2007). The occurrence of indicator bacteria on hands and aprons of food handlers in the delicatessen sections of a retail group. *Food Control.* 18, 326–332.

Mbithi, J.N., Springthorpe, V.S., Boulet, J.R. and Sattar, S.A. (1992). Survival of hepatitis A virus on human hands and its transfer on contact with animate and inanimate surfaces. *Journal of Clinical Microbiology.* 30, 757–763.

Meyer, B., Morin, V.N., Rödger, H.-J., Holah, J. and Bird, C. (2010). Do European standard disinfectant tests truly simulate in-use microbial and organic soiling conditions on food preparation surfaces? *Journal of Applied Microbiology*.108, 1344–1351.

Moore, G. and Griffith, C. (2002). A comparison of surface sampling methods for detecting coliforms on food contact surfaces. *Food Microbiology*. 19, 65–73.

Mosupye, F.M. and von Holy, A. (2000). Microbiological hazard identification and exposure assessment of street food vending in Johannesburg, South Africa. *International Journal of Food Microbiology.* 61,137–145.

Ness, S.A. (1994). *Surface and dermal monitoring for toxic exposures*. New York: John Wiley & Sons, Inc.

Pepper, I.L. and Gerba, C.P. (2009). Cultural methods. In *Environmental microbiology*. 2nd edition. R.M. Maier, I.L. Pepper and C.P. Gerba (Eds). Burlington: Elsevier, pp. 173–189.

Republic of South Africa. (1999). Regulation No. R.918 of 30 July 1999: Regulations governing general hygiene requirements for food premises and the transport of food, promulgated under the *Health Act, 1977 (Act No. 63 of 1977)*. Pretoria: Government Printer.

Samadi, N., Abadian, N., Bakhtiari, D., Fazeli, M.R. and Jamalifar, H. (2009). Efficacy of detergents and fresh produce disinfectants against microorganisms associated with mixed raw vegetables. *Journal of Food Protection.* 72, 1486–1490.

Scannell, A.G.M. (2012). Overview of foodborne pathogens. In *Handbook of food safety engineering.* D. Sun (Ed). Chichester: Wiley-Blackwell, pp. 18–56.

Skowronski, D.M., Janjua, N.Z., De Serres, G., Purych, D., Gilca, V., Scheifele, D.W., Dionne, M., Sabaiduc, S., Gardy, J.L., Li, G., Bastien, N., Petric, M., Boivin, G. and Li, Y. (2012). Cross-reactive and vaccine-induced antibody to an emerging swine-origin variant of influenza A virus subtype H3N2 (H3N2v). *Journal of Infectious Diseases.* 206, 1852–1861.

Snyder, O.P. Jr. (2004). HACCP-based fingertip rinse procedure. *Food Protection Trends*. 24, 162–165.

Stephan, O., Weisz, N., Vieths, S., Weiser, T., Rabe, B. and Vatterott, W. (2004). Protein quantification, sandwich ELISA, and real-time PCR used to monitor industrial cleaning procedures for contamination with peanut and celery allergens. *Journal of AOAC International.* 87, 1448–1457.

Stretch, A. and Southgate, H. (1991). *Food hygiene, health & safety*. England: Addison Wesley Longman Limited.

Taulo, S., Wetlesen, A., Abrahamsen, R.K., Narvhus, J.A. and Mkakosya, R. (2009). Quantification and variability of *Escherichia coli* and *Staphylococcus aureus* cross-contamination during serving and consumption of cooked thick porridge in Lungwena rural households, Malawi. *Food Control*. 20, 1158–1166.

Zottola, E.A. and Sasahara, K.C. (1994). Microbial biofilms in the food processing industry – should they be a concern? *International Journal of Food Microbiology*. 23, 125–148.

CHAPTER 4

FOOD SAFETY KNOWLEDGE, ATTITUDES AND PRACTICES OF FOOD HANDLERS AND REPRESENTATIVES OF A SCHOOL FEEDING PROGRAMME

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4.1. ABSTRACT

Training in food safety is an important contributor to the knowledge and practices of individuals tasked with the management and preparation of foodstuffs. Specific knowledge with regards to the risks associated with food provision in sensitive environments, such as where the beneficiaries include the elderly, pregnant, immunocompromised and young children, is of particular importance. School feeding schemes resort under this category due to the general under-nourishment of the pupils as well as the deficiencies of food service infrastructure at these schools. The purpose of this study was to assess the knowledge, attitudes, and behaviours of food handlers and representatives involved in the National School Nutrition Programme (NSNP) in Bloemfontein, central South Africa. This study aimed to determine whether general food safety principles were applied effectively while administering the programme in selected schools and was conducted by administering structured questionnaires, completed via interviews, in a representative sample of schools which are beneficiaries of the NSNP in the area. A secondary component of the investigation was to observe and note the actual food-handling practices of the food handlers in the schools under study. Although the majority of the participants recognized the essential role that personal hygiene plays in food safety, the results indicated a general lack of knowledge regarding issues such as implementing food safety principles. However, the majority of the respondents reflected a general positive behaviour and attitude relating to food safety by showing an interest in receiving training. Respondents reportedly adhered to some food hygiene practices such as regularly washing hands and using separate boards for raw and cooked foodstuffs. While the respondents may have reported positive behaviours, these did not always concur with the actual practices observed. Addressing the situation through food safety training programmes that also focus on behavioural aspects should address existing shortcomings. Creating food and personal hygiene awareness amongst the beneficiaries (the children themselves) should further assist in enhancing the general safety of foodstuffs served through the NSNP.

Keywords: Food safety, knowledge, attitude, National School Nutrition Programme, training, questionnaire survey

4.2. INTRODUCTION

Millions of people worldwide die annually from diarrhoea related diseases with a considerable proportion of these cases being attributed to consumption of contaminated food and drinking water (Department of Health, 2009; WHO, 2013). In South Africa, sizeable numbers of food poisoning cases are reported every year (Department of Health, 2009). According to Marriott (1989), humans are the leading sources of food contamination due to not adhering to good hygiene practices. Therefore, to reduce the cases of food poisoning outbreaks, all individuals who prepare and serve food should understand how food poisoning arises and can be prevented (Trickett, 2002). It is further essential that individuals who manage and serve food operate in a safe and hygienic manner while adhering to a strict personal hygiene routine (Marotz *et al.*, 1997). Areas of personal hygiene include hands, skin (cuts, boils, septic spots, grazes, sweat, etc.), hair, ear, nose, mouth and clothing/protective clothing (Marriott, 1989; Hazelwood and McLean, 1991; Tan *et al.*, 2013). Other sources of food-borne illnesses include ingesting unwashed foods, utilizing contaminated cutting boards and knives, and allowing prolonged periods between cooking and refrigeration. Some causes of food-borne illness may be less obvious, such as ingestion of raw foods. Although using more unprocessed fruits and vegetables is encouraged, it is important to be aware of such raw foods which are likely to cause illness since high cooking temperatures are required to destroy microorganisms (Marotz *et al.*, 1997).

Studies have indicated that food handlers in food environments often lack knowledge regarding basic food hygiene (Clayton *et al.*, 2002; Baş *et al*., 2006) and that ignorance and carelessness often result in poor hygiene which may have consequences for both food distributors and consumers (Hazelwood and McLean, 1991). According to Yiannas (2009), inadequate cooking of food and failure to maintain the cleanliness of hands, protective clothing and preparation surfaces, as well as failure to take the necessary precautions when injury and illnesses have occurred, are behavioural aspects which are underlining factors when administering food safety. There is therefore an increasing need for education and awareness among food handlers regarding safe food handling.

Food safety awareness is particularly important during administration of large-scale food service operations, such as food aid programmes, food provision at large events and school feeding schemes. The factors that render these activities particularly risky include the magnitude of the operation, knowledge of the food handlers and health statuses of the intended consumers. With regards to the National School Nutrition Programme (NSNP) in South Africa, volunteer food handlers are expected to maintain high levels of personal hygiene and hygiene of the preparation areas (DBE, 2009). Moreover, they are required to attend training workshops on health and hygienic standards to improve on the quality and safety of meals. However, previous studies found shortfalls while evaluating the practices, behaviours and environments associated with the NSNP (Noe, 2005; Manyatsa, 2007). The purpose of this study was therefore to evaluate the food safety knowledge, attitudes and practices (KAP) of food handlers and NSNP representatives towards general food safety principles while administering the programme in schools.

4.3. MATERIALS AND METHODS

A survey in the form of structured interviews was conducted in 20 schools in the Bloemfontein area of the Free State Province, South Africa. To obtain a representative sample, the schools were randomly selected from a list of NSNP-participating schools which resorted under various categories (primary, intermediate, combined and special schools which were categorised under quintiles 1 to 3 and were in the rural and urban regions) as assigned by the Department of Basic Education (DBE). Each interview was completed in the interviewee's preferred language with the aid of a structured questionnaire (Appendix 4). This enabled the interviewer to explain each question so as to avoid misinterpretation. The questions aimed to determine the perceptions, knowledge, attitudes and behaviours of the participants with regards to general food safety principles and practices required under the programme. The participants comprised two individuals from each school; the first was the NSNP representative/committee member allocated at the school (one of the teachers in the majority of the cases) and the second was a food handler (a community member selected by the School Governing Body). A total of 40 respondents were thus interviewed. In addition to the interviews, observations of the actual practices and behaviours of the food handlers were noted in accordance with the associated questionnaire categories and compared with the findings of similar studies in the region (Noe, 2005; Manyatsa, 2007).

4.4. RESULTS AND DISCUSSION

4.4.1. Demographic characteristics of participants

Table 4.1 shows that the interviewees were primarily black (92.5%), female (97.5%), above the age of 30 and had South Sotho as a home language. The majority of the respondents (65%) were permanently employed by the schools while 22.5% worked on contract. Fifty percent of the respondents were educators who were also responsible for administering the NSNP at the schools, while the rest were the food handlers (data not shown). Approximately 42.5% of the respondents had a tertiary qualification while 40% and 15% held a secondary and a primary level education, respectively, whereas 2.5% were uneducated. The majority of the participants (67.5%) were English proficient while others (27.5%) had a fair understanding of the language and only 5% had a poor understanding (Table 4.1). In a study by Dworkin *et al*. (2011), the authors indicated that non-English speaking persons tended to have less knowledge of food safety than those who were more fluent in English since training and information regarding food safety are predominantly conducted and distributed in English.

As illustrated in Table 4.1, 65% of the participants had been working at the schools for more than a year and the majority had been part of the NSNP for the same period as they had been at the schools. Forty-eight percent of the participants had received additional training, the majority of which was not in food safety. This does

Table 4.1. Demographic information of participants from various NSNP-participating schools in Bloemfontein

Variable	Frequency	Occurrence (%)
Gender (*n* = 40)		
Female	39	97.5
Male	1	2.5
Age (*n* = 40)		
Below 20	0	0
20-30	4	10
31-40	9	22.5
41-50	15	37.5
50 and above	12	30
Race (*n* = 40)		
Black	37	92.5
Coloured	1	2.5
White	2	5
Home language (*n* = 40)		
South Sotho	17	42.5
Tswana	10	25
Xhosa	10	25
Afrikaans	3	7.5
English proficiency (*n* = 40)		
Poor	2	5
Fair	11	27.5
Good	27	67.5
Employment status (*n* = 40)		
Permanent	26	65
Volunteer	5	12.5
Contract	9	22.5
Educational level (*n* = 40)		
None	1	2.5
Primary	6	15
Secondary	16	40
Tertiary	17	42.5
Additional training (*n* = 39)		
Yes	19	48
No	20	51
Period of employment at the school (*n* = 40)		
<3 months	3	7.5
3-6 months	7	17.5
7-12 months	4	10
>12 months	26	65

not reflect the requirement of the DBE that food handlers are expected to attend all training workshops on health and hygienic standards (DBE, 2009).

4.4.2. Personal hygiene behaviours

Table 4.2 shows that 90% of the participants did not have long nails and neither did they wear jewellery or nail polish while preparing food. Jewellery should not be worn during food preparation since the skin under the jewellery may not be washed and dried properly and may harbour bacteria, while parts of the jewellery could drop into the food (Hobbs and Roberts, 1993). Ninety-eight percent of the participants claimed to wash their hands several times during the day, 35% washed their hands with warm water and 7.7% used cold water. Ninety percent of the participants washed their hands with water and soap only while 10.3% claimed to also use hand sanitizing liquid (Table 4.2). Additionally, 97.5% of respondents reportedly always washed their hands before and during food preparation while 2.5% mostly adhered to this practice (data not shown). These results are in agreement with those obtained from a study by Tan *et al.* (2013) during which hand-washing was the most familiar practice performed by the respondents. Table 4.2 further illustrates that after washing their hands, 85% of the participants claimed to dry them using a dry cloth. Although none admitted to practising this, some of the food handlers were witnessed drying their hands on clothing such as aprons and overalls, which is likely to result in cross-contamination as ordinary clothing is frequently contaminated with dust and hair (Trickett, 2002).

Personal hygiene is the most effective manner of achieving food hygiene (Hobbs and Roberts, 1993; Trickett, 2002; Baş *et al*, 2006). The hands of food service employees may be vectors in the spread of food-borne diseases as a result of poor personal hygiene and cross-contamination. For example, an employee may contaminate the hands when using the toilet, or bacteria may be spread from raw meat to a salad by a food handler's hands (Hayes, 1985; Baş *et al.*, 2006). Therefore, food-borne illnesses may be transmitted through failure to wash hands thoroughly (Hayes, 1985; Marotz *et al*., 1997; Latif *et al.*, 2013). Trickett (2002) and

Table 4.2. Personal hygiene as reported by the participants

Variable	Frequency	Occurrence (%)
Do you have/wear long nails, nail polish, jewellery, etc. while preparing food? (*n* = 40)		
Yes	4	10
No	36	90
How often do you wash your hands? (*n* = 40)		
Once a day	0	0
A few times a day	39	97.5
When they are dirty	39	97.5
After using the toilet	39	97.5
Only when handling food	1	2.5
What do you wash your hands with? (*n* = 39)		
Cold water	3	7.7
Warm/hot water	12	30.8
Water and soap	35	89.7
Water, soap and hand sanitizing liquid	4	10.3
How do you dry your hands after washing them? (*n* = 40)		
With tissue paper	6	15
With a dry cloth	34	85
On whatever I am wearing	0	0
What do you do when you have a cold/illness? (*n* = 40)		
Do not work	24	60
Wear a mask	9	22.5
Continue working as normal	7	17.5
What do you do when you have wound (e.g. cut)? (*n* = 40)		
Wash it and continue working	0	0
Get it cleaned, covered and continue working	27	67.5
Wear gloves and continue working	6	15
Nothing, just continue working	2	5
Stop working	5	12.5
Do you wear an apron while preparing food? (*n* = 40)		
Yes	33	82.5
No	7	17.5
If yes, how often do you wash it?(*n* = 33)		
Daily	25	75.8
Weekly	5	15.2
Monthly	0	0
Only when it is dirty	3	9

Sharif *et al*. (2013) identify hands, fingernails, nose, throat and mouth as habitats of *Salmonella spp, Staphylococcus aureus* and *Shigella spp* which may cause illness upon entering the intestinal tract. These bacteria may be removed and destroyed by following proper hand-washing processes. The results of a study by Lee and Greiga (2010) indicated a reduction in the risk of food-borne illness when food handlers practised effective hand-washing techniques and received food safety training.

Table 4.2 shows that 60% of participants reportedly did not work when they were ill and 67.5% claimed to treat and cover wounds before progressing with food preparation. Individuals involved in food preparation and service should be free of communicable diseases. Those suffering from any communicable diseases should refrain from handling food. In some countries, those working in licensed child facilities are required to supply written proof to the school or child care centre that they are free of tuberculosis (Marotz *et al*., 1997). Treating and adequate covering of cuts and wounds with waterproof plasters is essential since even small wounds on the skin may be sources of *S. aureus* (Trickett, 2002; Arvanitoyannis and Varzakaz, 2009). Eighty-three percent of participants wore aprons of which 75.8% washed them daily (Table 4.2). Food handlers should wear clean, washable clothing and should change aprons frequently as they become dirty. In addition, hair should be covered with a net while handling food (Marotz *et al*., 1997); however, this practice was not observed among food handlers during the current study.

4.4.3. Self-reported behaviours regarding cleaning practices

All participants claimed to always clean surfaces (tables and trays) and equipment utilized during food preparation and before utilizing them for other food items. Ninety percent of the participants claimed to clean surfaces before and after preparing food, and reportedly always used separate utensils and cutting boards during preparation of raw and cooked food to minimize cross-contamination. Fifty-three percent of the participants cleaned the surfaces with water and soap while 47% claimed to also add a disinfectant. Preparation surfaces along with hands are the main vectors for cross-contamination. Therefore, maintaining food preparation surfaces in a clean and sanitised condition is essential as the majority of food items are prepared on these surfaces (Hobbs and Roberts, 1993). Although frequent cleaning of the kitchen reduces microbial contamination, cleaning tools and methods are critical for effective cleaning (Chen *et al.*, 2011).

4.4.4. Food safety knowledge of participants

As reported in Table 4.3, 40% of the respondents perceived food safety as a collective responsibility, including farmers, manufacturers/producers, retailers and consumers, while 57.5% perceived only those who prepare the food as responsible for ensuring food safety. Each individual that handles food is responsible for ensuring the hygiene of the food because food safety may be compromised at any stage during supply, processing, preparation, distribution, serving and consumption (Kemp, 2012). All respondents recognized the significance of food safety and although some (40%) believed that food safety is important for nutritional and quality purposes, the majority (75%) were aware that it is relevant in preventing illnesses by maintain food free of contaminates which may be pathogenic.

Table 4.3 shows that only 22.5% of the respondents had received training in food safety, of which 22% had completed a full course in food safety while the remaining 78% had only attended workshops. Table 4.1 indicates that only 48% of respondents had received training in addition to having academic qualifications. Ninety percent of the respondents were willing to receive training or further training in food safety (Table 4.3). The 10% who were not interested in receiving training were teachers who believed that training would only be applicable to the food handlers. This response matches the belief of the majority of the respondents (57.5%) that only individuals who prepare food should be responsible for food safety. A study by Latif *et al.* (2013) in relation to food handlers' knowledge revealed that 7% of the studied sample had unsatisfactory knowledge prior to a food safety educational program while 95% of the respondents obtained high knowledge scores post training. Although highly beneficial, training alone is not sufficient in encouraging daily food safety practices since people do not usually apply their

Table 4.3. Knowledge of respondents with regards to general food safety

Variable	Frequency (%)		
Who, in your opinion, is responsible for food safety?(*n* = 40)			
Everyone (manufacturer to consumer)	16 (40)		
People who prepare food	23 (57.5)		
Only the consumer	0		
Other (management)	1 (2.5)		
In your opinion, why is food safety important? (*n* = 40)			
To prevent illnesses	30 (75)		
To serve healthy, nutritious meals	16 (40)		
It is not important	0		
Have you had any training in food safety (GMP, GHP and HACCP)?(*n* = 40)			
Yes	9 (22.5)		
No	31 (77.5)		
If yes, what type of training? (*n* = 9)			
Full course	2 (22)		
Workshop(s)	7 (78)		
Would you go for training/further training in food safety?(*n* = 40)			
Yes	36 (90)		
No	4 (10)		
Indicate whether you find the following true or false: (n = 40)			
	True	***False***	***Not sure***
It is important to wash hands before handling food.	40 (100)	0	0
Wiping cloths can spread microorganisms.	32 (80)	4 (10)	4 (10)
The same cutting board can be used for raw and cooked foods provided it looks clean.	9 (22.5)	30 (75)	1 (2.5)
Cooked food does not need to be thoroughly reheated.	20 (50)	16 (40)	4 (10)
Temperature is not related to food safety.	8 (20)	30 (75)	2 (5)
Water quality has no impact on food safety.	4 (10)	36 (90)	0
Raw meat should not be transported in the same bag or container as fresh vegetables and fruit.	37 (92.5)	2 (5)	1 (2.5)
It is best to drink pasteurised milk and juice.	35 (87.5)	4 (10)	1 (2.5)
Person-to-person contact may cause contamination of food.	27 (67.5)	10 (25)	3 (7.5)

knowledge (Yiannas, 2009). Regular communication about food safety employing a variety of media between management and employee may also result in a notable improvement in attitude and behaviour (Lee and Greiga, 2010).

Table 4.3 further illustrates that 80% of the participants recognized that wiping cloths may spread microorganisms while 75% recognized that separate cutting boards should be used for raw and cooked food, or that the boards should be cleaned after they have been utilized for raw food. The results of a study by Chen *et al.* (2011) indicate that tools used for cleaning kitchen surfaces (dishcloths, sponges and dish pads) tended to be more contaminated than surfaces. Additionally, wash sponges and dishcloths are some of the items which may be found to be saturated with bacteria (Chen *et al.*, 2011).

Twenty percent of the respondents perceived temperature conditions as having no impact on food safety while 75% recognised the relation between temperature and food safety. Moreover, 88% believed that it is better to consume pasteurised milk and beverages, which indicates significant awareness of the danger of consumption of unpasteurised milk and fruit juices. In addition, 50% of the respondents deemed it unnecessary to thoroughly reheat prepared food prior to serving while 40% believed that it was necessary to thoroughly reheat cooked food (Table 4.3). Temperature has an impact on microbial growth since bacteria may remain dormant for long periods of time in frozen food, but will not survive at high temperatures. Bacteria will however multiply when the food is thawed and warmed (Kemp, 2012). Literature further reports that advanced preparation of food is one of the factors that reduce food poisoning outbreaks (Trickett, 2002). Table 4.3 also indicates that 93% of the participants were aware that raw meat should not be kept in close proximity to fresh vegetables and fruit. Intestines of animals often harbour bacteria that cause food poisoning and as a precaution, raw meat and poultry should be perceived as contaminated with food poisoning bacteria (Trickett, 2002), thus necessitating thorough cleaning and cooking methods. Sixty-eight percent of the participants believed that physical contact among people may ultimately result in the contamination of food.

4.4.5. Attitudes of participants towards food hygiene

An employee with the correct attitude will be more likely to take the correct actions (Yiannas, 2009). All participants agreed that frequent hand-washing is a necessity during food preparation and that the cleanliness of kitchen surfaces should be maintained to reduce the risk of illness (Table 4.4). Table 4.4 further indicates that the majority of the participants (92.5%) agreed that it is necessary to use separate knives and cutting boards for raw and cooked foodstuffs while 5% disagreed. Eighty-five percent of participants agreed that storage practices have an impact on food safety and 95% agreed that food should appear fresh upon delivery. Food should be covered or wrapped during transportation and all raw produce should be inspected for spoilage upon delivery and washed before use (Kemp, 2012). All respondents agreed that knowledge and training are essential in ensuring food safety (Table 4.4), whereas some of the teachers (who were also NSNP representatives at the schools) deemed it unnecessary to participate in the current survey and reasoned that the questions were not applicable to them since they were only responsible for the management and not involved in food preparation.

In addition to the questionnaire findings, some of the hurdles that food handlers faced included: not having proper kitchen facilities, which resulted in the use of classrooms and shacks to prepare food; kitchens that were not fully equipped and were not well-planned and easy-to-clean kitchens; water taps being located outside the kitchen area; not having readily available hot water; and disinfectants and protective clothing not being provided. Studies previously conducted with regards to the NSNP included checklists of storerooms and kitchens of the participating schools. From these checklists, it was concluded that the storerooms and kitchens were not well designed and maintained according to good storage and processing practices (Noe, 2005; Manyatsa, 2007). During the present study, no differences with regards to the infrastructure and resources were observed among various

Table 4.4. Respondents' attitudes towards food safety

Variable ***(n = 40)***	**Frequency (%)**		
Evaluate your opinion w.r.t the following by stating whether you agree or disagree:	***Agree***	***Not sure***	***Disagree***
Frequent hand washing during food preparation is necessary.	40 (100)	0	0
Keeping kitchen surfaces clean reduces the risk of illness.	40 (100)	0	0
Using different knives and cutting boards for raw and cooked foods is necessary.	37 (92.5)	1 (2.5)	2 (5)
Storage practices have an impact on food safety.	34 (85)	2 (5)	4 (10)
The freshness and appearance of food upon delivery is important.	38 (95)	0	2 (5)
I think it is important to throw away foods that have expired.	40 (100)	0	0
Knowledge and training are important in ensuring food safety.	40 (100)	0	0

categories of schools, i.e., the various quintiles and urban and rural schools. Furthermore, it is noteworthy that despite qualification inequalities, no noticeable difference was generally observed between NSNP representatives and food handlers with regards to food safety KAP.

4.5. CONCLUSIONS

According to the data obtained by means of the questionnaires, the attitudes and self-reported behaviours of the respondents were positive since the majority were interested in attending training courses. However, the practices with regards to food safety administration priorities in these schools is a concern since management deemed it unnecessary to participate in the survey comprising questions regarding food safety. Moreover, not all management representatives were willing to attend training courses as they reasoned that they were not involved in the actual preparation of food. All persons involved in the management and preparation of food need to go beyond accountability and need to believe in and be committed to food safety (Yiannas, 2009). Additionally, it is essential that food handlers comprehend their roles and responsibilities with regards to the children they serve and that their duties are vital and require skill (Latif *et al.*, 2013). In general, the data suggested that the respondents were aware of the basic importance of food safety practices though they may have been unable to adhere to these practices due to infrastructural challenges. Observations indicated a definite lack of resources in schools, which increased the difficulty for food handlers in adhering to food safety procedures.

Food safety education and training are of importance as the knowledge and skill gained through training influences the perceptions and attitudes towards food safety which may determine the behaviour and may ultimately result in practising proper food hygiene. Although food handlers are required by the DBE to attend food safety training programmes, the majority of the participants who had been employed to implement the NSNP for several years claimed to have received no, or very little, training in food safety. This indicates a possible need for implementation and monitoring of safety programmes by the DBE. In order to successfully achieve a high level of food hygiene, it is essential that the national and provincial Departments of Basic Education, which are responsible for the overall administration of the NSNP, and schools' personnel function in an integrated manner.

REFERENCES

Arvanitoyannis, I.S. and Varzakaz, T.H. (2009). Catering in *HACCP and ISO 22000: application to foods of animal origin.* I.S. Arvanitoyannis (Ed). Chichester: Wiley-Blackwell, pp. 453–529.

Baş, M., SafakErsun, A. and Kıvanç, G. (2006). The evaluation of food hygiene knowledge, attitudes, and practices of food handlers in food businesses in Turkey. *Food Control*. 17, 317–322.

Chen, F., Godwin, S.L. and Kilonzo-Nthenge, A. (2011). Relationship between cleaning practices and microbiological contamination in domestic kitchens. *Food Protection Trends*. 31, 672–679.

Clayton, D.A., Griffith, C.J., Price, P. and Peters, A.C. (2002). Food handlers' beliefs and self-reported practices. *International Journal of Environmental Health Research.* 12, 25–39.

Department of Basic Education (DBE). (2009). National School Nutrition Programme: 2008 Annual Report. Pretoria: Government Printers.

Department of Health. (2009). Statistical notes: foodborne illnesses in Mpumalanga Province. Available from: www.nmc.gov.za/Docs/Food_Poisoning.pdf. Date of access: 2013/05/17.

Dworkin, M.S., Udompat, P., Panchal, P. and Liu, L**.** (2011). A comparison of overall versus duty-specific food poisoning prevention knowledge among restaurant food handlers. *Food Protection Trends*. 31, 664–671.

Hayes, P.R. (1985). *Food microbiology and hygiene*. London: Elsevier Applied Science Publishers.

Hazelwood, D. and McLean, A.C. (1991). *Hygiene: a complete course for food handlers*. London: Hodder & Stoughton.

Hobbs, B.C. and Roberts, D. (1993). *Food poisoning and food hygiene*. 6th edition. London: Edward Arnold.

Kemp, R. (2012). Food safety, from farm to folk. *Farmlink*. 2, 10–13.

Latif, N.A., Elkarmalawy, E.M. and Esmail, G.M. (2013). Impact of food safety educational program on food handlers' knowledge and practice in Cairo governorate. *Journal of American Science*. 9, 429–434.

Lee, M.B. and Greiga, J.D. (2010). Review of gastrointestinal outbreaks in schools: effective infection control interventions. *Journal of School Health*. 80, 588–598.

Manyatsa, M.J. (2007). The influence of storage on vitamin degradation in fortified biscuits. M. Tech. Dissertation. Bloemfontein: Central University of Technology.

Marotz, L.R., Cross, M.Z. and Rush, J.M. (1997). *Health, safety, and nutrition for the young child*. 4th edition. New York: Delmar Publishers.

Marriott, M.N. (1989). *Principles of food sanitation*. 2nd edition. New York: Van Nostrand Reinhold.

Noe, M.H. (2005). The influence of aerosolized microorganisms on the safety and quality of fortified biscuits. M. Tech. Dissertation. Bloemfontein: Central University of Technology.

Sharif, L., Obaidat, M.M. and Al-Dalalah, M.R. (2013). Food hygiene knowledge, attitudes and practices of the food handlers in military hospitals. *Food and Nutrition Sciences*. 4, 245–251.

Tan, S.L., Cheng, P.L., Soon, H.K., Ghazali, H. and Mahyudin, N.A. (2013). A qualitative study on personal hygiene knowledge and practices among food handlers at selected primary schools in Klang valley area, Selangor, Malaysia. *International Food Research Journal*. 20, 71–76.

Trickett, J. (2002). *Food hygiene for food handlers*. 2nd edition. London: Thomson Learning.

World Health Organisation (WHO). (2013). Foodborne disease. Available from: http://www.who.int/foodsafety/foodborne_disease/en/. Date of access: 2013/07/23.

Yiannas, F. (2009). *Food safety culture: creating a behavior-based food safety management system*. New York: Springer Science+Business Media, LLC.

APPENDICES

Appendix 4. KAP of food handlers and NSNP representatives while administering the National School Nutrition Programme

Name of School: …………………………………………………………………………..

Date of interview: ………………………………………………………………………….

A: INFORMATION OF INTERVIEWEE

1.	***Gender***	Female	☐
		Male	☐
2.	***Age***	Below 20	☐
		20-30	☐
		31-40	☐
		41-50	☐
		Above 50	☐
3.	***Race***	Black	☐
		Coloured	☐
		White	☐
		Other (specify):...	
4.	***Home language***	South Sotho	☐
		Tswana	☐
		Xhosa/Zulu	☐
		Afrikaans	☐
		Other (Specify):……………………………………….	
5.	***English proficiency***	Poor	☐
		Fair	☐
		Good	☐

6. ***Employment status***

Permanent ☐
Volunteer ☐
Contract ☐
Other (Specify):……………………………………………

7. Educational level

None ☐
Primary ☐
Secondary ☐
Tertiary ☐

8. ***Additional Training***

Yes ☐
No ☐

If yes, specify:..

9. How long have you been preparing food for the school?

Less than 3 months ☐
3 to 6 months ☐
7 months to 1 year ☐
More than 1 year ☐

B: PERSONAL HYGIENE

10. Do you have/wear long nails, nail polish, jewellery, etc while preparing food?

Yes ☐
No ☐
Specify:................……………………………………………………………………………….

11. How often do you wash your hands?

Once a day ☐
A few times a day ☐

When they are dirty ☐
After using the toilet ☐
Only when handling food ☐
Other (specify):...

12. What do you wash your hands with? (May select more than one option)

Cold water ☐
Warm/hot water ☐
Water and soap ☐
Water, soap and hand sanitizing liquid ☐
Other (specify):...

13. How do you dry your hands?

With tissue paper ☐
With a dry cloth ☐
On whatever I am wearing ☐
Other (specify):...

14. What do you do when you have a cold/illness?

Do not work ☐
Wear a mask ☐
Continue working as normal ☐
Other (specify):...

15. ***What do you do when you have wound (e.g. cut)? (May select more than one option)***

Wash it and continue working ☐
Get the cleaned, covered and continue working ☐
Wear gloves and continue working ☐
Nothing, just continue working ☐
Stop working ☐

Other (specify):...

16. Do you wear an apron while preparing food?

Yes ☐

No ☐

If no, explain...

17. If yes, how often do you wash it?

Daily ☐

Weekly ☐

Monthly ☐

Only when it is dirty ☐

C: CLEANING PRACTICES

18. Do you clean surfaces, cutlery and cookery before and after preparing each food item?

Yes ☐

No ☐

19. How often do you clean preparation surfaces (tables and boards)

Before preparing food ☐

After preparing food ☐

Before and after preparing food ☐

Other (specify):...

20. How do you clean preparation surfaces (tables, boards, plates, etc.)?

With only water ☐

With water and suitable soap ☐

With disinfectants ☐

With water, soap and disinfectants ☐

Other

(specify):…………………………………………………………………………......

D: KNOWLEDGE OF THE INTERVIEWEE

21. Who, in your opinion, is responsible for food safety?

Everyone (manufacturer to consumer)

People who prepare food

Just the consumer

Other (specify):...

22. In your opinion, why is food safety important?

To prevent illnesses

To serve healthy, nutritious meals

It is not important

Other

(specify):...

23. Have you had any training in food safety (GMP, GHP and HACCP)?

Yes

No

24. If yes, what type of training?

Full course

Workshop(s)

Other (specify)...

25. Would you go for training/further training in food safety?

Yes

No

26. Indicate whether you find the following true or false:

	True	False	Not sure
It is important to wash hands before handling food.	☐	☐	☐
Wiping cloths can spread microorganisms.	☐	☐	☐
The same cutting board can be used for raw and cooked foods provided it looks clean.	☐	☐	☐
Cooked food does not need to be thoroughly reheated.	☐	☐	☐
Temperature is not related to food safety.	☐	☐	☐
Water quality has no impact on food safety.	☐	☐	☐
Raw meat should not be transported in the same bag or container as fresh vegetables and fruit.	☐	☐	☐
It is best to drink pasteurised milk and juice.	☐	☐	☐
Person-to-person contact may cause contamination of food.	☐	☐	☐

27. Where does the food you serve come from? (Supplier e.g. from which supermarket, farm, etc.)

Supplier ☐

Department of Basic Education ☐

I do not know ☐

28. Who delivers the food to the school?

Personnel from the Department of Basic Education ☐

Comes from supplier ☐

I do not know ☐

Other (specify)..

29. How is the food delivered to the school?

By truck(s) ☐

By car/van ☐

Not sure

30. Is the cold chain maintained from supplier to food preparation?

Yes

No

I don’t know

31. How long after delivery is the food prepared?

Within a day

Within a week

Within a month

32. Do you make use of the first-in-first-out principle when preparing food?

Always

Sometimes

Never

Not sure

33. Have you seen any child/children suffer from any of the following symptoms: nausea, vomiting, diarrhoea, dizziness, abdominal cramping and fever?

No

Yes

34. If yes, how frequently has it occurred?

Often

Seldom

Other

(specify)………………………………………………………………………………

D: ATTITUDE OF THE RESPONDENT

Please evaluate your opinion w.r.t. the following by stating whether you agree or disagree:

	Agree	Not sure	Disagree
Frequent hand washing during food preparation is necessary.	☐	☐	☐
Keeping kitchen surfaces clean reduces the the risk of illness.	☐	☐	☐
Using different knives and cutting boards for raw and cooked foods is necessary.	☐	☐	☐
Storage practices have an impact on food safety.	☐	☐	☐
The freshness and appearance of food upon delivery is important.	☐	☐	☐
I think it is important to throw away foods that have expired.	☐	☐	☐
Knowledge and training are important in ensuring food safety.	☐	☐	☐

E: SELF-REPORTED BEHAVIOUR OF THE RESPONDENT

	Always	Mostly	Seldom	Sometimes	Never
I wash my hands before and during food preparation.	☐	☐	☐	☐	☐
I clean surfaces and equipment used for food preparation before re-using on other food.	☐	☐	☐	☐	☐
I use separate utensils and cutting-boards when preparing raw and cooked food.	☐	☐	☐	☐	☐

After I have cooked a meal, I store any leftovers in a cool place within two hours.	☐	☐	☐	☐	☐
I wash fruit and vegetables with safe water before serving them.	☐	☐	☐	☐	☐

CHAPTER 5

CONCLUSIONS

5.1. GENERAL CONCLUSIONS

Malnutrition and food-related illnesses are persistent issues in many developing countries. Reducing under-nutrition may be complicated and might require lengthy periods to accomplish. However, Wardlaw *et al.* (2004) state that should swift action not be taken to curb the effects of malnutrition, projections indicate that on-going under-nutrition could leave more than 1 billion children with mental impairment by 2020. To overcome nutrient deficiencies, missing nutrients such as zinc may be restored to children's diets and improvement in health may be significant (Wardlaw *et al.*, 2004). Numerous food-aid and fortification programmes are therefore implemented in various countries to alleviate the consequences of under-nutrition. In South Africa, the National School Nutrition Programme (NSNP) was established to supplement the diet of school children across schools with the greatest need. One of the main objectives of the programme is to encourage learners to attend school and participate in school activities by alleviating short-term hunger. The safety of the food served through the NSNP is therefore important so as to assist in reducing illness and absenteeism amongst pupils. In addition to school feeding programs being important sources of nutrition, they also provide the opportunity to influence children's eating habits in ways that promote life-time health (Clark and Fox, 2009). Against this backdrop, this study set out to investigate possible inefficiencies in nutrition and safety of foods served by the NSNP in order to contribute towards improving the wellbeing of beneficiaries of the programme.

5.2. CONCLUDING REMARKS ON CHAPTERS 2, 3 AND 4

During the nutritional analysis in Chapter 2 of this dissertation, chemical analyses were conducted to the determine the moisture, total carbohydrates and sugars, total lipids and fatty acids, protein, vitamins and minerals contents of school meals. The results were compared against nutrient-based standards set by the United Kingdom as guidelines for an average school lunch for pupils within the age groups of 7–10 and 11–18 years. The investigation indicated shortcomings in the meals provided at the schools, particularly in the contents of carbohydrates and energy which were significantly ($P \leq 0.05$) below the standards for both age groups. The protein content of meals met the standard for the majority (90%) of the schools for individuals aged 7–10 years, however only 40% of the school meals met the standard for those ages 11–18 years. The meals did not exceed the maximum standard for lipids with 50% of the meals containing at least one essential fat and all meals met the required standards for vitamin C requirements for both age groups. The calcium and zinc values were significantly ($P \leq 0.05$) below the standards for the majority of the school meals for both age groups, while the iron content met the standards for 80% and 30% for pupils aged 7–10 and 11–18 years, respectively. Although generally not significantly deficient, initiatives towards further improving the nutritional quality of meals served through the programme may prove beneficial to the quality of health of recipients.

Interventions towards improving the microbiological safety of the foodstuffs may also contribute toward the quality of the meals served at the schools. The surfaces sampled during microbial analysis of the present study as reported in Chapter 3 produced colonies that were too numerous to count (over 100 colonies per plate) for total viable counts of the majority of the surfaces. When compared to the BCCDC guide, approximately 7% of all surfaces produced unsatisfactory enumeration of *S. aureus* and *E. coli* whereas approximately 10% and 37% of the counts were unsatisfactory for coliforms and yeast and mould respectively. Of the three surfaces analysed, preparation surfaces enumerated the highest counts of total coliforms, *E. coli* and *S. aureus*. Aprons yielded the highest counts of yeast and moulds while hands had the lowest counts. The hands of food handlers yielded lower counts of all enumerated organisms (total coliforms, *E. coli*, *S. aureus* and yeasts and moulds) than preparation surfaces, therefore the sources of contamination were more likely to result from the foodstuffs, animals (particularly rodents) in the vicinity of the preparation area and environmental elements (such as dust) rather than from the hands of food handlers. The data did not indicate significant difference ($P > 0.05$) among counts of the various organisms on surfaces which suggested possible occurrence of cross-contamination among food contact surfaces and possible shortfalls in the cleaning system such as using contaminated water and minimum contact time for disinfectants.

Participants who responded to the questionnaire survey (reported in Chapter 4) were aware of the significance of washing hands before handling food and the majority of the participants (approximately 98%) reportedly washed their hands several times during the day with water and detergent. This report was in agreement with the findings of the microbial analyses during which hands enumerated the low counts (the majority the counts were < 5 $CFU.cm^{-2}$ according to the BCCDC guide) for all detected organisms. To further minimize cross-contamination, the majority of the participants (53%) reportedly cleaned surfaces with water and detergent while some (47%) also claimed to add a disinfectant. All participants claimed to maintain the cleanliness of surfaces and equipment utilized during food preparation. However, upon conducting the surface microbial analysis, preparation surfaces yielded counts that were unsatisfactory (when compared to the BCCDC guide) for the detected organisms. Furthermore, the presence of total coliforms, *E. coli* and *S. aureus* indicated a necessity for improved sanitation practices. In addition, participants who wore aprons purported to wash their aprons daily; however the aprons were highly contaminated with yeasts and moulds. Food safety education and training may prove significant toward improving of the efficiency of the NSNP in schools because the knowledge and skill gained through training influences the perceptions and attitudes towards food safety which may determine the behaviour and may ultimately result in practising proper food hygiene.

In addition, the infrastructural limitations and the lack of resources that were observed may prove challenging in the preservation of food hygiene and manufacturing practices. Moreover, these challenges may negatively impact the maintenance of the optimum quality of the nutritional status of the foodstuffs. Storage is a contributing factor in food safety and more evidently in the nutritional quality of food. In order to operate effectively, it therefore has become a necessity to provide additional infrastructure and resources to ensure the safety and nutritional quality of foodstuffs served to children via the NSNP.

5.3. RECOMMENDATIONS

In developing countries, inadequate practices and surveillance systems persist with respect to food safety (Department of Health, 2000). According to Moore and Griffith (2002), preventative risk-based food safety management systems such as HACCP require that hygiene monitoring should provide results rapidly and in time for remedial action to regain control of the process and product to be implemented. Rapid hygiene monitoring kits are available to the food industry and results may be obtained in a much shorter time (Moore and Griffith, 2002). The detection and enumeration of indicator organisms, as discussed in Chapter 3 of this dissertation, are widely used to assess the efficacy of sanitation programmes. The DBE may incorporate such kits and programmes to render the school cleaning routines more effective. Additionally, documented food safety management systems and cleaning schedules may contribute to effective monitoring of cleaning procedures. Therefore, deficiencies in the correct use of cleaning methods may be identified. Cleaning practices should be outlined in a cleaning schedule and cleaning records should be maintained. Although budget constraints might be a limiting factor, the DBE may also conduct regular microbiological test to assist in the monitoring of sanitation practices as well as employ the services of pest control companies.

The primary focus should be on the improvement of infrastructure and the expansion of resources. Storage conditions and practices should also be monitored. The first-in-first-out principle should be adhered to at all times as prolonged storage of food may result in the deterioration of nutrients. Furthermore, establishment of cooking methods which preserve nutrients in food may prove beneficial. Regular training of all personnel, which is not limited to food handlers, in areas of food safety and nutrition should be a priority and the DBE should take strong ownership in this regard.

5.4. FUTURE RESEARCH

Pathogenic microorganisms of food items and meals served to children in feeding schemes such as the NSNP require further investigation. Additionally, determination of the impact of training on knowledge, attitude and practices (KAP) with regards to food safety and nutrition is required as well as the effects of storage conditions and practices on possible microbial growth and the nutritional deterioration of food should be established. The potential effect of bacterial contamination on the nutritional quality of foodstuffs should be further investigated. Microbiological and nutrition analyses of individual food items, before and after preparation, would be beneficial in providing clarity on optimum nutrition preservation methods during food preparation. Such analyses will also assist in identifying critical control points. Conducting a nutrient analysis of school meals using menus for a one-week period may further assist in identifying areas that require improvement in menu planning. Numerous studies have been conducted with regards to school feeding schemes, including the NSNP, and have yielded results similar to those reported in the present study. However, information regarding the impact of these studies is limited and strategies should be developed to create awareness and stimulate action in the DBE and the management at schools.

REFERENCES

Clark, M.A. and Fox, M.K. (2009). Nutritional quality of the diets of US public school children and the role of the school meal programs. *Journal of American Diet Association*. 109, S44–S56.

Department of Health, South Africa. (2000). Guidelines for environmental health officers on the interpretation of microbiological analysis data of food. Pretoria: Directorate of Food Control, Government Printer.

Moore, G. and Griffith, C. 2002. A comparison of surface sampling methods for detecting coliforms on food contact surfaces. *Food Microbiology*. 19, 65–73.

Wardlaw, G.M., Hampl, J.S. and DiSilvestro, R.A. (2004). *Perspectives in nutrition*. 6th edition. Boston: McGraw-Hill.