The potential of *Moringa oleifera* (Lam.) leaves for use in complementary foods to combat child food and nutrition insecurity among South African rural and peri-urban communities

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PREFACE

The work described in this dissertation was carried out in the school of Agricultural, Earth and Environmental Sciences, University of KwaZulu-Natal, from February 2015 to November 2017, under the supervision of Dr Muthulisi Siwela, Prof Unathi Kolanisi, Dr Hafiz Abdelgadir and Dr Ashwell Ndhlala.

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As supervisors of the candidate, we agree to the submission of this dissertation.

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DECLARATION

I, Sithandiwe Linda Ntila, declare that:

1. The research reported in this dissertation, except where otherwise indicated, is my original work.
2. This dissertation, or any part of it, has not been submitted for any degree or examination at any other university.
3. Where other sources have been used, they have not been copied and have been acknowledged properly.
4. This dissertation does not contain text, graphics or tables copied and pasted from internet, unless specifically acknowledged, and the source being detailed in dissertation and in the relevant reference section.

Signed: _____ _____ Date: _____01/12/2017___

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ABSTRACT

The inadequate nutritional quality of complementary foods is a major public health problem in developing countries such as South Africa, and contributes towards the reported high rates of child malnutrition. Consequently, there is an urgent need to investigate interventions aimed at improving the nutritional quality of complementary foods. The aim of this study was to assess the potential of *Moringa oleifera* (Lam.) leaves for use in complementary foods to combat food and nutrition insecurity amongst children in South African communities.

Mothers from Lebowakgomo village in Limpopo province (n=106) and Hammanskraal Township in Gauteng province (n=106), were recruited on a voluntary basis to participate in the survey which assessed the food and nutrition security status of their children, aged 7-12 months old. Additionally, six focus group discussions were conducted per study area to assess mothers' perceptions about children's food access and to further establish a recipe for a popular traditional cereal-based complementary food. The Children's Food Insecurity Access Scale (CFIAS) was used to assess the food security status (access) of the children. The Individual Dietary Diversity Score (IDDS) together with the unquantified food consumption frequency survey were used as a proxy measure of the nutritional quality of the children's diets. The age and weight of the children were obtained from the children's clinic health cards and were used to calculate Weight-for-Age Z scores (WAZ). These values were interpreted to determine the prevalence of underweight children. The popular cereal-based traditional complementary food recipe (white maize soft porridge) used by mothers from the studied communities was modified by substituting maize meal with MLP at 1, 2 and 3% (w/w) levels. The nutritional, phytochemical and antioxidant analysis of the popular traditional complementary soft porridge (control) and Moringa-added porridges (test samples) were determined using standard methods. The sensory acceptability of the porridges was evaluated by the mothers who were recruited on a voluntary basis (n= 60 per study area) and six focus group discussions were conducted per study area to assess mothers' perceptions on the inclusion of Moringa in complementary foods.

The findings of the survey showed that a large percentage of children were severely food-insecure, 87% and 78%, at Lebowakgomo and Hammanskraal, respectively. Additionally, children from Lebowakgomo (23.6%) and Hammanskraal (17.9%) were severely underweight. Overall, children's diets in both study areas were characterized by nutrient-deficient complementary foods. Cheaper foods with a higher satiety value such as white maize meal

(WMM) and sugar were the most commonly purchased and used. Hence, the children consumed very limited amounts of foods rich in proteins, minerals, and vitamins, which significantly increased the risk of malnutrition.

As the MLP was increased from 0 to 3% in the Lebowakgomo white maize soft porridge, a corresponding significant increase in nutrient content was observed: ash (from 0.52 to 0.87 g/100 g), calcium (0.01 to 0.09 mg/100 g), potassium (0.10 to 0.14 mg/100 g), protein (8.70 to 9.68 g/100 g), threonine (0.14 to 0.66 g/100 g), glutamine (1.28 to 1.56 g/100 g), provitamin A (0.81-1.16 µg/g), lutein (0.04-0.30 µg/g), zeaxanthin (0.21-2.18 µg/g), β-cryptoxanthin (0.11-0.14 µg/g), β-carotene (0.25-0.50 µg/g) and 9-cis-β-cryptoxanthin (0.25-0.31 µg/g). Increasing the MLP from 0 to 3% in the soft porridge at Hammanskraal, caused a significant increase in the levels of iron (from 52.50 to 101.0 mg/100 g), manganese (1.00 to 4.00 mg/100 g), phenylalanine (0.35 to 0.47 g/100 g), provitamin A (0.87-1.01 µg/g), lutein (0.05-0.22 µg/g), zeaxanthin (0.22-1.29 µg/g) and β-carotene (0.27-0.39 µg/g). Additionally, the antioxidant activity, total phenolic and flavonoid contents of Hammanskraal and Lebowakgomo white maize soft porridges increased as the concentration of MLP was increased.

The sensory evaluation results showed that the acceptance of each of the two traditional complementary foods decreased as the level of MLP increased. Mother's indicated in the focus group discussions that Moringa-added soft porridges had a bitter taste, which would not be suitable for children. Only the Moringa-added soft porridge from Lebowakgomo containing 1% of Moringa was rated similar in overall acceptability as the corresponding white maize soft porridge (control). Nevertheless, all mothers expressed willingness to use Moringa in complementary foods if they would be trained on how to process it into foods suitable for children. There is a need to vary product formulation and processing methods, which may contribute to increased acceptance of Moringa-based foods. Additionally, the safety of using MLP in complementary foods should be investigated.

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- International Maize and Wheat Improvement Centre (CIMMYT), Mexico for assistance with provitamin A analysis of the samples.
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- Finally, I would like to thank God, for his grace and giving me the strength and courage to complete the research project.

DEDICATION

This thesis is dedicated to my mother, Nana Annie Khoza 1950-2003

Gone too soon, I wish you could have shared this experience with me.

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ABBREVIATIONS

AI	Anthropometric Indicators
AOAC	Association of Official Analytical Chemists
CIMMYT	International Maize and Wheat Improvement Center
CoT	City of Tshwane
DAFF	Department of Agriculture, Forestry and Fisheries
DoH	Department of Health
DHIS	District Health Information Systems
DSD	Department of Social Development
DW	Dry Weight
FAO	Food and Agricultural Organization
FGDs	Focus Group Discussions
FIVIMS	Food Insecurity and Vulnerability Information Management System
GHS	General Household Survey
HAZ	Height-for-Age
HDDS	Household Dietary Diversity Score
HFIAS	Household Food Insecurity Access Scale
HSRC	Human Sciences Research Council
IDDS	Individual Dietary Diversity Score
IES	Income Expenditure Survey
IFIAS	Individual Food Insecurity Access Scale
IDP	Integrated Development Plan
INP	Integrated Nutrition Programme
LFS	Labour Force Survey
MAM	Moderate Acute Malnutrition
MAHFP	Monthly Adequate Household Food Provision
MAPs	Moringa Added Porridges
NFCS	National Food Consumption Survey
NDF	Neutral Detergent Fibre
OHS	October Household Survey
UNICEF	United Nations Children’s Fund
SASSA	South African Social Agency
SANHNES	South African National Health And Nutrition Examination Survey

SAM	Severe Acute Malnutrition
SSA	Sub-Saharan Africa
SPSS	Statistical Package for Social Sciences
StatsSA	Statistics South Africa
WAZ	Weight-for-Age
WHO	World Health Organization
WHZ	Weight-for-Height

CHAPTER 1 : THE PROBLEM AND ITS SETTING

1.1 Introduction to research problem

The first two years of a child's life is regarded as a critical period because the child is prone to growth faltering, micronutrient deficiencies and infectious diseases (WHO 2005; Aggarwal *et al.* 2008). Kuriyan and Kurpad (2012) indicated that such a vulnerable period is the time to provide nutrient and energy dense complementary foods to prevent macronutrient and micronutrient deficiencies and to promote optimal growth and cognitive development. In the first six months of life, breast milk alone is sufficient to meet all the nutritional needs of children. After six months of life, breast milk needs to be complemented by other foods (Manary and Sandige 2008; Bain *et al.* 2013). As a result, a variety of nutritious foods should be given to children over six months of age, in addition to breast milk (World Health Organization (WHO) 2012; Krebs and Hambidge 2007). Caregivers in developing countries, including South Africa, have been unable to provide children with a variety of foods, and have relied. profoundly on white maize meal (WMM), together with energy rich ingredients, such as sugar and margarine, when preparing complementary foods (Kruger and Gericke 2003; Faber and Benadé 2007; Nuss and Tanumihardjo 2010; Goosen *et al.* 2014).

Unfortunately, the milling of white maize involves the removal of the bran and germ which are rich in most nutrients. This significantly affects the nutritional composition of maize-derived products (Rana *et al.* 2014). Complementary foods made with unfortified WMM are sufficient in energy, fibre and B-vitamins, but are deficient in the essential amino acids, lysine and tryptophan, some minerals and, most notably, vitamin A (Duvenage and Schönfeldt 2007). Thus, the dependency on maize-based complementary foods increases the risk of micronutrient deficiencies resulting in several health conditions, including growth retardation and delayed development (Bain *et al.* 2013). Child malnutrition has been identified as a serious health problem, globally, and is on the rise in South Africa (WHO 2009; United Nations Children's Fund (UNICEF) 2012). The South African National Health and Nutrition Examination Survey (SANHANES-1) conducted by the Human Sciences Research Council (HSRC) revealed that poor micronutrient status was common amongst South African children under five years of age; Vitamin A deficiency prevalence was 43.6%, anaemia prevalence was 10.7%, iron depletion was 8.1% and iron deficiency anaemia was 1.9% (Shisana *et al.* 2014).

In order to address micronutrient deficiencies, the Integrated Nutrition Programme (INP) (which was initiated by the Department of Health (DoH) in 1995), had the elimination of micronutrient deficiencies as one of the key objectives within the focus area of micronutrient malnutrition control. The INP used a combination of strategies to address micronutrient deficiencies and these strategies included supplementation, fortification, biofortification and dietary diversity (Labadorios *et al.* 2005; Swart *et al.* 2008). However, various shortcomings have been reported with these strategies (Horton 2006; Smuts *et al.* 2008; Steyn *et al.* 2008; Stevens and Winter-Nelson 2008; Pillay *et al.* 2011; Faber *et al.* 2013a; Faber *et al.* 2013b). In contrast, the South African Food and Nutrition Security policy emphasized the utilization of indigenous plant products to combat malnutrition and further encouraged their production for improved livelihood options in rural communities [Department of Agriculture, Forestry and Fisheries (DAFF) and Department of Social Development (DSD) 2014]. Unfortunately, nutrient rich domesticated plants which are well adapted to prevailing environmental conditions in sub-Saharan Africa, including South Africa and could significantly contribute to improving the nutritional quality of complementary foods, are underutilized by caregivers.

In an attempt to improve the nutritional quality of cereal-based complementary food, Moringa Oleifera leaf powder (MLP) could be added as an ingredient when preparing complementary food for children. Moringa is a plant from the Moringaceae family which is native to sub-Himalayan tracks of India, Pakistan, Bangladesh and Afghanistan; however, it is now distributed all over the world (Fahey 2005). Various studies have reported on the nutritional quality of Moringa (Bennett *et al.* 2003; Siddhuraju and Becker 2003; Anwar *et al.* 2007; Lako *et al.* 2007), its ability to adapt to different environmental conditions (Price 2000; Manzoor *et al.* 2007; Sreelatha and Padma 2009), and its ease of production and processing (Foidle *et al.* 2001; Fahey 2005).The leaves of Moringa are a rich source of minerals and various phenolics (Bennett *et al.* 2003; Siddhuraju and Becker 2003; Lako *et al.* 2007), alkaloids, amino acids and proteins, and vitamins, including vitamin A precursors, especially beta-carotene (Sarwatt *et al.* 2002; Soliva *et al.* 2005; Anwar e*t al.* 2007; Lako *et al.* 2007). Thus, the plant seems to have the potential to improve the nutritional quality of cereal-based complementary foods in countries of the sub-Saharan region, including South Africa. The effect of adding Moringa on the nutritional quality and health promoting properties of traditional cereal-based complementary foods, has not been investigated. More so, caregiver's acceptability of Moringa-based complementary food is not known.

1.2 Importance of the study

The nutritional quality of traditional cereal-based complementary food needs to be improved in order to mitigate the prevalence of child malnutrition. As opposed to other strategies aimed at mitigating child malnutrition, the addition of MLP to traditional cereal-based complementary food seems to be the most cost-effective solution for improving the nutritional quality of traditional cereal-based complementary foods. The Moringa plant is easy to produce and process (Fahey 2005), adapts to different environmental conditions (Sreelatha and Padma 2009) and the leaves are of good nutritional quality (Lako *et al.* 2007). The expectation is that the addition of MLP to traditional, cereal-based complementary foods will improve the nutritional quality of complementary foods, and Moringa-added complementary food will be acceptable to caregivers. Consequently, caregivers may be encouraged to consider Moringa production and leaf powder processing at a household level for improved complementary food quality and livelihood options. In addition, results on the effect of adding MLP to traditional cereal-based complementary foods and its acceptability to caregivers could help to identify the traits requiring attention during product development.

1.3 Aim of the study

The aim of this study was to assess the potential of *Moringa oleifera* (Lam.) leaves for use in complementary foods to combat child food and nutrition insecurity among South African rural communities.

1.4 Research objectives

The objectives of the study were:

1.4.1 To assess the food and nutrition security and the nutritional status of children receiving complementary foods (7-12 months old).

1.4.2 To investigate child feeding practices and establish a recipe for a popular traditional cereal-based complementary food.

1.4.3 To modify a recipe of a popular traditional cereal-based complementary food by substituting the main ingredient with MLP at different levels *viz.* 1, 2 and 3% (w/w).

1.4.4 To determine the effect of adding MLP on the nutritional quality, antioxidant activity and phytochemical content (total phenolics and flavonoids) of the popular traditional cereal-based food.

1.4.5 To assess the mothers' perceptions and sensory acceptability of the Moringa-added traditional cereal-based complementary food.

1.5 Hypotheses

The hypotheses of this study were as follows:

1.5.1 Adding MLP to the popular traditional cereal-based complementary food s increases its nutritional quality and health promoting properties.

1.5.2 The Moringa-added complementary food is less acceptable compared to the popular, traditional cereal-based complementary food, due to unfamiliar sensory properties.

1.6 Study parameters

1.6.1 The study was carried out using caregivers of children aged 7-12 months from two Pedi communities namely Stinkwater, Hammanskraal (Gauteng province) and Ga-Mphahlele village, Lebowakgomo (Limpopo province) South Africa. The study was limited to maize meal sourced from commercial markets and MLP obtained from the communities.

1.6.2 In this study, only the weight-for-age Z scores (WAZ) were used to calculate anthropometric indices because health officials in the study areas generally do not measure the height of children due to lack of resources. Thus, the other two popular anthropometric indices *viz.* length-for-age Z scores (LAZ) and weight-for-length Z scores (WLZ) could not be calculated.

1.7 Assumptions

The assumptions of this study were as follows:

1.7.1 The survey participants answered all questions honestly and without bias.

1.7.2 The focus group discussion participants responded honestly with regards to their perceptions.

1.7.3 The consumer panel for the sensory evaluation were free from sensory defects.

1.8 Definition of terms

1.8.1 Caregiver

A caregiver is a person who takes care of the basic needs of a person who, does not have the capacity to take care of themselves (Hermanns and Mastel-Smith 2012). A caregiver in this study refers to the biological mother of the child aged 7-12 months.

1.8.2 Child feeding practices

In this study, child feeding practices refers to breastfeeding and complementary feeding.

1.8.3 Complementary foods

These are foods that are given to children above six months of age to complement breastfeeding or formula milk (WHO 2012).

1.8.4 Consumer acceptability

The degree of liking or disliking a food product based on the consumers sensory perceptions in terms of the products appearance, taste, aroma and texture (White and Prescott 2007).

1.8.5 Food recipe

A food recipe is a set of instructions which describes how to prepare a food dish

18.6 Food and nutrition security

Food and nutrition security means the consumption and utilization of safe, adequate and quality food that is socio-culturally acceptable, available and accessible to be satisfactorily utilized (balanced diet and satisfactory nutrient absorption) by all people, at all times in order to live a healthy and happy life (McDonald 2010).

18.8 Health-promoting potential

Health-promoting potential in this study refers to antioxidant properties.

18.9 Nutritional quality

Nutritional quality in this study refers only to the determined nutritional composition.

1.8.9 Perceptions

A person's frame of reference emerging from previous experiences, beliefs, likes, dislikes opinions, feelings and other psychological factors of unknown origin (Barrios and Costell 2004).

1.9 Outline of the thesis

The thesis is laid out as follows:

Chapter 1: The problem and its setting.

Chapter 2: Literature review.

Chapter 3: Study conceptual framework, study design and description of study areas.

Chapter 4: An assessment of the food and nutrition security status of weaned 7–12-month-old children in rural and peri-Urban Communities of Gauteng and Limpopo Provinces, South Africa.

Chapter 5: The effect of Moringa leaf powder on the nutritional and phytochemical composition of complementary white maize soft porridge

Chapter 6: Acceptance of a Moringa-added complementary soft porridge by mothers in Hammanskraal, Gauteng province and Lebowakgomo, Limpopo province, South Africa

Chapter 7: Conclusions and recommendations

The publications from this work are listed in Appendix A. The referencing style used in this thesis is according to the guidelines used in the Discipline of Food Security, University of KwaZulu-Natal, Pietermaritzburg.

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CHAPTER 2 : LITERATURE REVIEW

2.1 Introduction

This chapter covers a review of the food and nutrition security status of children from limited-resource communities with reference to malnutrition. The challenges associated with measuring food and nutrition security are considered. Complementary feeding practices and the nutritional quality of complementary foods in rural South African households are reviewed. The strategies employed to combat malnutrition in South Africa are outlined. The proposal to use Moringa Oleifera in complementary foods is reviewed and evaluated.

2.2 Food and nutrition insecurity in limited-resource households with reference to child malnutrition

Despite the adequate food supplies at a national level within South Africa, there are reports of increasing household food insecurity (Hendriks 2005; Lemke 2005; Tathiah *et al.* 2013). The HSRC (2004) reported that 62% of rural households in South Africa experienced food poverty, whereby food spending was less than the cost of a nutritionally adequate low-cost diet. Rural households in South Africa have also been reported to give their children a limited variety of food (Tshabalala *et al.* 2014). As a result, the prevalence of child malnutrition is consistently higher in rural households in South Africa. Malnutrition is defined as either under-nutrition (underweight, wasting and stunting) or over nutrition (overweight and obesity) (Joosten and Hulst 2008; UNICEF 2013; WHO 2013). Malnutrition can be classified using anthropometric measurements (Table 2.1). Depending on the presented symptoms, malnutrition can be categorised as Severe Acute Malnutrition (SAM) or Moderate Acute Malnutrition (MAM) (DoH 2012). SAM is characterised by the presence of severe wasting and can clinically present as marasmus, kwashiorkor or marasmic kwashiorkor, while MAM is characterised by the presence of moderate wasting with no oedema (DoH 2012).

Table 2.1: The classification of malnutrition using anthropometric measurements (WHO and UNICEF 2009)

Anthropometric Measurement	Measurement	Classification
Weight for height	Below -3SD	SAM
	Above -3SD, Below -2SD	MAM
Mid upper arm circumference (Children aged 6-60 months)	Less than 11.5 cm	SAM
	Above 11.5 cm, Below 12.5 cm	MAM
Weight for age	Below -2SD Below -3SD	Underweight Severely underweight
Height for age	Below -2SD	Chronic malnutrition

SD= Standard deviation

SAM= Severe Acute Malnutrition

MAM= Moderate Acute Malnutrition

According to the WHO (2013), malnutrition is the leading cause of death during childhood, resulting in more than 33% of child deaths worldwide. In SSA there was an increase in the percentage of underweight children from 11.7% to 13.5%between 1990 and 2010 (Lutter *et al.* 2011). In 2011, 40% of children less than five years of age living in sub-Saharan Africa were stunted (UNICEF 2013). In South Africa, diet related diseases linked to under and over nutrition are major challenges, with the rise of these diet related diseases accounting for 28% of the burden of disease (Tathiah *et al.* 2013). The South African National Health and Nutrition Examination Survey (SANHANES) conducted by the HSRC revealed that poor micronutrient status was common among South African children under 5 years of age. At a national level, the prevalence of vitamin A deficiency was 43.6%, the prevalence of anaemia was 10.7%, iron depletion was 8.1% and iron deficiency anaemia was 1.9% (Shisana *et al.* 2014). There are various factors which contribute to the viscous cycle of child malnutrition; these factors are reviewed in the next section.

2.3.1 The causes of malnutrition in children

According to UNICEF (1990), the causes of malnutrition are classified as basic, underlying and immediate as illustrated by the UNICEF conceptual framework in Figure 2.1

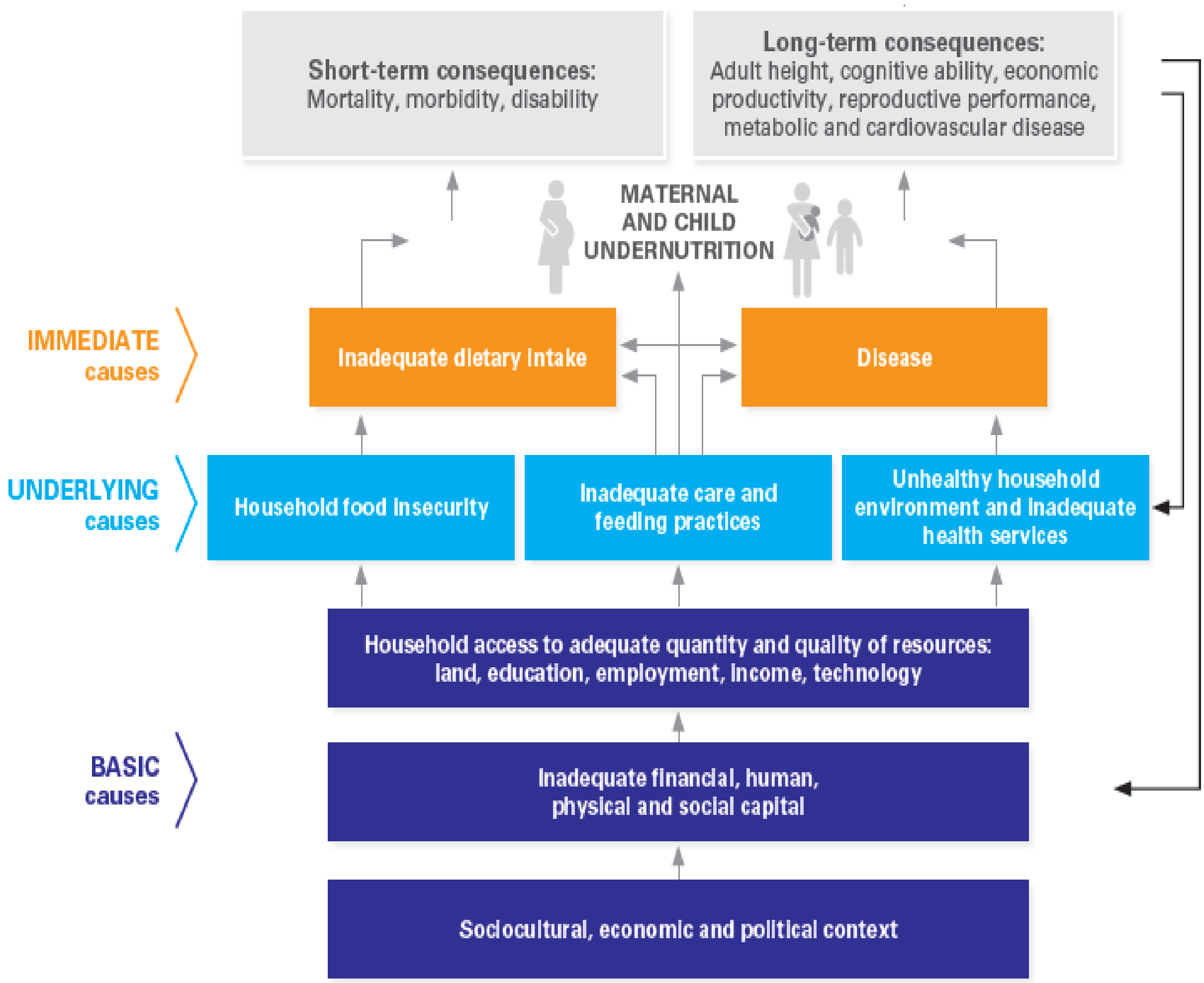

Figure 2.1: Conceptual framework of the determinants of child malnutrition (UNICEF 1990)

2.3.1.1 Basic causes

The basic causes of malnutrition include limited access to resources and environmental technology, cultural beliefs, religion and tradition, which together can influence how children are fed and cared for within the household. This consequently impacts on the nutritional status of children (UNICEF 1990). Women as female caregivers are one of the vulnerable groups in rural communities because the economic, cultural and religious structures offer more resources to men than women, leading to a lack of access to productive resources such as land, credit, improved technologies, seeds and fertilizers (FAO 2009). Consequently, this affects the ability of women to engage in agricultural related activities aimed at providing food for their households, resulting in food and nutrition insecurity for children in the household (McDonald 2010).

2.3.1.2 Underlying causes

The underlying causes of malnutrition in children include household food insecurity, inadequate maternal and child care, poor sanitation and inadequate health services, as well as a lack of education and information (UNICEF 1990). Household food insecurity remains a problem despite adequate food supply worldwide (Hendriks 2005; Schonfeldt *et al.* 2010). High poverty and unemployment rates are the main cause of malnutrition because the rise in food prices directly affects the amount and variety of foods consumed by children in the household (Kruger *et al.* 2008). Poverty results in food insecurity and food insecurity is directly related to inadequate dietary intake and increased levels of stunting and underweight, which lead to poor nutritional status of children (Chanyalew 2005; Kimani-Murage *et al.* 2010). The lack of education and knowledge on adequate maternal and child care increases the risk of childhood malnutrition. Caregiver's nutritional knowledge has been reported to determine child feeding practices, which consequently affects the nutritional status of children (Manu and Khetarpaul 2006; Bain *et al.* 2013). Unsanitary conditions and practices at a household level such as a lack of safe drinking water, unsafe waste disposal and unhygienic behaviour in child care and food preparation creates a dangerous environment with health risks, which can lead to poor nutritional status in children (Chopra *et al.* 2009; Schoeman *et al.* 2010)

2.3.1.3 Immediate causes

The immediate causes of malnutrition in children are associated with inadequate dietary intake and disease related factors (UNICEF 1990). Poor dietary intake in children is exacerbated by the lack of physical and economic access to nutrient rich foods by caregivers at a household level (Faber and Benadé 2007), consequently increasing the burden of disease. Infectious diseases which are common in children such as diarrhoea, acute respiratory disease and HIV/AIDS increases nutrient needs and at the same time may reduce appetite, resulting in lowered food intake and impaired absorption of nutrients, which in turn, may lead to malnutrition (Strotton *et al.* 2003; Manary and Sandige 2008; Bain *et al.* 2013). Poor child feeding practices are the leading cause of inadequate dietary intake for children, which later results in malnutrition (WHO 2009; Muchina and Waithaka 2010; UNICEF 2012).

Although various researchers have documented information on malnutrition, there are several challenges associated with measuring food security; these challenges are reviewed in the next section.

2.3 The conundrum of measuring food security

Food and nutrition insecurity are among the most urgent social issues in sub-Saharan Africa (SSA), including South Africa. Unfortunately, due to the complexities of measuring food and nutrition security, South Africa is deemed to be food secure at a national level, yet child malnutrition is a major challenge at a household level (Hendriks 2005; FAO 2008). Food and nutrition security refers to the consumption and utilization of safe, adequate and quality food that is socio-culturally acceptable, available and accessible to be satisfactorily utilized (balanced diet and satisfactory nutrient absorption) by all people at all times, to live a healthy and happy life (McDonald 2010; Weingartner 2010). Availability as a dimension of food security refers to the physical availability of food which is related to the levels of food production, stock levels, and net trade, while accessibility refers to the physical and economic ability to acquire food. Utilization involves supplying an adequate and balanced diet in a way that satisfies the physiological needs of people, to enable them to lead healthy and active lives, whilst stability refers to constant food supply over time (McDonald 2010).

Although these dimensions are interconnected, they can also exist and be measured in isolation (Webb *et al.* 2006). However, measuring one dimension does not mean that all the other dimensions can be determined, since food security is complex and multidimensional, with a range of factors impacting on food supply, access, adequacy, utilisation and acceptability. As a result, measuring food and nutrition security is very complex, expensive and thus challenging (Hendriks 2005).

The Household Food Insecurity Access Scale (HFIAS), Individual Food Insecurity Access Scale (IFIAS), Household Dietary Diversity Score (HDDS), Individual Dietary Diversity Score (IDDS), Anthropometric Indicators (AI) and the Monthly Adequate Household Food Provision (MAHFP) have been used internationally as tools to measure food security (Webb *et al.* 2006). However, each tool fails to measure all four dimensions of food and nutrition security (Hendriks 2005; Webb *et al.* 2006). The HFIAS measures the household's ability to access food of sufficient quantity, quality and preferences in the preceding 30 days, while the IFIAS measures the same aspects but at an individual level. Although the HFIAS and the IFIAS capture one of the underlying causes of malnutrition, which is a lack of access to food at a household and individual level respectively, both tools do not capture the nutritional status of the household's members or individuals (Webb *et al.* 2006).

The HDDS measures the dietary quality of households using a 24hr recall period while the IDDS measure the same aspects using the same recall period but at an individual level (Chitigu-Mabugu *et al.* 2013). Both tools are suitable when used as a measure for food access because more food groups at a household level or individual level reflect better access to food. The assumption is that an average of four food groups implies that the household diet or individual diet offers some diversity in both micro and macronutrients (Saaka and Osman 2013). However, both the HDDS and the IDDS fail to capture utilization and stability as dimensions of food security, because although households might have access to a variety of food groupsthe way the food is prepared determines the nutritional quality of the food consumed, and the access to these food groups might not be stable over time (Barret 2010). Anthropometric indicators such as stunting (low height for age), underweight (low weight for age) and wasting (low weight for height) measure nutritional outcomes at an individual level (De Haen *et al.* 2011). Although nutritional outcomes might be measured, anthropometric indicators do not highlight the specific nutrients that might be deficient (Walker *et al.* 2007). Lastly, the MAHFP only measures adequate food provision at a household level and ignores the other dimensions of food security (Bilinsky and Swindale 2005; Fan 2012).

In South Africa, there is no single tool which measures all dimensions of food and nutrition security. As a result, different methods of survey design and different variables to define and measure food and nutrition security have been adopted and used by different researchers (Jacobs 2010; Labadarios *et al.* 2009). These include national surveys which use direct measures of food insecurity, namely the National Food Consumption Survey (NFCS); Income and Expenditure Survey (IES); October Household Survey (OHS); Food Insecurity and Vulnerability Information Management System (FIVIMS). There are also national surveys which use indirect measures of food insecurity such as the General Household Survey (GHS), Labour Force Survey (LFS), community surveys and national HIV/AIDS surveys. Still, challenges are associated with these methods. For instance, the OHS has been inconsistent in the phrasing of questions between different survey years, which has made comparisons over time difficult (Koch 2011). The NFCS only measures food procurement, anthropometric indicators and food baskets in households that have children aged 1-9 years. This tool is limiting because it excludes the households without children and the households with children younger than one year old (Hendriks 2005). The GHS only focuses on measuring hunger over a certain period. Moreover, the FIVIMS only provides information on geographical areas and sectors of populations that suffer from hunger (Chitiga-Mubugu *et al.* 2013), and the IES only collects information on the sources of income and patterns of household expenditure and does not directly measure food security (Chitiga-Mubugu *et al.* 2013).

The challenges highligted above clearly illustrate that the dimensions of food and nutrition security cannot be measured using a single tool. Therefore, it is necessary to integrate different tools when trying to measure food and nutrition security, as the integration of different tools will provide valuable information and counter balance the deficiencies of using a single tool. This will enhance the researcher's ability to obtain multiple perspectives from the results.

With different tools, researchers have been able to document child feeding practices. South African complementary feeding practises are reviewed in the next section.

2.4 Complementary feeding practises in South African households

According to the WHO (2008), complementary feeding is the process which occurs when breast milk alone or infant formula alone is no longer sufficient to meet the nutritional requirements of children and therefore other foods and liquids are given, together with breast milk or a breast-milk substitute. Breastfeeding alone is sufficient for the first six months of life but after six months, breast milk or other forms of breast-milk substitutes alone are no longer sufficient to meet the nutritional requirements of a growing child (Krebs and Hambidge 2007; WHO 2012). Therefore, it is recommended that safe and nutritious complementary foods be introduced to children from six months of age, once they can tolerate solid foods (WHO 2012; Whitney *et al.* 2011).

Various studies have indicated that complementary feeding practices in South Africa are inappropriate. A study conducted by Kruger and Gericke (2003) in the Moretele district, North West Province, indicated that caregivers started weaning their children as early as three months of age and most children were given soft porridge prepared with maize meal. The soft porridge was over cooked and over diluted, and formula powder or margarine was added to the cooked soft porridge. Similar findings were reported by Faber and Benadé (2007) in the Valley of a Thousand Hills, a rural area in KwaZulu-Natal. Caregivers initiated complementary feeding earlier than four months of age, and 55% of the caregivers gave their children maize meal soft porridge as their first complementary food, with margarine added. In contrast, the study further reported that stiff pap (*phuthu*, a crumbly maize meal porridge) was given to children and more than 40% of the children consumed savoury snacks at least four days a week (Faber and Benadé 2007).

A study conducted by Goosen *et al.* (2014) in a low-income setting of the Western Cape indicated that 75% of mothers introduced solid foods such as commercial child cereals before their children were three months old. Liquid foods such as water and rooibos tea were also given to infants if not enough formula milk was available. A study by Mushaphi *et al.* (2008) in Limpopo province revealed that caregivers gave their children complementary foods as early as two months of age. A traditional dish called "*Tshiunza"* (prepared from maize and roots and fermented to make a soft sour porridge) was given to children as caregivers believed that breast milk was not sufficient (Mushaphi *et al.* 2008).

According to the reviewed literature, complementary feeding practices in South Africa are similar to the practices used by caregivers in other developing countries with similar socio-economic status. In Kinshasa, Democratic Republic of Congo 65% of caregivers gave their children liquid and solid foods which included sugar water, water, tea and porridge as early as two to three months of age (Yotebieng *et al.* 2013). In Bangladesh, 70% of the mothers started complementary feeding before six months old, with solids and liquid foods such as sweetened water, honey and mashed rice given to children as it was believed that breast milk alone was insufficient (Rahman *et al.* 2009). Similarly, a study in Bhaktapur, Nepal revealed that caregivers introduced semi-solid foods before six months of age because breast milk was perceived as inadequate (Ulak *et al.* 2012). The nutritional quality of South African complementary foods will be discussed in the next section.

2.4.1 The nutritional quality of complementary foods in South Africa

From the review in the previous section, it appears that white maize, a low nutrient density food, is widely used by caregivers when preparing complementary foods. Unfortified maize meal is a bulky food that contains limited quantities of micronutrients (Faber and Benadé 2007; Nuss and Tanumihardjo 2010). Complementary foods made with unfortified maize meal as a major ingredient are sufficient in energy, fibre and B-vitamins, but are deficient in the essential amino acids lysine and tryptophan, some minerals and, most notably, vitamin A. A diet that consists predominantly of white maize tends to be low in the amino acids phenylalanine, tyrosine, tryptophan, threonine, methionine, cystine, leucine, valine, isoleucine and histidine. The most limiting amino acid found in maize-based diets is lysine (Duvenage and Schönfeldt 2007).

Soft porridge prepared with unfortified maize meal is the food most often used by South African caregivers to complement breast feeding or formula feeding (Faber 2005). Although white maize soft porridge as a complementary food is sufficient in energy, fibre and B-vitamins, white maize naturally contains phytates which hinder the absorption of minerals such as iron, calcium and zinc (Raboy 2007; Duvenage and Schönfeldt 2007). The addition of energy rich ingredients such as sugar and margarine to white maize soft porridge increases the risk of micronutrient deficiencies. A study conducted by Faber (2005) indicated that although energy-rich ingredients such as margarine and sugar were added to white maize soft porridge, children were still deficient in calcium, iron and zinc. The poor nutritional quality of South African complementary foods exacerbates the risk of malnutrition in children and it accounts for the high prevalence of malnutrition in children less than 5 years of age (Faber and Benadé 2007). Various studies have shown that in low-income rural communities, complementary feeding is viewed as inappropriate due to the caregiver's lack of knowledge and poor access to affordable and nutritious food resources (Kruger and Gericke 2003; Goosen *et al.* 2014). To address micronutrient malnutrition in South Africa, the government has employed a number of strategies which are reviewed in the next section.

2.5 Strategies employed to combat malnutrition in South Africa and their shortcomings

In 1995, the Department of Health (DoH) initiated the Integrated Nutrition Programme (INP) with the aim of ensuring optimum nutrition for all South Africans, by preventing and managing malnutrition (DoH and UNICEF 2007). The main objective within the focus area of micronutrient malnutrition control is the elimination of micronutrient deficiencies. The INP used various strategies to address micronutrient deficiencies which included supplementation, food fortification, biofortification and dietary diversification (Labadorios *et al.* 2005, Swart *et al.* 2008). These strategies are briefly discussed below.

2.5.1 Supplementation

In 2002, the South African DoH implemented a vitamin A supplementation programme as part of the routine immunization program, maternal health and integrated management of childhood illnesses (Labadarios *et al.* 2005). The vitamin A supplementation programme provided routine and therapeutic doses of vitamin A to children who presented with clinical signs of vitamin A deficiency, were severely malnourished and were 6-59 months of age (DoH 2012). A programme evaluation study conducted by Hendricks *et al.* (2007) in the Western Cape revealed that there was poor awareness of the programme amongst caregivers, and the nurses who provided supplements needed training. Du Plessis *et al* (2007) also conducted a programme evaluation study in the Western Cape and similar observations were reported. The distance between rural households and health facilities made it difficult for caregivers to bring their children to receive vitamin A supplements (Smuts *et al.* 2008). Many caregivers were not informed about the importance of vitamin A, and consequently did not bring their children to receive the supplements (Faber and Benadé 2007).

2.5.2 Food fortification

Food fortification refers to the addition of micronutrients to foods regularly consumed by a significant proportion of a population at risk of micronutrient deficiencies (UNICEF 2007). The NFCS of 1999 identified the most commonly consumed foods which would be most appropriate vehicles for fortification in South Africa. This resulted in the fortification of two staple foods, namely maize meal and wheat flour with Vitamin A, thiamine, niacin, pyridoxine, folate, riboflavin, iron and zinc which was legislated in October 2003 (DoH and UNICEF 2007; Labadarios *et al.* 2005). Fortification may be seen as a cost-effective way of increasing the micronutrient intake of individuals, however, fortified food products are not always accessible to children in rural communities due to the physical and economic constraints in accessing the fortified foods (Horton 2006, Steyn *et al.* 2008). Steyn *et al.* (2006) argued that it was unlikely food fortification would fully compensate for a significant inadequate dietary intake particularly in children who cannot eat large portions of fortified staple foods at a time.

2.5.3 Biofortification

Biofortification involves enhancing popular staple crops with vitamins and minerals through conventional breeding or genetic modification (Khush *et al.* 2012; Saltzman *et al.* 2013). Although there is less risk of vitamin A toxicity from biofortification as compared to excessive consumption of fortified foods and massive doses of vitamin A supplements (Penniston and & Tanumihardjo 2006), consumer acceptability is a major challenge with biofortified crops. Various studies have reported that sensory attributes of biofortified crops and consumer perceptions towards biofortified crops restrict consumer acceptability of biofortified crops (Pillay *et al.* 2011; Stevens and Winter-Nelson 2008).

2.5.4 Dietary diversification

Dietary diversification refers to a variety of approaches which aim to increase the production, availability and access to micronutrient-rich foods (Latham *et al.* 2001). A diversified diet consists of a variety of food types including fruits, vegetables, legumes, starch and animal products. Dietary diversification can be achieved through various approaches which include horticultural approaches, behavioural change, improved methods of food preparation and preservation that improves micronutrient content (Smuts *et al.* 2008). However, the major focus in South Africa is on horticultural approaches, whereby rural households are encouraged to engage in food gardens to ensure dietary diversity (Smuts *et al.* 2008; Faber *et al.* 2011). There are various limiting factors to household gardens; these include lack of knowledge, crop diseases and lack of agricultural inputs (Faber *et al.* 2013a; Faber *et al.* 2013b). Dietary diversification appears to not be a feasible strategy for the low-income communities of South Africa as the strategy requires significant economic resources (Faber *et al.* 2013a).

From the strategies reviewed, caregivers need to be informed on how to process crops suitable to their environments into nutrient rich complementary foods for their children. The gap between knowledge and practice should be filled with proper interaction and education of mothers and family members in order to achieve appropriate complementary feeding practices. The proposal to use Moringa in complementary foods is reviewed in the next section.

2.6. Moringa leaf powder (MLP) as an ingredient in complementary foods to combat malnutrition

Moringa oleifera (Lam.) is a plant from the Moringaceae family, which is native to sub-Himalayan tracks of India, Pakistan, Bangladesh and Afghanistan; however, it is now distributed all over the world (Fahey 2005). There are about 13 species in the Moringaceae family, of which *Moringa oleifera* is the species most widely known and cultivated. It is already an important plant in India, Ethiopia, the Philippines, Sudan and is grown in west, east and South Africa, tropical Asia, Latin America, the Caribbean, Florida and the Pacific Islands. The plant consists of leaves, pods, seeds, flowers, fruits and roots which are edible (Figure 2.2); as a result, the plant is often referred to as the "multipurpose" tree.

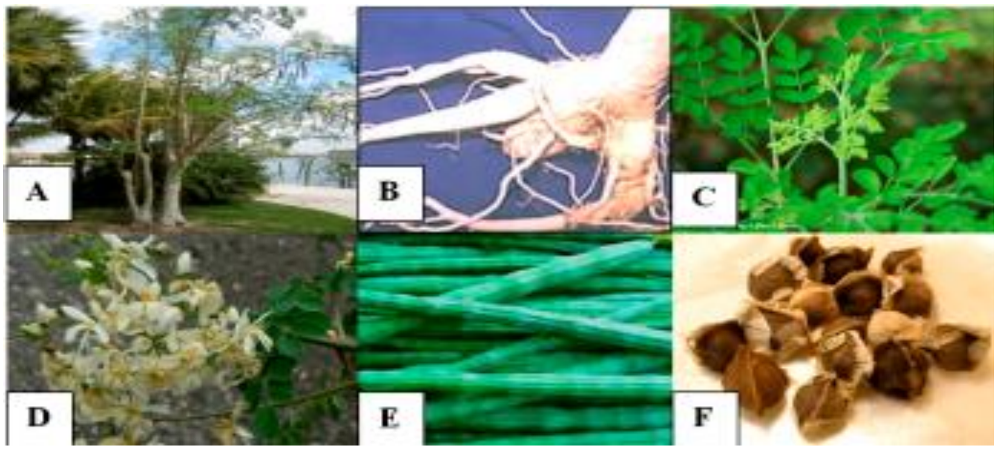

Figure 2.2: Various useful parts of Moringa (A) Tree, (B) roots (C) Leaves (D) Flowers (E) Fruit and (F) Seeds (Source; Paliwal *et al.* 2011)

The different parts of Moringa have been largely used for medicinal purposes, water purification, oil production and, to a lesser extent, as a food source (Anwar *et al.* 2007; Fahey 2005; Fuglie 2001). The leaves of Moringa have been reported to be the most nutritious compared to other parts of the plant (Gupta *et al.* 1989; Bennett *et al.* 2003; Siddhuraju and Becker 2003; Soliva *et al.* 2005; Lako *et al.* 2007). Literature has confirmed that processing Moringa leaves into leaf powder does not affect the nutritional quality of the leaves (Fahey 2005; Arabshahi-D *et al.* 2007). Therefore, the use of MLP could be suitable for use in complementary foods, to improve the nutritional quality of these complementary foods while diversifying livelihood options for rural communities. This is reviewed in the next section.

2.6.1 The advantages of using Moringa leaf powder in complementary foods

2.6.1.1 Nutritional quality

According to Yang *et al.* (2006), the nutritional and functional properties of MLP are highly influenced by genetic variation of the leaves, soil, climate and postharvest handling practices such as processing and storage. Moringa leaves are considered a rich source of minerals (Gupta *et al*. 1989), polyphenols (Bennett *et al.* 2003), flavonoids (Siddhuraju and Becker 2003; Lako *et al.* 2007), alkaloids, proteins, vitamins, beta-carotene, amino acids and various phenolics (Sarwatt *et al.* 2002; Anwar et al. 2007; Lako *et al.* 2007). Table 2.2 represents the recommended average daily nutrient intake for children aged 7 to 12 months, compared to the nutritional value of fresh and powdered Moringa leaves.

Table 2.2: Nutritional value of Moringa fresh (raw) leaves and dried leaf powder (per 100 g of edible portion) (Rajput *et al.* 2017) and the recommended average daily adequate intake (AI) for children aged 7 to 12 months (Institute of Medicine, Food and Nutrition Board 2005; FAO and WHO 2001)

Nutrients	**Moringa fresh leaves**	**Moringa leaf owder**	**AI for children aged 7-12 months**
Protein (g)	5.29±0.396.7	20.42±1.01	11
Carbohydrates (g)	10.57±0.86	50.16±1.66	95
Fiber (g)	5.57±0.39	22.03±0.42	5
Calcium (mg)	475.33±40.47	2032.83±118.14	270
Magnesium (mg)	40.33±11.09	387.83±63.02	75
Potassium (mg)	328.33±64.32	1545.33±2219.79	0.7
Copper (mg)	0.15±0.07	0.83±0.19	220
Iron (mg)	7.63±1.11	26.69±5.47	11
Total phenols (mg)	62.32±1.20	253.00±10.79	ND

ND=Not determined
AI= Adequate Intake
Mean ± standard deviation

Macronutrients and micronutrients are needed for the growth, maintenance and repair of children's bodies, and as they enter puberty, for reproduction. Each nutrient provides one or more of these functions, but all nutrients together are needed to maintain human health (Smolin and Grosvenor 2007). For proper growth and development, young children must obtain adequate amounts of nutrients from the complementary foods provided (Faber and Benadé 2007). The nutrients could be obtained by incorporating different food groups into children's diets. Considering the recommended average daily adequate intake for children, it seems that the nutrients in MLP have the potential to contribute towards meeting the nutritional requirements of children aged from 7-12 months (Table 2.2).

Various studies have investigated the bioavailability of Moringanutrients in Moringa for human consumption. For instance, Girija *et al*. (1982) investigated the bioavailability of thiamine, riboflavin and niacin from dried Moringa leaves among 17-20-year-old subjects in India. Subjects were given a series of experimental curry-based diets with leaves of trees noted for their contents of thiamine, riboflavin, and niacin. Diets containing Moringa leaves resulted in urinary excretion of 11.72% of thiamine, 10.78 % of riboflavin, and 9.44 % of niacin intake, leading the authors to conclude that this equated to bioavailability. In their study, Pankaja and Prakash (1994) fed rats with calcium-rich diets containing 15 g dried MLP, 30 g milk powder and 4 g Amaranthus tricolor leaf powder per 100 g of basal diet. Although milk did provide for the best absorption and retention of calcium, 73% of the calcium provided by Moringa was absorbed and 59% was retained, thus providing a good alternative or ancillary source of calcium when milk is not available (Pankaja and Prakash 1994).

The comparative bioavailability of β-carotene in fresh and dried Moringa leaves was evaluated by Nambiar and Seshadri (2001) using a rat model. The findings revealed that rats receiving Moringa leaves increased their food intake and weight gain compared to rats given either synthetic vitamin A or vitamin A adequate diets. β-carotene and lutein from Moringa leaves in India was found to be highly bioavailable in an *in vitro* model (Pullakhandam and Failla 2007). A study conducted by Yang *et al.* (2006) using a rat model showed that the consumption of nutrient and phytochemical-rich leaves, like Moringa leaves, led to a better immune response compared to consumption of vegetables rich in fiber but lower in nutrient content. Similarly, a study conducted by Zongo *et al.* (2013) in Burkina Faso revealed that the use of MLP as a dietary supplement was successful in rehabilitating severely malnourished children. *2.6.1.2 Environmental adaptability*

The Moringa tree can adapt in different environmental conditions. The production yields of MMoringa can be improved when the plant is grown under warm and dry conditions supplemented with irrigation (Price 2000). The suitable temperature for Moringa production is 12-35 degrees Celsius. Well dained soils are suitable for the growth of Moringa (Price 2000). Yet, Moringa is adaptable to a wide range of environmental conditions from hot and dry to hot, humid, wet conditions and tolerates both sandy soils, heavier clay soils and limited water conditions, alkaline soils up to pH 9 as well as acidic soils as low as pH 4.5 (Price 2000). The plant further tolerates different rainfall climates, with a minimum annual rainfall requirement estimated at 250mm and a maximum requirement at over 3000mm (Morton 1991; Palada and Changl 2003). In the tropics, Moringa can tolerate light frosts but does not survive as a perennial under freezing conditions (Price 2000). Although a freeze can kill a mature Moringa tree back to the roots, Moringa can recover by quickly sending out new growth from the ground. Being a deciduous plant, Moringa does not have any negative effect on crops because it is deep rooted and doesn't compete with other crops for nutritional concerns. It also helps improve organic matter in the soil, and ultimately soil fertility (Manzoor *et al.* 2007; Sreelatha and Padma 2009).

2.6.1.3 Ease of production and processing

The production of Moringa requires little financial investment because its cultivation requires minimal agricultural inputs (Adeloye 2014). The trees only need pruning to obtain bushy leaf growth, and regular but limited amounts of water and organic manure (Price 2000). Sun-drying in direct sunshine and under shade is a common practice used in most parts of Africa to preserve food for dry season consumption (Bechoff *et al*. 2011). This method has been used successfully to dry meat, cereals, fruits and vegetables by rural households (Sagar and Suresh Kumar). The advantage of sun-drying is that it increases the shelf-life of dried food products and it is the least expensive food preservation method. According to Foidle *et al.* (2001) and Fahey (2005), sun drying is an inexpensive, efficient method to process Moringa leaves into powder. In contrast, Fuglie (2001) argues that Moringa leaves should be dried in the shade and not in direct sunlight, since sunlight destroys vitamin A.

The different methods of food processing may significantly affect the concentration and availability of minerals, vitamins and the essential compounds in food, with reported losses of nutrients during vegetable drying and the cooking process (Kidmose *et al.* 2006). A study conducted by Yang *et al*. (2006) showed that a mild-heat drying process of 50 °C for 16 hours maintained most nutrients and phytochemicals in Moringa leaves except for vitamin C. It is also important to note that the study found that cooked Moringa leaves provided more bioavailable iron, and the dried leaves provided many kinds and types of nutrients and bioactives, which would lead to better nutrition and health.

The next section reviews the uses of Moringa leaves either fresh or in powdered form by rural communities.

2.6.2 The uses of Moringa leaves, either fresh or in powdered form

Studies conducted on the uses of Moringa leaves demonstrate that MLP has not been used to improve the nutritional quality of complementary foods. Table 2.3 summaries studies on the uses of Moringa leaves.

Table 2.3: Summary of reported studies on the uses of Moringa leaves

Author	**Type of study**	**Study area**	**Findings**
Estrella *et al.* (2001); Siddhuraju and Becker (2003)	Survey	Philippines	- MLP was consumed by lactating women as they believed that it increased milk production.
Odeyinka *et al.* (2007)	Survey	Nigeria	-Farmers used Moringa leaves as cattle fodder to improve milk yield in their livestock and the extracted juice from the leaves was used to make foliar, which was used to increase plant growth and green manure to improve soil fertility.
Kasolo *et al.* (2010)	Survey and focus group discussions	Uganda	-Moringa leaves were used for the treatment of twenty-four medical conditions and only 10.8 appreciated its use as a supplement to prevent malnutrition.
Kola-Oladiji *et al.* (2014)	Survey	Nigeria	- 73.3% of the respondents valued Moringa leaves for medical purposes while 15.6% used it for food and cultural purposes.
Oyewole *et al.* (2014)	Survey	Nigeria	-85% of the respondents were aware of Moringa leaves; however, only 65% consumed the leaves. 32.5% consumed Moringa leaves as a vegetable, 30% consumed MLP blended with other foods and only 2.5% consumed it as a capsule.
Farinola *et al.* (2014)	Survey	Nigeria	-80.7% of the respondents claimed they consumed Moringa, whereby 47.9% preferred it fresh, and 34.7% either preferred it dried or processed.

Author	Type of study	Study area	Findings
			-The consumption of Moringa leaves was based on the belief that it had health benefits including weight loss, improvement of overall physical strength, treatment of diarrhoea, gonorrhoea, and asthma, and helped combat stress and depression.
Obayelu *et al.* (2015)	Survey	Nigeria	-All the respondents consumed and purchased labelled and certified tea and spice powder made from Moringa leaves. -62% of the respondents indicated that they consumed and purchased Moringa leaf products because of the nutritional value.

Findings summarised in Table 2.3 indicate that, in general, Moringa leaves or leaf powder is not valued as a food source, especially for use in complementary foods. The consumption of Moringa leaves is based on the belief that it has healing properties which are capable of treating medical conditions. In addition, Moringa leaves were consumed by lactating women and fed to cattle because rural communities believed that the leaves were capable of increasing milk yield in both women and cattle (Estrella *et al.* 2001; Siddhuraju and Becker 2003; Odeyinka *et al.* 2007). This highlights that in rural communities, Moringa leaves are highly valued for medicinal and functional purposes, rather than improving the nutritional quality of complementary foods. The nutritional quality of Moringa leaves, its ease of production and processing, and the capability of the tree to tolerate different environmental conditions makes MLP a convenient solution to improving the nutritional quality of complementary foods.

2.7 Proposal to use Moringa leaf powder in complementary foods

Moringa leaf powder should be suitable for use as an ingredient when preparing complementary foods. Rural communities could be trained on Moringa production and processing for use in complementary foods while improving their livelihood options through the line of selling MLP or products made from Moringa. This would be critical in addressing the risk of micronutrient deficiencies associated with South African complementary foods, while improving livelihood options for rural communities. However, the use of MLP in complementary foods could result in poor consumer acceptability of such foods due to unfamiliar sensory attributes. Previous studies have shown that new food products are likely to be unacceptable to consumers because of unfamiliar sensory properties (Oteku *et al.* 2006; Muthial *et al.* 2012). The acceptability of Moringa based complementary foods would largely depend on caregivers as they usually decide what is consumed by their infants (UNICEF 2012). Nevertheless, UNICEF (2012) revealed that caregivers have been found willing to try new food products, especially if they are of nutritional benefit to their children.

2.8 Conclusion

Complementary feeding practices in sub Saharan Africa, including South Africa, have been reported to be inappropriate due to poor nutritional quality. The inadequate nutritional quality of complementary foods exacerbates the risk of malnutrition in children, and accounts for the high prevalence of malnutrition in children under 5 years of age. Moringa leaves are nutritious, easy to produce and process into Moringa powder and the tree can tolerate different environmental conditions. Therefore, MLP seems suitable for use as an ingredient in complementary foods to improve nutritional quality, consequently improving the nutritional status of children while diversifying livelihood options for rural communities through the line of producing and selling MLP, or products made from Moringa. There is a lack of data on the use of MLP in complementary foods in South Africa, nutritional composition and mother's acceptability of these foods. It would therefore be highly beneficial to investigate the effect of Moringa addition on the nutritional quality of traditional popular complementary foods and caregiver's acceptability of Moringa-based complementary foods.

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CHAPTER 3 : STUDY CONCEPTUAL FRAMEWORK, STUDY DESIGN AND DESCRIPTION OF STUDY AREAS

3.1 Study conceptual framework

Mothers have reportedly been relying profoundly on white maizebased complementary foods to feed their young children. Unfortunately, cereal-based complementary foods are deficient in nutrients. Moringa leaf powder (MLP) could be used as an ingredient when preparing complementary foodto improve the nutritional quality of popular traditional cereal-based complementary food because of its nutritional value. Moreover, the acceptability of Moringa-based complementary food by caregivers could fuel the production and processing of Moringa at a local level, consequently, improving livelihood and entrepreneurship opportunities. The diagram of the study conceptual framework is presented in Figure 3.1.

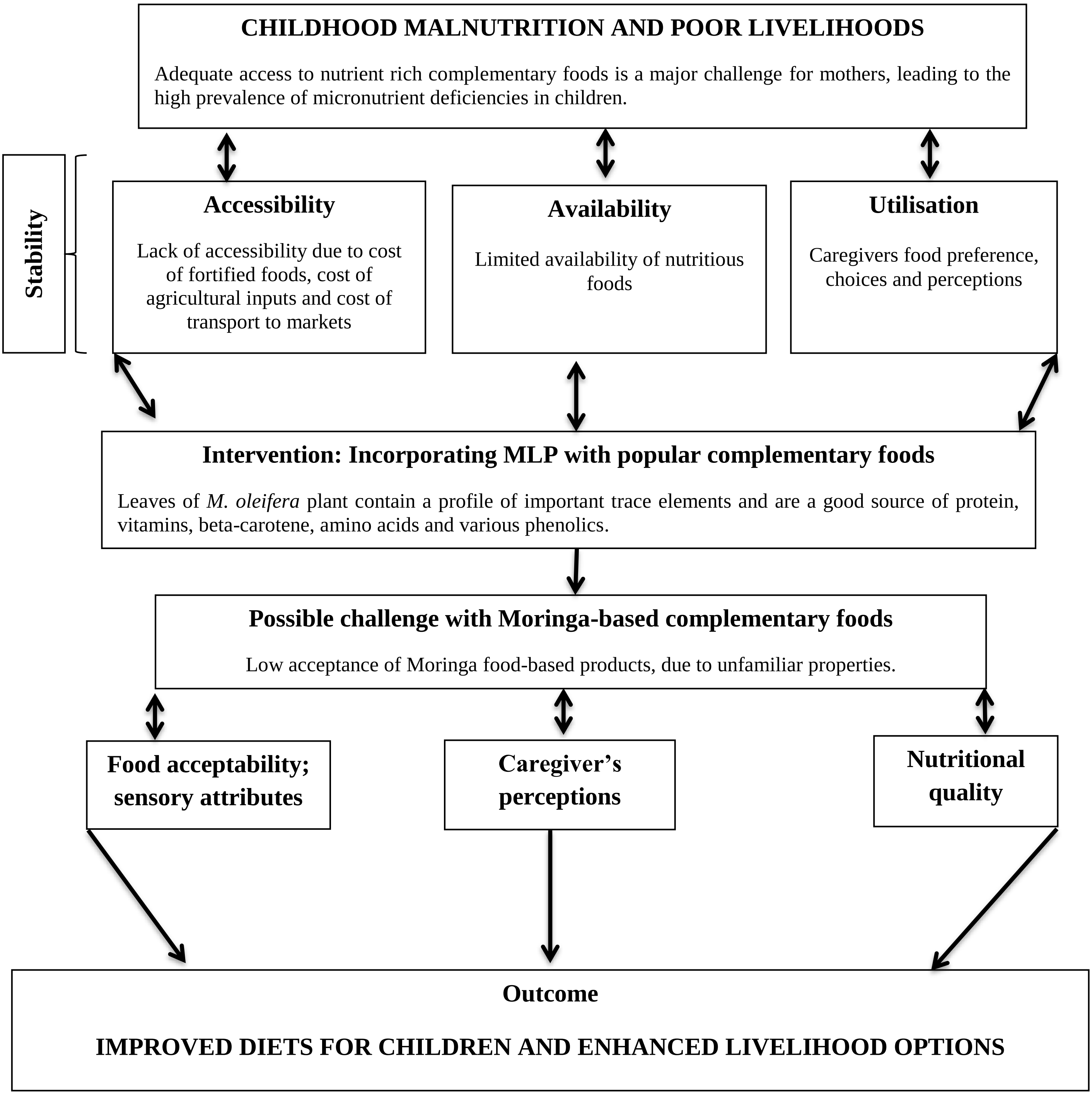

Figure 3.1: The conceptual framework of the study

3.2 Study design

A survey through a structured questionnaire was conducted to measure the food and nutrition security status of children receiving complementary food. Focus group discussions were conducted to determine mothers' perceptions on child feeding practices, awareness and utilization of Moringa and to further establish a common traditional cereal-based complementary food recipe. The established common complementary food recipe was modified by substituting maize meal with MLP at different levels, 1, 2 and 3% (w/w). The samples were tested for their nutritional quality and health promoting properties using standard methods and evaluated for consumer acceptability through a sensory evaluation by mothers of children aged 7-12 months. The diagram for the design of the study is presented in Figure 3.2.

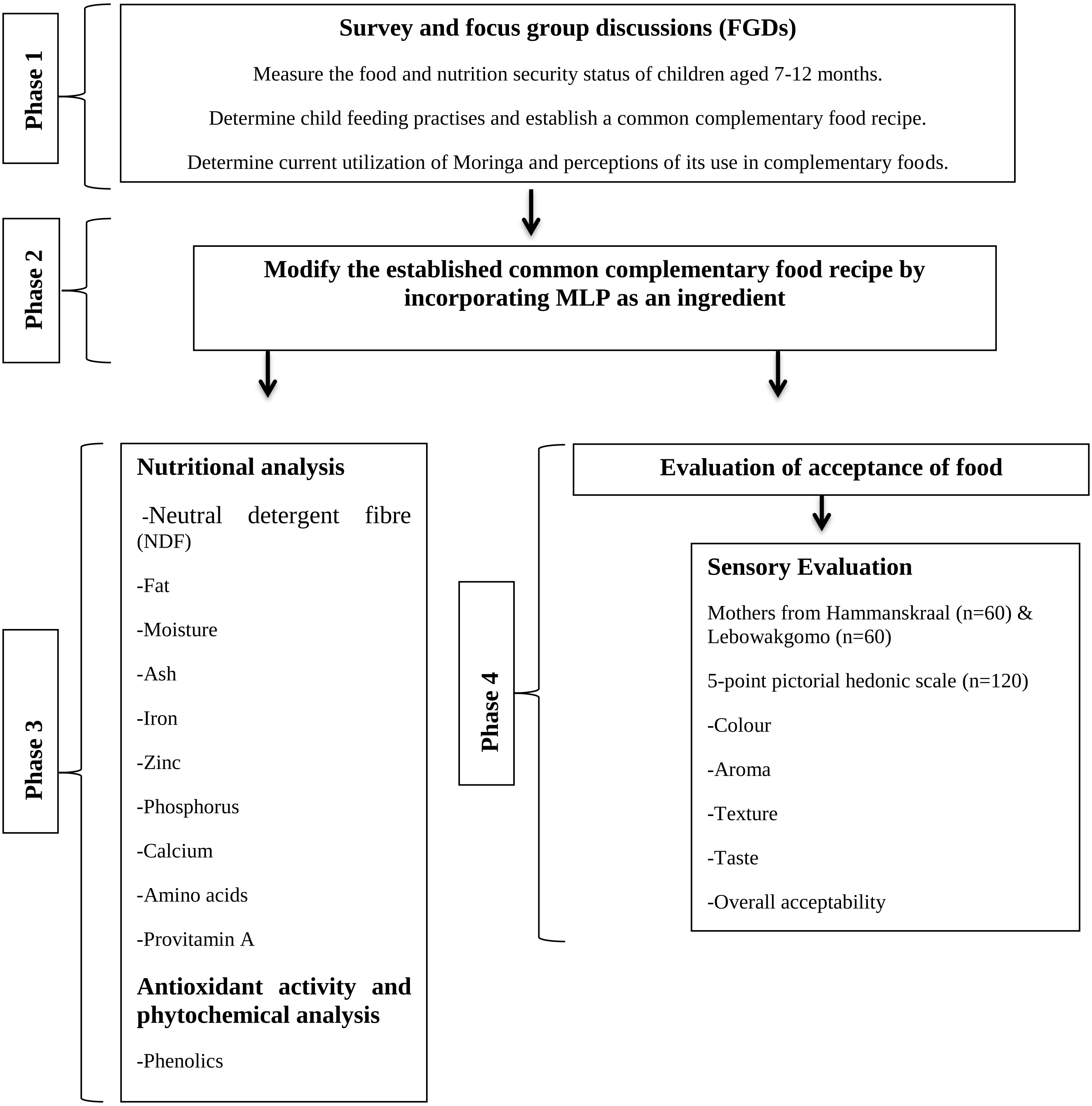

Figure 3.2: The design of the study

3.3 Description of study areas

It was decided that the study be carried out on black African mothers from rural and peri-urban settings, as children from these settings would be more prone to malnutrition. Additionally, the selected areas are regarded as low income due to high unemployment rates and low average household income as discussed below. Mothers were selected as the study participants because they were responsible for preparing food for their children.

The study was conducted in two separate communities that are both of Pedi ethnic culture. The two communities are in Stinkwater, Hammanskraal, in the Gauteng province (25° 23' 59.99" S: 28° 16' 60.00" E) and Ga-Mphahlele village, Lebowakgomo, in the Limpopo province (24°18'0.83"S: 29°32'33.61"E), South Africa. Figure 3.3 shows the location of Gauteng and Limpopo province in South Africa.

Figure 3.3: Gauteng province and Limpopo province [Statistics South Africa (StatsSA) 2012a]

In the Gauteng province, the study was conducted in Hammanskraal which is in region 2 of the City of Tshwane (CoT) Metropolitan Municipality. Region 2 of the municipality is bordered by the Magaliesberg mountain range to the south and the PWV9 freeway to the west, the N1 runs through the middle of the region. Figure 3.4 shows the CoT Metropolitan Municipality in Gauteng province and Figure 3.5 shows the location of region 2 in the CoT Metropolitan Municipality.

Figure 3.4: The CoT Municipality in Gauteng province [Integrated Development Plan (IDP) 2014]

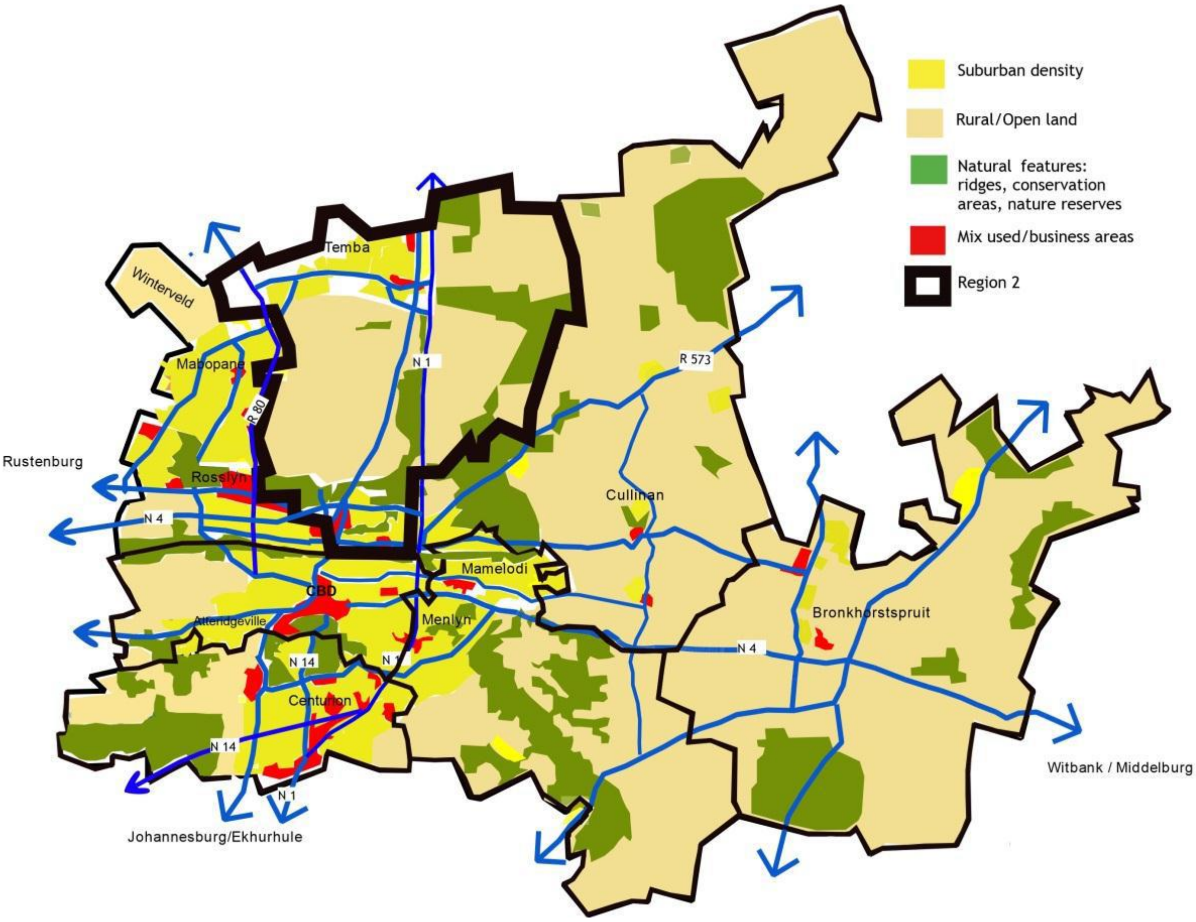

Figure 3.5: The location of region 2 in the City of Tshwane Metropolitan Municipality (IDP 2014)

Region 2 consists of peripheral urban settlements in the north, a suburban setting and nodal development in the south and a large rural area (IDP 2014). The study area, Hammanskraal, is in the northern periphery of CoT. The northern periphery of CoT is characterised by low density settlements with concentrations of subsidised housing and informal settlements (IDP 2014). Although the area is urban in character, it is not integrated with the larger urban environment of the metropolitan area. In 2011, region 2 of CoT had a total population of 339 175 people and the age group below 30 years made up most of the population, Hammanskraal and surrounds had the highest population density (StatsSA 2012b). The high population density in the northern periphery of the region accounts for the additional pressure on job creation and high dependency ratio because limited economic activities occur, and most employment opportunities are in the inner city. Hence, in 2011, 28% of the economically active people were unemployed (IDP 2016). The level of education is very low in the region, and as a result, access to employment and economic growth is a major challenge (IDP 2016).

In Limpopo, the study was conducted in Lebowakgomo which is in Lepelle-Nkumpi local municipality. Lepelle-Nkumpi local municipality is one of the five local municipalities within the Capricorn District municipality in the province, and it is situated in the Southern part of Capricorn district, 50km South of Polokwane (Figure 3.6).

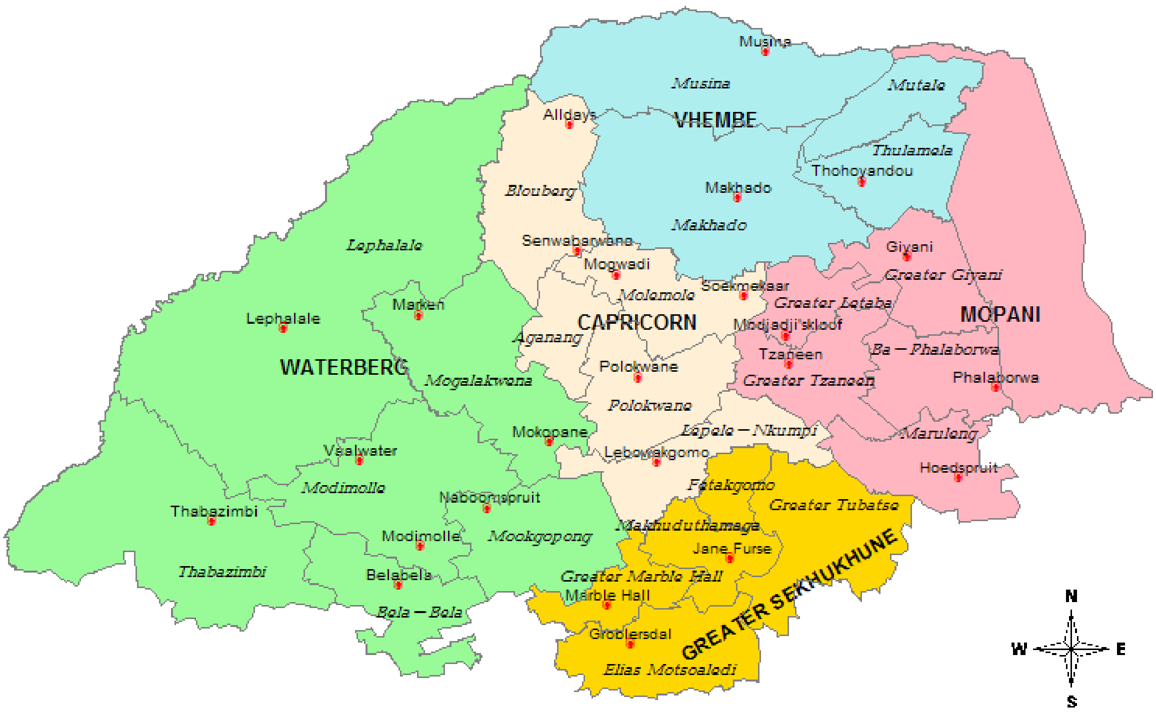

Figure 3.6: Location of Lebowakgomo in Lepelle-Nkumpi local municipality, Capricorn district (IDP 2015)

Lepelle-Nkumpi local municipality is pre-dominantly rural and covers 3455.78 km which represents 16% of the district's total land area. The municipality is divided into 29 wards where 95% of its land falls under the jurisdiction of traditional authorities (IDP 2015). The municipality is the second largest in the district, harbouring 18% of the districts population. The average population size is 8000 people per ward. Ward 22, 15 and 26 are the largest with population sizes of more than 100 000 each (StatsSA 2012c). In 2007, the population was estimated to be 241 414 people with a total of 58 483 householdsand an average of 4.13 people per household. In 2011, the population was estimated to be 230 350 people with a total of 59 682 households and an average household size of 3.9 people (StatsSA 2012c).

The municipality has a proportionally high number of functionally illiterate people; consequently, there are high rates of unemployment in the area. For instance, in 2007, 32% of the population had no form of income while only 0.2% of the population earned more than R12 800 per annum. Many households relied on government grants; 82 828 grants were issued monthly in the municipal area by the South African Social Agency (SASSA), which is 21% of the total grants issued within the district (39 8270). Child support grants *viz.*, 55 432 out of 268 032 were received in the municipality (StatsSA 2012c). In 2011, Lepelle-Nkumpi municipality still had very high levels of poverty with 48% of the population being unemployed.

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CHAPTER 4 : AN ASSESSMENT OF THE FOOD AND NUTRITION SECURITY STATUS OF WEANED 7–12 MONTHS OLD CHILDREN IN RURAL AND PERI-URBAN COMMUNITIES OF GAUTENG AND LIMPOPO PROVINCES, SOUTH AFRICA.

4.1 Abstract

This study assessed the food and nutrition security status of children receiving complementary food in rural and peri-urban communities. A group of mothers from Lebowakgomo village (n=106) and Hammanskraal Township (n=106), participated in the survey. Additionally, six focus group discussions were conducted per study area to assess the mothers' perceptions about their children's access to food. The Children's Food Insecurity Access Scale (CFIAS) was used to assess the food security status (access) of the children. The Individual Dietary Diversity Score (IDDS) together with the unquantified food consumption frequency survey were used as a proxy measure of the nutritional quality of the children's diets. The age and weight of the children were obtained from the children's clinic health cards and were used to calculate Weight-for-Age Z scores (WAZ), in order to determine the prevalence of underweight children. The findings showed that child feeding practices in both study areas were inappropriate; mothers discontinued breastfeeding and initiated complementary feeding before the recommended 6 months of age. Regardless of geographical location, a large percentage of children (87% and 78%, in rural and peri-urban areas respectively) were severely food insecure. Additionally, 23.6% of Lebowakgomo children and 17.9% of Hammanskraal children were severely underweight, with a WAZ below the minus 3. Overall, children's diets in both study areas were characterized by nutrient-deficient complementary foods. Cheaper foods with a greater satiety effect such as white maize meal (WMM) and sugar, were the most commonly purchased and used. Hence, the children consumed very limited amounts of foods rich in proteins, minerals, and vitamins, which significantly increased their risk of malnutrition.

4.2 Introduction and background

Food and nutrition security exists when all people always have physical, social and economic access to sufficient, safe and nutritious food and they are able to adequately utilize and absorb the nutrients in the food in order to live a healthy and active live (FAO 2008). In developing countries, the failure to achieve adequate nutrition is aggravated by basic, underlying and immediate factors which contribute to the causes of child malnutrition (UNICEF 1990). The basic causes of malnutrition, namely limited access to resources and environmental technology, cultural beliefs, religion and tradition together with the underlying causes such as household food insecurity, inadequate maternal and child care, poor sanitation, inadequate health services and lack of information all contribute to the immediate causes of malnutrition which are associated with inadequate dietary intake and disease related factors (UNICEF 1990).

During the first two years of life, children are prone to growth faltering and micronutrient deficiencies. The nutritional vulnerability in this period is due to poor breastfeeding and complementary feeding practices coupled with high rates of infectious diseases (Aggarwal *et al.* 2008; Kuriyan and Kupad 2012). Exclusive breastfeeding is sufficient for the first six months of life but after six months, exclusive breastfeeding or other forms of breast-milk substitutes alone are not sufficient to meet the nutritional requirements of a growing child (WHO 2012). Therefore, the World Health Organization (WHO) recommends the introduction of safe and nutritious complementary foods to children after six months of age. Unfortunately, regardless of the WHO recommendation and the mandate of Section 28 (1) of the South African constitution, which states that every child has a right to adequate food (The constitution of the republic of SA 1996), most households in South Africa reportedly lack a variety of food for their children (Tshabalala 2014), thereby depriving them of their basic right to proper food.

Malnutrition is the leading cause of death during childhood, resulting in more than 33% of child deaths worldwide (WHO 2013). In sub-Saharan Africa there was an increase in the percentage of underweight children from 11.7% to 13.5% between 1990 and 2010 (Lutter *et al.* 2011). In 2011, 40% of children less than five years of age living in sub-Saharan Africa were stunted (UNICEF 2013). The South African National Health and Nutrition Examination Survey (SANHANES-1) conducted by the Human Sciences Research Council (HSRC), revealed that poor micronutrient status was common among South African children who are under 5 years of age. At a national level, vitamin A deficiency prevalence was 43.6%, anaemia prevalence was10.7%, iron depletion was 8.1% and iron deficiency anaemia was 1.9% (Shisana *et al.* 2014). The South African Department of Health reported that 17%, 6% and 3% of 1-5 years old children in Gauteng province were stunted, underweight and wasted respectively. In Limpopo province 24%, 12% and 4% of 1-5-year-old children were stunted, underweight and wasted respectively (DoH and UNICEF 2007). In addition, a high percentage of 1-5-year-old children in Limpopo province were deficient in vitamin A (76%) and iron (14%), compared to Gauteng where slightly fewer 1-5-year-old children were deficient in vitamin A (65%) and iron (10%) (DoH and UNICEF 2007). Studies conducted in Gauteng province reported that 18% of preschool children were stunted (Willey *et al.* 2009) and the prevalence of overweight and stunting were 14.1% and 16.5%, respectively (Symington *et al.* 2015). In Vhembe district, Limpopo province, several studies assessed the nutritional status of 3-5-year-old children. One study reported 24.4% of 3-5-year-old children to be stunted (Mushaphi *et al.* 2008), while the prevalence of wasting, stunting and underweight was reported to be 1.4%, 18.6% and 0.3%, respectively. The prevalence of zinc deficiency and anaemia were 42.6% and 28.5%, respectively (Motadi *et al.* 2015).

Several studies have assessed the food and nutrition security status of children, but the focus has been on the age ranges 1-5 years and 3-5 years. There is limited or no reported data on the food access and nutritional status of children aged 7-12 months. As stated earlier, this is a critical period, because complementary feeding is generally initiated within this age category. More so, there is often the misperception that food and nutrition insecurity is applicable to rural communities only. Baseline data of the food and nutrition security status of children in the two study areas was deemed important as it could guide nutrition interventions targeting children aged 7-12 months. Therefore, the study assessed the food and nutrition security and the nutritional status of children aged 7-12 months in rural and peri-urban communities of Lebowakgomo, Limpopo province and Hammanskraal, Gauteng province, respectively.

4.3 Research methodology

4.3.1Research technique and sampling technique

A mixed research methodology was used for the study, i.e. both quantitative and qualitative methods were used. A mixed research methodology is used to answer research questions which a single methodology cannot answer (Tedlie and Tashokkori 2009). This methodology was considered appropriate for this study because the study aimed to find answers for a variety of questions, which included socio-economic, psychological and technical questions.

To gain entry into the community's *of* Stinkwater Township in Hammanskraal, Gauteng province and Ga-Mphahlele village in Lebowakgomo, Limpopo province, the researcher arranged meetings with community councillors from both study areas to seek permission to conduct the study. The researcher was assigned a community leader who acted as a gate keeper and assisted with the organising of venues for the initial meeting. A questionnaire was administered to 212 mothers (106 from Lebowakgomo and 106 from Hammanskraal). A 95% confidence level was considered as significant. The mothers were recruited using purposive sampling. Purposive sampling is the deliberate choice of an informant due to the qualities the informant possesses (Cochran 2007; Teddlie and Yu 2007). The criteria for including participants in the study was that they were mothers of children aged 7-12 months and were easy to contact and willing to participate in a study. Six focus group discussions (FGDs) were conducted per study area, the participants of the focus group discussion were recruited on a voluntary basis from the survey participants; each focus group was made up of 12 mothers because the recommended size for a focus group discussion is 8-12 individuals (Tedlie and Tashokkori 2009).

4.3.2 Data collection procedure

4.3.2.1 Survey

Prior to the main survey, a pilot study was conducted with the purpose of detecting and correcting any methodological problems related to the survey. Ten mothers participated in the pilot study. The outcome of the pilot study was the modification of some of the survey questions. The English version of the questionnaire (Appendix B) was translated into Sepedi (Appendix C) by a translator who is proficient in both languages. The questionnaire was made up of three sections: Section 1 enquired about the mothers' and their children's demographic data, including child feeding practises; Section 2 assessed the food security status of the children; and Section 3 assessed the nutritional quality of the children's diet and the prevalence of underweight children.

Section 1: Demographic data

This section captured the general demographic profile of the children including child feeding practises and the socio-demographic profile of the mothers.

Section 2: Food security assessment

The Children Food Insecurity Access Scale (CFIAS) was used to assess the food security status (access) of children aged 7–12 months. The Household Food Insecurity Access Scale (HFIAS) (Coates *et al.* 2007) was adjusted to accommodate children, resulting in the CFIAS. HFIAS measures three domains of food insecurity (access), *viz.* anxiety and uncertainty about food supply, insufficient food quality, and insufficient food quantity. The CFIAS used in this study measured the same aspects, but at an individual level. This approach was found appropriate because children receiving complementary food have unique and individual-level food access experiences, influenced by their age and developmental stage. The CFIAS consisted of nine occurrence questions that represented an increasing level of severity of food insecurity (access), and nine frequency-of-occurrence questions that were asked as follow-up to each occurrence question, to determine how often the condition occurred. Using a 30-day recall, mothers were requested to recall whether they had experienced any anxiety and uncertainty about food supply, and if there had been insufficient quality and quantity of food consumption by their children. The mothers were first asked an occurrence question in relation to whether the condition in the question had happened in the previous four weeks. For those mothers who answered "yes" to an occurrence question, a frequency-of-occurrence question was then asked to determine whether the condition had happened rarely (once or twice), sometimes (three to ten times) or often (more than ten times), in the previous four weeks. The frequency-of-occurrence question was omitted for those mothers who reported that the condition described in the corresponding occurrence question was not experienced in the previous 30 days.

Section 3: Nutritional status assessment

The Individual Dietary Diversity Score (IDDS) together with the unquantified food consumption frequency survey were used as a proxy measure of the nutritional quality of the children's diet. This method has been used successfully previously (Faber and Benade 2007). Mothers were asked to recall all the foods consumed by their children in the previous 24 hours, both inside and outside of the home. Mothers were asked a series of "yes" or "no" questions. In addition, mothers were asked to recall how frequently each food group was consumed by their children, in the previous 30 days.

In order to calculate anthropometric indices which were useful in determining the nutritional status of children (prevalence of underweight children), the age and weight of the children were obtained from the child's health card. Mothers were requested to bring their child's health card on the day of the survey, and with the caregiver's consent, trained field workers assisted with the recording of the child's weight and age from the health card onto the survey questionnaire.

4.3.2.2 Focus group discussions

A series of six focus group discussions were conducted per study area to determine caregiver's perceptions on child feeding practises and children's food access. The participants of the focus group discussion were recruited on a voluntary basis from the survey participants; each group was made up of 12 individuals. The focus group discussions were conducted following a focus group discussion guide which contained questions related to food access and child feeding practices. The focus group discussions were facilitated by trained field workers that were fluent in Sepedi. The focus group discussion guide was first formulated in English (Appendix D) and then translated into Sepedi (Appendix E). The researcher requested consent from mothers to use a digital video camera to record the discussion sessions, and the recorded data was transcribed into text. The transcribed text, together with hand written notes, were used to generate the main findings of the focus group discussions.

4.4 Validity and reliability of methods

The questions in the HFIAS and HDDS were modified to ask mothers whether their children either experienced any of the food insecurity conditions or consumed foods from different food groups. Hence, both IFIAS and IDDS were used in this study. Both the scores were first reviewed with a group of key informants in order to adapt the phrases, definitions and examples to the local context and to ensure that the questions were understood appropriately. Ten mothers who were not part of the survey participated in the pilot study. The questions were directed to mothers who were involved with food preparation for their children.

4.5 Data analysis

4.5.1 Children Food Insecurity Access scale (CFIAS)

The responses from the CFIAS were captured on the Statistical Package for Social Sciences (IBM SPSS), version 21. f Three types of indicators were calculated to help understand the characteristics of and changes in children's food insecurity (access). The correlation between the calculated indicators and mothers socio-demographic characteristics was determined. A value of ($p < 0.05$) was considered statistically significant. A brief description of how the three types of indicators were calculated is provided below.

<u>Indicator 1: Children's food insecurity access-related conditions</u>

Descriptive statistics were generated to determine the percentage of children experiencing the conditions at any level of severity.

<u>Indicator 2: Children's food insecurity access-related domains</u>

The three domains reflected in the CFIAS are anxiety and uncertainty, insufficient quality and insufficient food intake, and its physical consequences. The following equations were used to calculate the prevalence of children experiencing one or more behaviours in each of the three domains;

1. Anxiety and uncertainty

$$\frac{No.\ of\ mothers\ who\ answered\ "yes"\ to\ Q1}{Total\ No. of\ mothers\ who\ answered\ Q1} \times 100$$

2. Insufficient quality

$$\frac{No.\ of\ mothers\ who\ answered\ \text{"yes"}\ to\ Q2 + Q3 + Q4}{Total\ No. of\ mothers\ who\ answered\ Q2\ +\ Q3\ +\ Q4} \times 100$$

3. Insufficient food intake and its physical consequences

$$\frac{No.\ of\ motherswho\ answered\ \text{"yes"}\ to\ Q5 + Q6 + Q7 + Q8 + Q9}{Total\ No. of\ motherswho\ answered\ Q5\ +\ Q6\ +\ Q7\ +\ Q8\ +\ Q9} \times 100$$

Indicator 3: children's food insecurity access prevalence

The CFIAS prevalence categorizes children into four different levels of child food insecurity (access). These categories are food secure, mildly food insecure, moderately food insecure and severely food insecure. The following equations were computed on SPSS to categorise the children;

Category 1: Food secure

A child is food secure if [(Q1a=0 or Q1a=1) and Q2=0 and Q3=0 and Q4=0 and Q5=0 and Q6=0 and Q7=0 and Q8=0 and Q9=0]

Category 2: Mildly food insecure

A child is mildly food insecure if [(Q1a=2 or Q1a=3 or Q2a=1 or Q2a=2 or Q2a=3 or Q3a=1 or Q4a=1) and Q5=0 and Q6=0 and Q7=0 and Q8=0 and Q9=0]

Category 3: Moderately food insecure

A child is moderately food insecure if [(Q3a=2 or Q3a=3 or Q4a=2 or Q4a=3 or Q5a=1 or Q5a=2 or Q6a=1 or Q6a=2) and Q7=0 and Q8=0 and Q9=0]

Category 4: Severely Food insecure

A child is severely food insecure if [Q5a=3 or Q6a=3 or Q7a=1 or Q7a=2 or Q7a=3 or Q8a=1 or Q8a=2 or Q8a=3 or Q9a=1 or Q9a=2 or Q9a=3]

4.5.2 Nutrition security [Individual Dietary Diversirty Score (IDDS) and weight-for-age (WAZ)]

***IDDS and* Unquantified food frequency**

The Statistical Package for Social Sciences (IBM SPSS), version 21 for Windows was used to compute descriptive statistics; mainly the frequency of children consuming different food groups and food groups consumed in the previous 24 hrs.

WAZ

WHO Anthro version 3.2.2 for personal computers software using the Nutritional Survey (NS) module was used to record the anthropometric data of the children, and the WAZ scores were generated using the software. The software uses Z-score reference points which were adopted by the WHO from the National Centre for Health Statistics (NCHS) based growth curves (WHO 2009). The anthropometric data of the children (age and weight) was used to yield one measure of nutritional status which is expressed as Z-scores, namely, weight-for-age (WAZ). The prevalence of underweight children was classified into two categories namely severely underweight and underweight.

4.5.2 Focus group discussions

Focus group discussion recordings were transcribed and then translated into English immediately after each session. The transcripts were then subjected to content analysis, to identify and interpret key concepts and themes from the discussions. For each theme, supporting verbatim quotes were included.

4.6 Ethical considerations

The ethical approval to conduct the study was obtained from the University of KwaZulu-Natal, Humanities and Social Science Research Ethics Committee (HSS/1244/0150) (Appendix G). Approval to conduct the study in Hammanskraal was obtained from Tshwane Municipality issued by the councillor (Appendix G). The approval to conduct the study in Limpopo was obtained from Lebowakgomo municipality issued by the social development extension manager (Appendix H).

4.7 Results and discussion

4.7.1 Demographic profile of mothers and their children

The demographic profile of mothers and their children is shown in Table 4.1.

Table 4.1: Socio-demographic profile of mothers and their children

Variables	Hammanskraal (%)	Lebowakgomo (%)
Age of children		
7-8 months	50.0	75.5
9-10 months	30.2	15.1
11-12 months	19.8	9.4
Gender of children		
Female	58.5	47.2
Male	41.5	52.8
Breastfeeding		
Yes	53.8	86.8
No		
Breastfeeding type		
Partially	58.6	46.2
Predominantly	39.7	53.8
Initiation of complementary foods		
As early as 2-6 months	71.7	75.5
After 6 months	28.3	24.5
Failure to exclusively breastfeed for the first 6 months		
Milk insufficient	27.6	25.3
Age appropriate	30.2	29.1
Return to work	2.6	3.8
Child unwilling to suckle	10.7	10.1
Medical conditions	13.1	17.7
Child always crying	15.8	13.9
Age of mothers		
17-25 years	66	19.8
26-35 years	26.4	73.6
36-45 years	4.7	6.6
46-55	2.8	0
Marital status		
Single	88.7	90.6
Married	11.3	6.6
Widowed	0	2.8
Divorced	0	0
Level of Education		
No formal education	3.8	26.4
Primary	8.5	21.7
Secondary	78.3	45.4
Tertiary	9.4	6.6
Employment status		
Employed full time	0.9	2.8
Employed part-time	7.5	4.7
Unemployed	91.5	92.5
Household income per month		
Below R800	78.3	81.1
R801-R1500	14.2	15.1
R1501-R3500	3.8	1.9
Above R3500	3.8	1.9

Variables	Hammanskraal (%)	Lebowakgomo (%)
Household water source		
Communal tap	94.3	33
Both communal & household tap	5.7	17
River	0	27
Communal & river	0	14.2
Vegetable garden		
Yes	2.8	57.5
No	97.2	42.5
Fruit production		
Yes	31.1	63.2
No	68.9	36.8
Livestock		
Yes	3.8	48.5
No	96.2	51.5
Education on child feeding practices		
Radio	5.7	7.1
TV	10.4	2.9
Publc health facilities	47.2	65.7
Adult in household	8.5	22.9
None	28.2	1.4

A total of 212 mothers (n=106 from Hammanskraal and n=106 from Lebowakgomo) of children aged 7-12 months participated in the study. A high percentage of mothers from Hammanskraal were in the 17-25-year age category, whilst most Lebowakgomo mothers were in the 26-35 years age category. In both study areas, a minimal number of mothers had acquired employable skills from tertiary education. Consequently, a high percentage of the mothers were unemployed. Most mothers from both study areas reported a household income of less than R800 per month. It was revealed from focus group discussions (FGDs) that such income is sourced from government child grants as mothers had no other forms of financial support. Although agricultural inputs such as water were reported in the FGDs to be a major challenge, a high percentage of Lebowakgomo mothers were involved in agricultural activities compared to Hammanskraal mothers; agricultural activities were used as coping strategies during periods of financial stress.

All mothers reported that they received informal education on child feeding practises. Sources of information ranged from public health facilities, television, radio and adults in the households. Community health workers from public health facilities were the main source of child feeding information in both study area

Most of the mothers acknowledged that they breastfed their children on the day of the survey. The early initiation of breast feeding was evident in this study, 84.2% of Hammanskraal mothers and 87.1% of Lebowakgomo mothers initiated breastfeeding less than one hour after birth. FGDs revealed that those mothers who did not breastfeed their children substituted breast milk with formula milk. Mothers from both study areas revealed that most of them discontinued breastfeeding their children once they were two to three months of age, due to the breastfeeding challenges as reported in Table 4.2.

Table 4.2: The perceived benefits and challenges of breastfeeding by Hammanskraal and Lebowakgomo mothers

Question	Study area	Theme	Concept	Quotes
How important is breastfeeding?	Hammanskraal	Health status Socio-emotional aspect	Childs health Mother-child relationship	*"Breastfeeding makes our children to be strong and it prevents our children from becoming sick."* *"It gives child food, vitamins and nutrients."* *"Breast feeding helps create a strong bond between mother and child."*
	Lebowakgomo	Health status	Child's health	*"Breast fed children have strong bones, good memory and they are free from disease."* *"Breastfeeding prevents children from experiencing severe diarrhea."*
What are the challenges of breastfeeding?	Hammanskraal	Socio-economic aspect Physical aspect	Work Mother's weight Breast milk Pain	*"We need to work to provide for our families, this affects breastfeeding patterns."* *"Some of us loose or gain weight during breastfeeding and this is not good for our health."* *"If we do not have enough breast milk, health officials tell us to stop breastfeeding and try other alternatives."* *"The soreness of nipples is a major challenge during breastfeeding."*
	Lebowakgomo	Physical aspect Hygiene	Sickness Pain Childs Hygiene	*"Breast cancer restrict the trend of breastfeeding."* *"Nipples develop rash which becomes very sore when breastfeeding."* *"Children are exposed to poor hygiene as children are breastfed anytime, even before the mother takes a bath."*

Although various challenges were associated with breast feeding, mothers in Hammanskraal perceived breast feeding as beneficial for the child's health and developing an emotional bond between mother and child. Mothers in Lebowakgomo acknowledged the health of the child as the only major benefit of breastfeeding. The early introduction of solid food was evident in both study areas. Hammanskraal mothers (71.7%) and Lebowakgomo mothers (75.5%) started introducing complementary foods as early as two months of age.

The results on the early initiation of breastfeeding reported in this study are different to those reported in literature. Mothers have been reported to fail to initiate breastfeeding within one hour of birth due to operative obstetrical intervention (Chien and Tai 2006; Meedya *et al.* 2010; Saeed *et al.* 2011). Other studies have reported that mothers and their children become separated for a long time immediately after caesarean section, hence mothers are unable to breastfeed leading to poor maternal milk surge (Rowe-Murray 2002; Saeed *et al*. 2011). The findings on the challenges experienced by mothers during breastfeeding are consistent with those reported in the literature. Motee *et al.* (2013) reported that during breastfeeding, mothers encountered problems such as soreness of nipples, sickness and lack of breast milk supply. Similarly, other studies have reported women to encounter challenges such as cracked nipples and low milk supply (Gatti 2008; Shams 2011). In contrast, Motee *et al.* (2013), Gatti (2008) and Shams (2011) further reported challenges such as breast engorgement, back pain, fatigue and reluctance of child to suckle. However, employment, physical appearance and child's hygiene were not reported as challenges, as indicated in this study. Nevertheless, the findings on the early initiation of breastfeeding are encouraging as early initiation of breastfeeding has been associated with increased breastfeeding success and establishment of milk production (Faber and Benade 2007). Unfortunately, the early discontinuation of breast feeding by mothers as reported in this study increases the risk of infectious diseases, since breast milk has been reported to decrease the incidence and severity of a wide range of infectious diseases (Chantry *et al.* 2006). The continued breastfeeding by most mothers and the early initiation of breastfeeding in both study areas reflects the contribution of education on breastfeeding practices, influenced by cultural feeding practises which are enforced by elders in the household, public health facilities and the media, as reported in Table 4.1.

The results on the early introduction of complementary food reported in this study are similar to those reported in literature; studies in South Africa have reported the early introduction of solid foods by mothers (Kruger and Gericke 2003; Faber and Benade 2007; Mushaphi *et al.* 2008; Gooseen *et al.* 2014). Similar trends have also been reported in other developing countries with similar socio-economic status (Yotebieng *et al.* 2013, Rahman *et al.* 2009, Ulak *et al.* 2012). According to World Health Organization recommendations, mothers should only provide breast milk to their children in the first six months of life, since breast milk alone can improve the child's survival by protecting the child against morbidity and mortality, whilst providing nutritional and psychosocial benefits (WHO 2012).

However, the majority of mothers from both Hammanskraal and Lebowakgomo failed to adhere to the WHO recommendations of exclusive breastfeeding for six months and initiating complementary foods from six months of a child life. Only 28.3% of Hammanskraal mothers and 24.5% of Lebowakgomo mothers adhered to the WHO recommendations. 'Insufficient milk' and mothers 'felt it was the right age for their child to consume solid foods' were the major reasons as to why mothers failed to exclusively breastfeed their children for the first 6 months of life. FGDs confirmed that mothers initiated complementary feeding early because "*we do not have enough breast milk, we are forced to give our children other foods*"; "*children are always crying and not sleeping, this is a sign of hunger*" and *"Some children don't want breast milk, we cannot leave them to starve".* Although trained health care workers were the main source of child feeding information, various inappropriate child feeding practises were identified in both study areas namely lack of exclusive breast feeding and early introduction of solid foods. The early introduction of complementary foods and early discontinuation of breastfeeding should be addressed. Mothers from both study areas should be encouraged to continue breastfeeding while providing a variety of complementary foods for their children at the right time, as recommended by the WHO.

4.7.2 Children's complementary food insecurity access-related conditions, domains and prevalence

Mothers from both study areas acknowledged that they experienced food insecurity access-related conditions (Table 4.3) and food insecurity access-related domains (Table 4.4). Consequently, high levels of food insecurity (access) were observed in both study areas (Figure 4.1).

Table 4.3: Percentage of Hammanskraal and Lebowakgomo children who experienced each food insecurity access-related condition

Conditions	Children who experienced each condition (%)		Frequency of occurrence (%)							
			Never		Once/twice		Three to ten times		More than ten times	
	HNS	LBM	HNS	LBM	HNS	LBM	HNS	LBM	HNS	LBM
Mothers who were anxious and uncertain about accessing enough food for their children	72.6	92.5	27.4	7.5	32.1	41.5	33.0	38.7	7.5	12.3
Mothers who were not able to feed their children the preferred kinds of food	69.8	92.5	30.2	7.5	28.3	38.7	34.0	41.5	7.5	12.3
Mothers who fed their children a limited variety of food	78.3	88.7	21.7	11.3	32.1	41.5	44.3	38.7	1.9	8.5
Mothers who fed their children foods that were not preferred at the time	70.7	84.0	29.0	16.0	31.1	41.5	23.6	25.5	16.0	17.0
Mothers who fed their children a smaller meal	60.4	77.4	39.6	22.6	19.8	37.7	30.2	29.2	10.4	10.4
Mothers who fed their children fewer meals in a day	66.0	80.2	34.0	19.8	17.0	32.1	47.2	39.6	1.9	8.5
Mothers who experienced complete lack of food to feed their children	70.8	82.1	29.2	17.9	30.2	38.7	34.9	32.1	5.7	11.3
Mothers who let their children go to sleep at night hungry	51.9	77.4	48.1	22.6	26.4	38.7	18.9	26.4	6.6	12.3
Mothers who never fed their children any complementary food the whole day and night	44.3	57.5	55.7	42.5	17.0	31.1	24.5	23.6	2.8	2.8

HNS – Hammanskraal; LBM - Lebowakgomo

Table 4.4: Food insecurity access-related domains; percentage of Hammanskraal and Lebowakgomo children who experienced each food insecurity access-related domain

Hammanskraal	**Lebowakgomo**
Domain 1: Anxiety and uncertainty about food supply	
$\frac{\text{No. of mothers who answered "yes" to Q1}}{\text{Total No. of mothers who answered Q1}} \times 100$ $\frac{72.6}{106} \times 100$ =68.5%	$\frac{\text{No. of mothers who answered "yes" to Q1}}{\text{Total No. of mothers who answered Q1}} \times 100$ $\frac{92.5}{106} \times 100$ =87.2%
Domain 2: Insufficient food quality	
$\frac{\text{No. of mothers who answered "yes" to Q2 + Q3 + Q4}}{\text{Total No. of mothers who answered Q2 + Q3 + Q4}} \times 100$ $\frac{74 + 83 + 75}{318} \times 100$ = 72.9%	$\frac{\text{No. of mothers who answered "yes" to Q2 + Q3 + Q4}}{\text{Total No. of mothers who answered Q2 + Q3 + Q4}} \times 100$ $\frac{92.5 + 88.7 + 84}{318} \times 100$ = 83.4%
Domain 3: Insufficient food quantity	
$\frac{\text{No. of mothers who answered "yes" to Q5 + Q6 + Q7 + Q8 + Q9}}{\text{Total No. of mothers who answered Q5 + Q6 + Q7 + Q8 + Q9}} \times 100$ $\frac{64 + 70 + 75 + 55 + 47}{530} \times 100$ = 58.6%	$\frac{\text{No. of mothers who answered "yes" to Q5 + Q6 + Q7 + Q8 + Q9}}{\text{Total No. of mothers who answered Q5 + Q6 + Q7 + Q8 + Q9}} \times 100$ $\frac{77.4 + 80.2 + 82.1 + 77.4 + 57.5}{530} \times 100$ = 70.7%

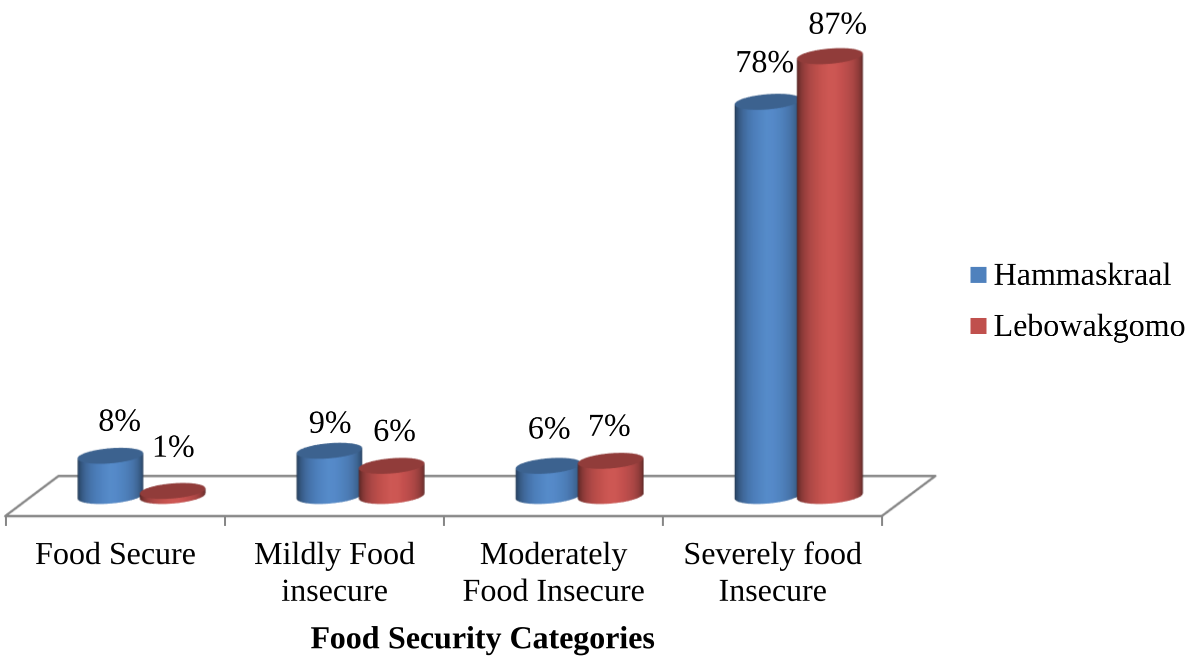

Figure 4.1: Hammanskraal and Lebowakgomo children's food security categories

In Hammanskraal, mothers were anxious and uncertain about food supply for their children (68.5%) and fed them inadequately, with respect to both quality (72.9%) and quantity (58.6%). On the other hand, Lebowakgomo mothers were also anxious and uncertain about food supply for their children (87.2 %) and fed them inadequately, in terms of both quality (83.4%) and quantity (70.7%). The high level of anxiety and uncertainty about food supply could be attributed to the fact that many mothers were unemployed as described in Section 4.7.1. Consequently, this limited their ability to provide their children with a diversified diet. FGDs indicated that government child grants were the main source of income for mothers in both study areas and agricultural activities were used as a coping strategy during periods of financial stress. The findings of this study suggest that a decrease in household per capita income and limited utilization of agricultural produce when preparing complementary foods, increased the level of anxiety and uncertainty about supply of adequate quality food ($p < 0.05$). Similarly, a previous study found that limited production coupled with low income increased the tendency of households to pursue diets (including children's diets) that were inadequate in both quantity and quality (Chingondole 2006).

4.7.3 Food consumption frequency, Individual Diet Diversity Score (IDDS) and Weight-for-Age (WAZ) as measures of nutritional quality of Hammanskraal and Lebowakgomo children's diet and nutritional status of the children.

Mothers acknowledged that various food groups were rarely consumed by the children. (Table 4.5). It was also revealed from the FGDs that the economic access to complementary foods was a major challenge for mothers in both study areas; consequently, the majority of the children had not consumed various food groups in the previous 24 hours (Figure 4.2). Poor food consumption patterns could account for the prevalence of underweight in Hammanskraal and Lebowakgomo children, which can be seen from the results in Table 4.6.

Table 4.5: The intake of food items by 7–12-month-old children as determined by an unquantified food frequency questionnaire administered in two communities (Hammanskraal and Lebowakgomo)

Food Items	Most Days (%)	Once a Week (%)	Seldom (%)	Never (%)
Cereals/Starches				
Bread	23.6[a](5.7)[b]	7.5(2.8)	10.4(6.6)	57.5(84.9)
Maize meal porridge-Soft	86.8(88.7)	4.7(4.7)	3.8(4.7)	3.8(1.9)
Maize meal porridge-Stiff	25.5(25.5)	8.5(11.3)	17.9(21.7)	47.2(41.5)
Maize meal porridge-Fermented	17.0(29.2)	10.4(12.3)	9.4(17.9)	62.3(40.6)
Cooked porridge other than maize meal	34.0(45.3)	10.4(8.5)	5.7(10.4)	49.1(35.8)
Infant Cereal	29.2(4.7)	11.3(0)	7.5(6.6)	50.9(8.7)
Rice	14.2(0)	16(0)	3.8(0)	65.1(0)
Potato	41.5(13.2)	17.9(41.5)	6.6(8.5)	33(36.8)
Dairy products				
Fresh milk	16(0)	8.5(0)	8.5 (3.8)	66(96.2)
Milk powder	32.1(15.1)	11.3(8.5)	5.7(11.3)	50(65.1)
Yoghurt	26.4(0)	11.3(0)	19.8(15.1)	41.5(84.9)
Animal foods				
Red Meat	1.9(6.6)	11.3(0)	1.9(2.8)	84(90.6)
Chicken	11.3(2.8)	6.6(0)	0.9(3.8)	80.2(93.4)
Fish	8.5(0)	7.5(0.9)	6.6(6.6)	76.4(92.5)
Eggs	21.7(11.3)	2.8(7.5)	9.4(0.9)	65.1(80.2)
Legumes				
Beans	1.9(8.5)	8.5(6.6)	8.5(17.0)	80.2(67.9)
Peanut butter	41.5(17.0)	10.4(1.9)	10.4(13.3)	36.8(68.9)
Vegetables				
Butternut	21.7(11.3)	15.1(6.6)	16(16.0)	46.2(66.0)
Carrots	17(3.8)	9.4(2.8)	6.6(6.6)	66.0(86.8)
Dark-green leafy vegetables	6.6(27.4)	7.5(9.4)	5.7(16.0)	79.2(47.2)
Cabbage	8.5(12.3)	12.3(5.7)	2.8(7.5)	75.5(74.5)
Tomato	16(31.1)	2.8(9.4)	2.8(10.4)	77.4(62.3)
Fruits				
Apple	12.3(6.6)	8.5(0)	6.6(13.2)	71.7(80.2)
Banana	16.0(31.1)	4.7(9.4)	12.3(17.9)	66(41.5)
Orange	17.9(22.6)	9.4(10.4)	9.4(12.3)	62.3(54.7)
Miscellaneous				
Sugar	54.7(39.6)	18.9(17.9)	6.6(10.4)	18.9(32.1)
Biscuits	24.5(16)	11.3(12.3)	22.6(18.9)	40.6(52.8)
Sweets	20.8(22.6)	12.3(11.3)	21.7(16.0)	44.3(50.0)
Savoury snacks	13.2(14.2)	21.7(16.0)	19.8(14.2)	45.3(55.7)
Carbonated drinks	11.3(0.9)	10.4(0)	16.0(22.6)	61.3(76.4)

Food Items	Most Days (%)	Once a Week (%)	Seldom (%)	Never (%)
Concentrated Juice	67.9(58.0)	12.3(12.3)	5.7(10.4)	13.2(22.6)
Tea	67(54.7)	5.7(6.6)	7.5(14.2)	18.9(24.5)
Coffee	3.8(0.9)	1.9(1.9)	1.9(97.2)	91.5(97.2)

[a]Hammanskraal

[b]Lebowakgomo.

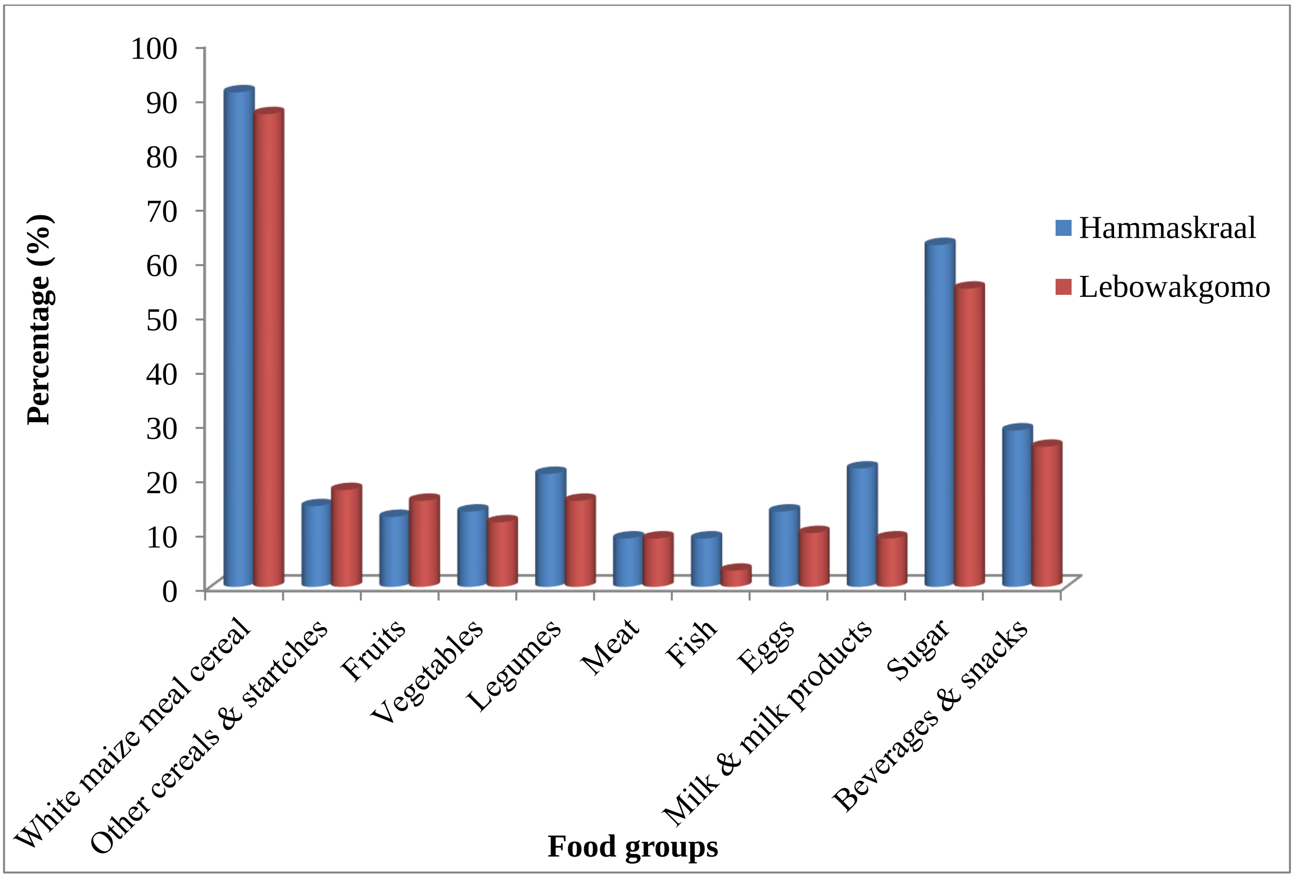

Figure 4.2: Food groups consumed by Hammanskraal and Lebowakgomo children determined using a 24hr recallperiod

Table 4.6: The prevalence of underweight children in Hammanskraal and Lebowakgomo determined by WAZ

Age Groups (Months)	n	Severely Underweight (<−3SD) %	Underweight (<−2SD) %	WAZ (SD)
Hammanskraal				
7–8	53	13.2	34.0	−1.04 (1.81)
9–10	32	31.3	34.4	−0.95 (2.35)
11–12	21	9.5	19.0	−0.95 (1.14)
7–12	106	17.9	31.1	−0.99 (1.9)
Lebowakgomo				
7–8	80	22.5	38.8	−1.12 (2.32)
9–10	16	31.6	43.8	−1.99 (2.09)
11–12	10	20.0	30.0	−1.09 (1.99)
7–12	106	23.6	38.7	−1.25 (2.26)

SD= Standard Deviation
WAZ= Weight-for-age scores

The results from the IDDS and the unquantified food consumption frequency survey show that children were generally fed monotonous diets, which were based mainly on starchy and sugary foods, such as soft porridge, sugar, concentrated juice and tea with sugar. FGDs revealed that household food baskets in both study areas were composed of energy rich foods as they were perceived to be more affordable and filling compared to fruits, vegetables and meat products, which were more expensive. Mothers indicated in the FGDs that in order to prepare complementary foods for children, ingredients were sourced from the household's food basket. White maize meal (WMM) formed a starch base of almost all the complementary meals given to children during breakfast, lunch and supper. Similarly, other studies have found white maize the dominant base ingredient for complementary foods (Kruger and Gericke 2003; Faber and Benade 2007; Goosen *et al.* 2014).

WMM was sourced from commercial markets, mothers from Hammanskraal preferred super-sun maize meal produced by premier manufacturer while mothers from Lebowakgomo preferred Magnifisan produced by VKB milling manufacturer. The most common complementary food in Hammanskraal and Lebowakgomo was white maize meal soft porridge and the recipe was similar (Appendix I). WMM Soft porridge was given to children during any time of the day; other ingredients such as sugar, milk powder (powdered formula milk or coffe creamers), margarine or peanut butter were added to white maize soft porridge to "*enhance taste*". Stiff porridge prepared with WMM, together with household relish of the day or with diluted liquid milk were usually given to children as supper. Savoury maize snacks, sweets, juice and tea were consumed in-between the main meals. The argument made by Tshabalala (2014) that households in South Africa do not provide their children with a variety of nutritious food is also evident in the findings of this study.

Unfortunately, white maize is high in starch and limited in micronutrients (Faber and Benade 2007). As a result, complementary foods made with unfortified white maize as the main solid food, such as soft maize porridge, is generally adequate in energy, fibre and B-vitamins, but deficient in protein and minerals such as iron, calcium and zinc (Raboy 2007; Duvenage and Schonfeldt 2007). Although mothers in the current study indicated that other ingredients such as sugar, milk powder, margarine or peanut butter were added to white maize soft porridge, the porridge may still be nutritionally deficient as the nutrients may be reduced by over cooking and over dilution of ingredients. The predominant consumption of cereal grain foods and energy-rich foods such as sugar, sweetened tea and concentrated juice, coupled with the limited consumption of fortified commercial foods, fruits, vegetables and meat products is likely to increase the risk of micronutrient deficiencies. Consumption of fruits and vegetables has been associated with reduced risk of several chronic diseases later in life (Van-Duyn and Pivonka 2000). The Child Health Study Group (2009) recommends that caregivers should gradually include a variety of fruits and vegetables in the diets of children because good health begins in childhood and children are vulnerable to malnutrition (Child Health Study Group 2009). In addition, meat has been recommended for children because it is a major source of bioavailable nutrients, including zinc and iron (WHO 2003; PAHO/WHO 2003).

The inadequacy of food variety and quality for children observed in this study could account for the generally poor WAZ scores, which were observed in different age groups of both male and female children in both study areas. In both study areas, a high prevalence of severely underweight and underweight children was observed in the 9-10-month age group. A high prevalence of underweight and severely underweight children in all the age groups was observed in Lebowakgomo. This could be attributed to the fact that mothers in Lebowakgomo were more anxious and uncertain about food supply and fed their children inadequately with respect to both quality and quantity, compared to Hammanskraal mothers. Approximately

87.7% of Hammanskraal mothers and 52% of Lebowakgomo mothers had completed secondary and post-secondary education. The mothers also indicated that health care centres were the major providers of children's nutrition education in Hammanskraal (47.2%) and Lebowakgomo (65.7%). However, the current study findings which indicate poor dietary intake suggest that the likelihood of children being fed adequately does not necessarily increase with the level of education, or provider of children's nutrition education.

4.8 Conclusion

The study shows that child feeding practices in Hammanskraal and Lebowakgomo were inappropriate; mothers discontinued breastfeeding and initiated complementary feeding early. High rates of severely food insecure (access) children were observed in both study areas, this contributed to the prevalence of underweight and severely underweight children. Overall, the children's diets (complementary foods) were characterised by inadequacy in both quantity (variety) and quality. These findings provide insight for developing comprehensive and user-friendly food consumption guidelines for these population groups and other population groups of similar socio-economic status. Strategies should be developed to address inappropriate feeding practices through the implementation of programmes aimed at empowering mothers with knowledge on dietary diversity, and which promote locally available, nutritious and safe complementary foods.

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CHAPTER 5 : THE EFFECT OF MORINGA LEAF POWDER ON THE NUTRITIONAL AND PHYTOCHEMICAL COMPOSITION OF COMPLEMENTARY WHITE MAIZE SOFT PORRIDGE

5.1 Abstract

This study determined the effect of Moringa leaf powder (MLP) on the nutritional quality and health promoting-potential of a traditional complementary food (white maize soft porridge). A recipe used by mothers from Hammanskraal and Lebowakgomo, was modified by substituting maize meal with MLP at 1, 2 and 3% (w/w) levels. As MLP was increased from 0 to 3% in the Lebowakgomo white maize soft porridge, there was a significant increase in total mineral content: ash (from 0.52 to 0.87 g/100 g), calcium (0.01 to 0.09 mg/100 g), potassium (0.10 to 0.14 mg/100 g), protein (8.70 to 9.68 g/100 g), threonine (0.14 to 0.66 g/100 g), glutamine (1.28 to 1.56 g/100 g), provitamin A (0.81-1.16 µg/g), lutein (0.04-0.30 µg/g), zeaxanthin (0.21-2.18 µg/g), β-cryptoxanthin (0.11-0.14 µg/g), β-carotene (0.25-0.50 µg/g) and 9-cis-β-cryptoxanthin (0.25-0.31 µg/g). As for the Hammanskraal soft porridge, increasing MLP from 0 to 3% caused a significant increase in the levels of iron (from 52.50 to 101.0 mg/100 g), manganese (1.00 to 4.00 mg/100 g), phenylalanine (0.35 to 0.47 g/100 g), provitamin A (0.87-1.01 µg/g), lutein (0.05-0.22 µg/g), zeaxanthin (0.22-1.29 µg/g) and β-carotene (0.27-0.39 µg/g). Additionally, the antioxidant activity, total phenolic and flavonoid contents of the white maize soft porridges increased as the concentration of MLP was increased. Generally, the antioxidant activity, total phenolic and flavonoid contents of the white maize soft porridges increased as the concentration of MLP was increased. The findings indicate that MLP improves the nutritional and health-promoting properties of the traditional complementary white maize soft porridges studied.

5.2 Introduction and background

Cereal-based traditional complementary foods used in developing countries have been reported to be low in micronutrients and of poor protein quality. Almost all population groups in South Africa rely profoundly on white maize meal (WMM) as a food source. The maize meal is used to prepare several food forms, with complementary foods amongst the most popular (Kruger and Gericke 2003; Faber and Benadé 2007; Mushaphi *et al.* 2008; Goosen *et al.* 2014). The milling of maize into maize meal involves the removal of the outer layers and germ, which are rich in phytochemicals and nutrients, particularly micronutrients. This reduces the nutritional value and health-promoting potential of foods processed from the maize meal (Rana *et al.* 2014; Lee *et al.* 2007). Thus, dependency on maize-based complementary foods increases the risk of micronutrient deficiencies in children, which can lead to several health conditions, such as growth retardation and delayed cognitive development (Faber and Benadé 2007).

Several strategies have been implemented to address micronutrient deficiencies in South Africa including supplementation, food fortification, biofortification and dietary diversification (Labadorios *et al.* 2005; Swart *et al.* 2008). Unfortunately, several studies have reported on the shortcomings of these strategies. For instance, the distance between rural households and health facilities makes it difficult for children to receive vitamin A supplements (Smuts *et al.* 2008). Fortified food products are not accessible to children in rural communities due to physical and economic constraints (Horton 2006; Steyn *et al.* 2008). The sensory attributes of biofortified crops have been found unacceptable to consumers (Stevens and Winter-Nelson 2008; Pillay *et al.* 2011) and dietary diversification requires significant economic resources (Faber *et al.* 2013a; Faber *et al.* 2013b). There is a need to investigate and develop methods for improving the nutritional quality of cereal-based complementary foods using local botanical resources that are accessible, cost-effective and acceptable to consumers.

Various studies have reported on the nutritional quality of the Moringa plant (Bennett *et al.* 2003; Siddhuraju and Becker 2003; Fahey 2005; Anwar *et al.* 2007; Lako *et al.* 2007), its ability to adapt to different environmental conditions (Price 2000; Johnson 2005; Manzoor *et al.* 2007; Sreelatha and Padma 2009) and its ease of production and processing (Foidle *et al.* 2001; Fahey 2005; Adeyoye 2014). Moringa leaves are rich in minerals and various phenolic compounds (Bennett *et al.* 2003; Siddhuraju and Becker 2003; Lako *et al.* 2007), alkaloids, amino acids and proteins, and vitamins, including vitamin A precursors, especially β-carotene (Sarwatt *et al*. 2002; Soliva *et al.* 2005; Anwar *et al.* 2007; Lako *et al.* 2007). Numerous studies have confirmed the bioavailability of Moringa nutrients after human consumption, including thiamine, riboflavin and niacin (Girija *et al.* 1982), calcium (Pankaja and Prakash 1994), β-carotene (Nambiar and Seshadri 2001), and lutein (Pullakhandam and Failla 2007). Other authors have reported that the consumption of Moringa leaves led to enhanced immune response (Yang *et al.* 2006) and that the use of MLP as a dietary supplement was successful in rehabilitating severely malnourished children (Zongo *et al.* 2013). Therefore, MLP seems a suitable candidate for improving the nutritional quality and health-promoting potential of maize-based complementary foods.

While there are a number of publications on the nutritional quality and bioavailability of Moringa nutrients, it appears that thus far no published studies have investigated the effect of adding MLP to the nutritional quality and health-promoting potential of white maize-based complementary foods. The aim of the current study was to determine the effect of adding MLP on the nutritional composition, antioxidant activity and phytochemical content (total phenolics and flavonoids) of complementary WMM soft porridge.

5.3 Materials and methods

5.3.1 Maize meal and Moringa leaf powder samples

As discussed in section 4.7.3, the WMM popularly used in Hammanskraal (Hammanskraal white maize meal [HWMM]) (Super-sun, Premier manufacturer, South Africa) (Figure 5.1a) was purchased from local commercial markets around Hammanskraal and MLP (Figure 5.1b) was sourced from Phedisanang Moringa project in Hammanskraal, Gauteng Province, South Africa. Similarly, Lebowakgomo white maize meal (LWMM) (Magnifisan super, VKB milling manufacturer, South Africa) (Figure 5.1c) was purchased from local commercial markets around Lebowakgomo and MLP was sourced from Sedikong Sa Lerato Moringa Farm, Limpopo Province, South Africa (Figure 5.1d).

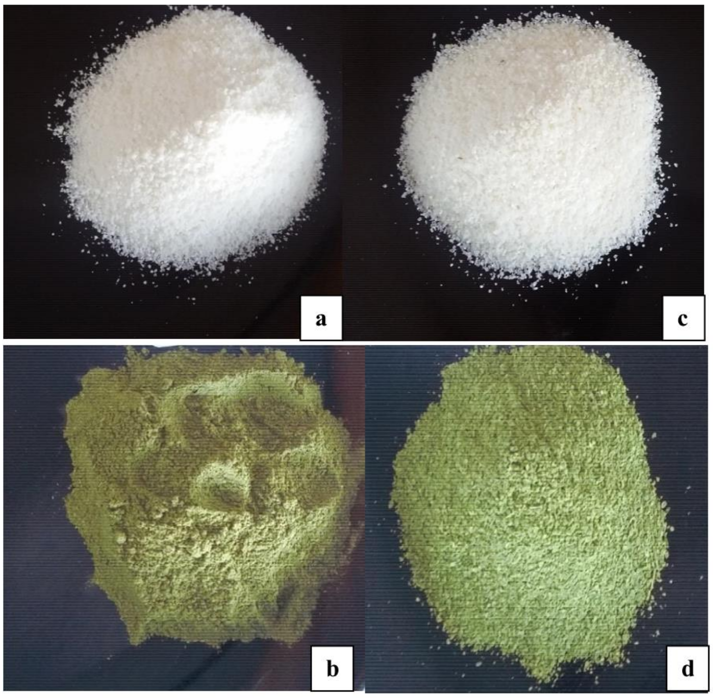

Figure 5.1: Hammanskraal white maize meal (a); Hammanskraal MLP (b); Lebowakgomo white maize meal (c) and Lebowakgomo MLP (d) used in the study

The two Moringa-producing projects were funded by the South Africa Department of Science and Technology (DST) and mentored by the Agricultural Research Council (ARC) to comply with the South African government for Good Agricultural Practices (GAPs). Fresh leaves were harvested from 12 weeks old plants, uniformly dried under the shade (25 ± 2°C) for 72 hours and then processed into powder using an agro-processing facility at ARC, Roodeplaat, South Africa.

5.3.2 Preparation of porridge samples

The control and test porridges were prepared following a recipe (Appendix I) for traditional complementary food used by mothers from Hammanskraal and Lebowakgomo. The recipe for a standard (traditional) complementary soft porridge was used to prepare the control, except that deionized water was replaced with tap water. The traditional recipe was as follows: 500 ml of deionized water was heated to a boiling point and 120 g of WMM was combined with 250 ml of deionized water in a bowl to make a smooth paste. The paste was then added to the boiling water and stirred until it was smooth. The mixture was left to cook for 20 minutes. To prepare test samples (Moringa-added soft porridges), white maize meal was mixed with MLP at 1, 2 and 3% w/w substitution levels. The cooked samples were cooled before freeze drying. The freeze-dried samples were ground into powder and stored in airtight containers until use.

5.3.3 Nutritional analysis of white maize meal, Moringa leaf powder and Moringa-added soft porridges

The nutritional composition of the samples was determined using standard methods; a brief description of each nutrient is given below:

5.3.3.1 Moisture

The moisture content of the samples was measured according to the official method 934.01 Association of Official Analytical Chemists (AOAC) (2003)

5.3.3.2 Fat

The fat content was analysed using soxhlet procedure following AOAC official method 920.39 (AOAC 2002). Petroleum ether was used for extraction. Percentage crude fat was calculated using the equation below.

$$\%\ \text{crude fat} = \frac{\text{Beaker} + \text{fat} - \text{Beaker}}{\text{Sample mass}} \times 100$$

5.3.3.3 Fibre

Fibre was determined as neutral detergent fibre (NDF). The fibre content of the samples was determined as the neutral detergent fibre (NDF). The NDF was determined following AOAC official method 2002.04 (AOAC 2002). The equation below was used to calculate NDF.

$$\% \text{ NDF} = \frac{(\text{crucible} + \text{dry residue}) - (\text{crucible} + \text{ash})}{\text{Sample mass}} \times 100$$

5.3.3.4 Ash

The ash was measured according to the AOAC official method 942.05 (AOAC 2003).

5.3.3.5 Individual minerals

The calcium, magnesium, manganese, zinc, iron, potassium, copper and phosphorus were analysed following the AOAC method 6.1.2 (AOAC 1984). The minerals were determined after dry ashing, the samples were freeze dried and ashed overnight at 550^{o}C, in a furnace.

5.3.3.6 Protein and Amino acids

The protein content was determined by the Dumas combustion method (AOAC official method 968.06) (AOAC 2002). The amino acid profile of the samples was analysed by the Pico-Tag method using a waters breeze High-Performance Liquid Chromotography (HPLC) with empower software. Samples (400 mg) were hydrolysed with 6 N HCI for 24 hours and then derivatized with phenylisothiocyanate (PITC) to produce phenyltiocarbamyl (PTC) amino acid, which were analysed by reverse phase HPLC.)

5.3.3.7 Provitamin A carotenoids

The provitamin A content was determined using a high performance liquid chromatography (HPLC) following procedures described by Lacker *et al.* (1999). The total pro-vitamin A concentration was calculated as β-carotene using the formula below.

Total pro-vitamin A = (all-trans+9-*cis*+13-*cis β-carotene* isomers) + 0.5(β-cryptoxanthin).

5.3.4 Phytochemical analysis and antioxidant activity of white maize meal, Moringa leaf powder and Moringa-added soft porridges

5.3.4.1 Extraction for phytochemical analysis and antioxidant activity

Ground samples of WMM, MLP and Moringa-added soft porridges were extracted (1:20 w/v) with 50% aqueous methanol in an ultrasonic water bath for 1 hour. The extracts were filtered under vacuum through Whatman's No. 1 filter paper. The extracts were then concentrated under pressure using a rotary evaporator set at 30°C and dried under a stream of air. Fresh extracts (in 50% aqueous methanol) were used in the phytochemical analysis, while the dried extracts were dissolved in 50% methanol to determine the concentrations for the antioxidantsassays.

5.3.4.2 Total phenolic content

Total phenolic content of the extracts was determined in triplicate using the Folin Ciocalteu (Folin C.) method as described by Makkar *et al*. (1990) with modifications (Ndhlala *et al*. 2007). Extracts (50 µl) were transferred into test tubes and made up to 1 ml with distilled water. Folin C. reagent (500 µl) and sodium carbonate (100 µl, 2% w/v) were added to the dilute sample. The mixtures were incubated for 40 minutes at room temperature and absorbance was measured at 725 nm using a spectrophotometer. Total phenolic concentrations were expressed as gallic acid equivalents (GAE), derived from a standard curve.

5.3.4.3 Flavonoid content

The flavonoid content of the extracts was determined in triplicate following a method described by Hagerman (2002) with modifications. Exactly 500 µl of each fresh extract (in 50% aqueous methanol) was made up to 1 ml with water in a test tube before adding methanol-HCI (2.5 ml) and vanillin reagent (2.5 ml) to the reaction mixture, 50% aqueous methanol was used as the blank. After 20 minutes of incubation at 30°C, absorbance was measured at 500 nm with a spectrophotometer. The number of flavonoids in the extracts was expressed as catechin equivalents, derived from a standard curve.

5.3.4.4 DPPH Radical Scavenging Activity (Antioxidant activity)

The DPPH radical scavenging assay was determined in triplicate following a method described by Karioti *et al.* (2004). Under dimmed light, each extract (15 µL) at different concentrations *viz.* 0.065, 0.26, 0.52, 1.04, 6.26, 12.5, 25 and 50 mg/ml was diluted with absolute methanol (735 µL) and added to a freshly prepared DPPH solution. The reaction mixtures were incubated at room temperature for 30 minutes and the absorbance was read at 517 nm using a spectrophotometer. A standard antioxidant (ascorbic acid) at varying concentrations, viz. 5, 10, 20, 40, 80 µM, was used as a positive control. A solution with the same chemicals, excluding extracts or standard antioxidants, and with absolute methanol served as the negative control. The assay was repeated twice. The free radical scavenging activity (RSA), as determined by the decolouration of the DPPH solution, was calculated according to the formula:

$$\text{RSA (\%)} = \left\{1 - \left(\frac{\text{Abs}_{517\text{ nm}}\ \text{Sample}}{\text{Abs}_{517\text{ nm}}\ \text{Neg Control}}\right)\right\} \times 100$$

Abs517 sample is the absorbance of the reaction mixture containing the extract or positive control solution, and Abs517 Neg control is the absorbance of the negative control. The EC50 (effective concentration) values, representing the amount of extract required to decrease the absorbance of DPPH by 50% was calculated from the percentage radical scavenging activity.

5.4 Data analysis

The Statistical Package for Social Sciences (IBM SPSS) version 21 for Windows was used to analyse quantitative data. The data were analysed using analysis of variance (ANOVA). Comparison of two means was perfomed using independent samples t-test and comparison of multiple means was performed using Tukey test. A p-value of < 0.05 was considered statistically significant.

5.5 Results and discussion

5.5.1 Effect of Moringa leaf powder on the nutritional composition of complementary white maize soft porridge

The levels of moisture and total mineral content (ash) of Hammanskraal MLP were significantly higher than those in Lebowakgomo MLP. There was no significant difference in the levels of fat and NDF (Table 5.1). Fuglie (2001) reported moisture content of 7.5 g/100 g MLP; this is similar to the moisture content of Hammanskraal MLP and different to the moisture content of Lebowakgomo MLP. The difference in moisture content could be attributed to different processing methods used.

There was no significant difference in the total mineral content (ash), fat and NDF content of Lebowakgomo and Hammanskraal WMM. Only the moisture content was significantly different between the two maize meal types. The NDF levels of both maize meal types reported in this study were higher than those reported by Johnson (2000) *viz.* maize meal was reported to contain 3.0/100 g of NDF. The fat and ash contents of both maize meal types were lower than those reported in the literature. Johnson (2000) found higher amounts of fat (4.1 g/ 100 g) and ash (4.1 g/ 100 g).

The addition of MLP in WMM porridge samples did not have a significant effect on the moisture, fat and NDF content of Hammanskraal and Lebowakgomo WMM porridge. Only a significant increase in the ash content of Lebowakgomo white maize soft porridge was observed when 3% MLP was added to the porridge.

Table 5.1: Nutritional composition of Hammanskraal and Lebowakgomo Moringa based complementary soft porridge compared to the control, white maize soft porridge

	Moisture g/100 g	**Ash[c] g/100 g**	**Fat g/100 g**	**NDF g/100 g**
Moringa leaf powder				
Lebowakgomo	**6.80±0.23**	**11.16±0.08**	7.68±0.82	37.98±6.96
Hammanskraal	**7.75±0.13**	**16.80±0.08**	4.89±3.29	41.93±2.66
Maize meal				
Lebowakgomo	**12.59±0.13**	0.52±0.07	2.48±0.42	9.59±4.45
Hammanskraal	**10.56 ± 0.16**	0.37±0.12	1.55±0.17	10.39±2.58
Lebowakgomo SP				
1% Moringa	1.39 ± 0.05d	0.57±0.35d	1.43±0.16d	21.36±6.17d
2% Moringa	1.56± 0.30d	0.65±0.00d	1.63±0.25d	17.71±5.95d
3% Moringa	1.14±0.78d	0.87±0.57e	3.18±1.15d	16.13±4.46d
Control	1.78±0.18d	0.52±0.01d	1.42±0.45d	19.24±2.70d
Hammanskraal SP				
1% Moringa	3.06±1.17g	0.52± 0.15g	1.99±1.32g	24.85±8.27g
2% Moringa	2.27±1.01g	0.76± 0.14g	2.10±0.92g	21.90±3.34g
3% Moringa	1.64±0.12g	0.86±0.03g	4.19±4.62g	22.59±8.22g
control	2.44±0.37g	0.46±0.16g	1.69±0.95g	19.66±3.86g

NDF= Neutral Detergent Fibre
SP= Soft porridge
Mean ± standard deviation
[c]Total mineral content
Values in bold within same column are significantly different at $p<0.05$ according to the Independent Samples t-test.
Values within the same column with different letters are significantly different at $p<0.05$ according to the Tukey test.

Protein and amino acid

The effect of MLP on the protein and amino acid content of white maize soft porridge are shown in Table 5.2 and Table 5.3.

The results show appreciable protein levels of MLP, which is in agreement with the findings of Fuglie (2005). The protein content of Lebowakgomo MLP was significantly higher than that of the Hammanskraal MLP. The Lebowakgomo MLP had significantly higher contents of non-essential amino acids, namely serine, arginine and glutamine. There was no significant difference in the protein, essential amino acid and non-essential amino acid contents of Hammanskraal and Lebowakgomo WMM. The protein content of both maize meal types reported in this study was higher than those reported by Johnson (2000) viz., 8.7 g/100 g. However, the protein values of this study are similar to those reported by Machida *et al.* (2010) who obtained 8.9 g/100 g to 10.5 g/100 g in WMM.

The addition of MLP in WMM porridge samples seems to have improved the protein content of the porridges. The protein, essential amino acid and non-essential amino acid contents of the Moringa-added porridges increased with increasing levels of the MLP. A significant increase in the protein content of Lebowakgomo Moringa-added porridge was observed when 3% of MLP was added. The addition of 2% and 3% MLP significantly increased the threonine content of the porridge, and the glutamine content significantly increased when 3% of Moringa was added. In contrast, the addition of 1, 2 or 3% MLP did not have a significant effect on the protein content of Hammanskraal Moringa-added porridges. Only a significant effect was observed in the phenylalanine content of the Moringa-added porridge when 2 and 3% of MLP was added. This could be because the protein content of Lebowakgomo MLP was significantly higher than that of the Hammanskraal MLP.

Table 5.2: Protein and essential amino acid composition of Hammanskraal and Lebowakgomo Moringa based porridges (g/100 g)

	Protein	Histidine	Threonine	Lysine	Tryptophan	Methionine	Valine	Isoleucine	Leucine	Phenylalanine
Moringa leaf powder										
Lebowakgomo	**30.40±0.75**	0.57±0.00	1.54±0.37	1.13±0.60	1.07±0.10	0.22±0.02	1.35±1.2	3.76±0.05	1.99±0.08	1.57±0.02
Hammanskraal	**24.53±0.49**	0.49±0.10	2.06±1.59	1.12±0.08	1.01±0.08	0.26±0.01	1.27±0.02	4.34±0.61	1.93±0.07	1.57±0.22
Maize meal										
Lebowakgomo	9.07±0.21	0.14±0.07	1.37±0.49	0.05±0.047	0.29±0.04	0.12±0.00	0.30±0.11	1.60±0.05	1.03±0.34	0.28±0.12
Hammanskraal	8.91±0.29	0.17±0.01	0.27±0.15	0.12± 0.01	0.29±0.04	0.18±0.60	0.43±0.04	2.28±1.54	1.41±0.21	0.68±0.02
Lebowakgomo SP										
1% Moringa	8.84±0.19d	0.21±0.02d	0.22±0.02d	0.98±0.02d	0.39±0.04d	0.07±0.01d	0.39±0.00d	1.34±0.02d	1.37±0.04d	0.47±0.08d
2% Moringa	9.19±0.01de	0.22±0.00d	0.65±0.01e	0.12±0.00d	0.42±0.04d	0.11±0.01d	0.35±0.03d	1.77±1.43d	1.36±0.07d	0.46±0.22d
3% Moringa	9.68±0.35e	0.28±0.07d	0.66±0.03e	0.11±0.04d	0.44±0.10d	0.14±0.03d	0.40±0.02d	2.89±2.52d	1.44±0.01d	0.50±0.02d
Control	8.70±0.03d	0.18±0.04d	0.14±0.19d	0.11±0.02d	0.39±0.00d	0.04±0.05d	0.39±0.01d	1.32±0.26d	1.22±0.13d	0.39±0.03d
Hammanskraal SP										
1% Moringa	8.91±0.34f	0.19±0.00f	1.35±0.11f	0.12±0.01f	0.36±0.01f	0.69±0.00f	0.40±0.00f	3.19±0.18f	1.29±0.06f	0.41±0.03de
2% Moringa	8.95±0.11f	0.20±0.02f	1.84±0.96f	0.14±0.03f	0.40±0.03f	0.08±0.03f	0.40±0.00f	3.73±1.14f	1.31±0.01f	0.45±0.19e
3% Moringa	9.35±0.12f	0.20±0.00f	2.52±0.40f	0.13±0.00f	0.44±0.04f	0.10±0.01f	0.42±0.04f	3.81±1.26f	1.36±0.01f	0.47±0.01e
Control	8.87±0.07f	0.17±0.00f	0.89±0.88f	0.04±0.05f	0.33±0.02f	0.13±0.96f	0.39±0.01f	2.55±0.19f	1.28±0.09f	0.35±0.02d

SP= Soft porridge
Mean±standard deviation
Values in bold within same column are significantly different at $p<0.05$ according to the Independent Samples t-test.
Values within the same column with different letters are significantly different at $p<0.05$ according to the Tukey test.

Table 5.3: Protein and non-essential amino acid composition of Hammanskraal and Lebowakgomo Moringa based porridges (g/100 g)

	Protein	**Serine**	**Arginine**	**Glycine**	**Asparagine**	**Glutamine**	**Alanine**	**Proline**
Moringa leaf powder								
Lebowakgomo	**30.40 ± 0.75**	**1.39± 0.05**	**1.50± 0.01**	1.59± 0.18	2.97±0.22	**3.00±0.17**	1.76±0.09	1.32±0.10
Hammanskraal	**24.53± 0.49**	**0.92± 0.02**	**1.27± 0.02**	1.44± 0.08	1.93±0.22	**1.91±0.06**	1.47±0.17	1.20±0.05
Maize meal								
Lebowakgomo	9.07± 0.21	0.37± 0.11	0.22± 0.10	0.36± 0.00	0.42±0.09	1.33±0.11	0.60±0.18	0.74±0.28
Hammanskraal	8.91± 0.29	0.46± 0.05	0.39± 0.08	0.40± 0.10	0.55±0.06	1.95±0.46	0.75±0.03	1.01±0.03
Lebowakgomo SP								
1% Moringa	8.84± 0.19d	0.41± 0.02d	0.28± 0.00d	0.32± 0.00d	0.44±0.72d	1.41±0.09de	0.69±0.02d	0.92±0.01d
2% Moringa	9.19 ± 0.01de	0.43± 0.40d	0.30± 0.00d	0.37± 0.02d	0.52±0.15d	1.42±0.06de	0.74±0.02d	0.98±0.07d
3% Moringa	9.68± 0.35e	0.47± 0.00d	0.30± 0.03d	0.37± 0.00d	0.54±0.00d	1.69±0.12e	0.75±0.05d	1.03±0.13d
Control	8.70± 0.03d	0.39± 0.03d	0.27± 0.02d	0.31± 0.00d	0.43±0.02d	1.32±0.06d	0.67±0.06d	0.92±0.02d
Hammanskraal SP								
1% Moringa	8.91± 0.34f	0.44± 0.01f	0.28± 0.02f	0.38± 0.00f	0.50±0.06f	1.49±0.14f	0.72±0.01f	0.98±0.09f
2% Moringa	8.95± 0.11f	0.46± 0.02f	0.31± 0.21f	0.39± 0.08f	0.56±0.04f	1.55±0.08f	0.73±0.02f	0.99±0.02f
3% Moringa	9.35± 0.12f	0.46± 0.07f	0.33± 0.01f	0.39± 0.00f	0.57±0.13f	1.56±0.23f	0.75±0.04f	1.03±0.06f
Control	8.87± 0.07f	0.45± 0.06f	0.26± 0.03f	0.37± 0.04f	0.47±0.03f	1.28±0.02f	0.70±0.06f	0.96±0.09f

SP= Soft porridge
Mean±standard deviation
Values in bold within same column are significantly different at $p<0.05$ according to the Independent Samples t-test.
Values within the same column with different letters are significantly different at $p<0.05$ according to the Tukey test.

The results indicate that adding Lebowakgomo MLP to the WMM porridge significantly improved protein, threonine and glutamine content of the porridge, while the addition of Hammanskraal MLP significantly improved only the phenylalanine content of the porridge. The improved content of protein could contribute to the mitigation of protein-energy malnutrition (PEM), which is a serious health problem globally, and its prevalence within South Africa is increasing (Scrimshaw and Viteri, 2008; Raynaud-Simon *et al.* 2011; Tathiah *et al.* 2013). However, it is important to highlight that, even without correcting for protein digestibility; the levels of protein in all Moringa added porridges were lower than the Recommended Dietary allowance (RDA) (11g) for children (7-12 months). Nevertheless, the protein content in 3% Moringa-added porridges has the potential to meet the RDA for protein if the mother's breastfed their children, resulting in an additional protein intake of 1.3 g per day.

The individual mineral element content

The effect of MLP on the individual mineral composition of white maize soft porridge is shown in Table 5.3.

Generally, the fat, NDF, calcium, magnesium, phosphorus, zinc and copper content of the Lebowakgomo and Hammanskraal MLP were not significantly different. Varying levels of nutrients in MLP have been reported previously (Fuglie 2001; Siddhuraju and Becker 2003; Lako *et al.* 2007), suggesting that the nutritional composition of Moringa leaves varies with geographical location, irrigation practices, harvest season, leaf age, drying and storage methods (Price 2007).

The calcium, magnesium, phosphorus, copper, and manganese contents of Lebowakgomo and Hammanskraal WMM were not significantly different. Only the potassium, iron and zinc contents were significantly different between the two maize meal types. The zinc and iron levels of both maize meal types were higher than the levels reported in the literature, which range from 1.69 to 2.07 mg/100 g and 1.85 to 2.04 mg/100 g, respectively (Oikeh *et al*. 2004). Although this study reported higher levels of iron and zinc, white maize is known to be a poor source of dietary minerals, including iron and zinc (Raboy 2007; Duvenage and Schönfeldt 2007).

Table 5.4: Individual mineral element content of Hammanskraal and Lebowakgomo Moringa based complementary soft porridge compared to the control, white maize soft porridge

	Ca mg/100 g	**Mg mg/100 g**	**K mg/100 g**	**P mg/100 g**	**Zn mg/100 g**	**Cu mg/100 g**	**Mn mg/100 g**	**Fe mg/100 g**
Moringa leaf powder								
Lebowakgomo	2.12±0.01	0.57±0.03	1.88±0.57	0.28±0.01	22.50±2.12	6.50±0.71	**76.00±1.41**	**257.00±9.19**
Hammanskraal	2.29±0.64	0.63±0.01	1.63±0.21	0.29±0.00	22.00±0.00	6.50±0.71	**89.00±0.00**	**1630.00±2.5**
Maize meal								
Lebowakgomo	0.00±0.00	0.35±0.01	0.09±0.01	**0.09±0.01**	**10.00±1.4**	1.00±0.00	1.00±1.41	**13.5±3.54**
Hammanskraal	0.00±0.00	0.20±0.00	0.07±0.00	**0.06±0.01**	**22.00±0.00**	0.00±0.00	1.00±1.41	**50.00±1.41**
Lebowakgomo SP								
1% Moringa	0.03±0.01d	0.05±0.00d	0.11±0.01d	0.10±0.00d	14.00±5.66d	1.50±0.71d	2.00±0.00d	12.00±0.00d
2% Moringa	0.05±0.00e	0.05±0.00d	0.12±0.00e	0.10±0.00d	15.50±7.78d	1.00±0.00d	3.00±1.41d	13.00±7.07d
3% Moringa	0.09±0.01f	0.06±0.00d	0.14±0.00f	0.10±0.00d	16.00± 1.13d	1.50±0.71d	4.00±0.00d	15.00±1.41d
Control	0.01±0.00d	0.04±0.01d	0.10±0.00d	0.09±0.01d	10.00±0.00d	1.25±0.00d	2.00±0.00d	11.00±1.41d
Hammanskraal SP								
1% Moringa	0.03±0.03g	0.03±0.01g	0.08±0.01g	0.07±0.01g	30.00±9.87g	1.00±0.00g	2.00±0.00g	56.00±2.26g
2% Moringa	0.06±0.00g	0.04±0.00g	0.09±0.01g	0.07±0.01g	32.00±1.27g	1.00±0.00g	2.00±0.00g	73.50±4.95h
3% Moringa	0.09±0.00g	0.05±0.01g	0.11±0.00g	0.07±0.01g	36.00±7.07g	1.50±0.71g	4.00±0.00h	101.00±1.41i
Control	0.03±0.02g	0.03±0.01g	0.08±0.01g	0.06±0.00g	24.00±0.00g	1.00±0.00g	1.00±1.41g	52.50±2.19g

SP= Soft porridge
Mean±standard deviation
Values in bold within same column are significantly different at $p<0.05$ according to the Independent Samples t-test.
Values within the same column with different letters are significantly different at $p<0.05$ according to the Tukey test.

Generally, the ash, fat, calcium, magnesium, potassium, zinc, copper, manganese and iron contents of Hammanskraal and Lebowakgomo WMM porridge samples increased as the concentration of MLP was increased. Adding Lebowakgomo MLP to WMM porridge significantly increased the ash, calcium and potassium content of Lebowakgomo WMM porridge samples. Adding Hammanskraal MLP significantly increased the iron and manganese contents of Hammanskraal WMM porridge samples.

Although adding MLP significantly increased the calcium content of Lebowakgomo WMM porridge, the increase in the calcium content was not sufficient to meet the Adequate Intake (AI) (270 mg) of calcium per day for 7-12-month-old children (Institute of Medicine (IOM) 2005; IOM 2006). This suggests that there is a need to include other calcium-rich ingredients in complementary foods in order to meet the AI of calcium, whilst taking into consideration the Tolerable Upper Intake Level (UL) (1500 mg) for 7-12-month-old children. Both Hammanskraal and Lebowakgomo Moringa-added porridges had iron contents that were higher than the WMM porridge samples and were above the Recommended Dietary Allowance (RDA) (11 mg) for 7-12-month-old children, but below the UL (400 mg). Although adding up to 3% MLP had no significant effect on the zinc content of the WMM porridge, the zinc content of all Moringa-added soft porridges was higher than the control and the UL (5 mg). These findings suggest that there is a need to investigate the bioavailability of zinc levels in Moringa-added porridges. If the zinc is largely in a bioavailable form, its levels above the UL would be a health concern for the children, as the risk of toxicity could be increased. Nevertheless, the fact that MLP significantly increased the calcium and iron content of white maize soft porridge is encouraging. It indicates that MLP has the potential to improve the calcium and iron contents of complementary WMM soft porridge, which are currently limited in porridges processed from non-fortified WMM (Faber and Benadé 2007).

Provitamin A carotenoids

The effect of MLP on the carotenoid content of white maize soft porridge is shown in Table 5.5.

There was no significant difference in the carotenoid content of Hammanskraal and Lebowakgomo WMM. The carotenoid content of both WMM types reported in this study were low and similar to those reported in the literature. Howe and Tanumihardjo (2006) reported low contents of lutein (0.10 nmol/g), zeaxanthin (0.09 nmol/g) and β-carotene (0.05nmol/g). Similarly, Pillay *et al.* (2014) also reported low contents of Zeaxanthin (0.3 μg/g), β-cryptoxanthin (0.1 µg/g) and total provitamin A carotenoids (0.1 µg/g) in white maize variety. Generally, the carotenoid content of the Hammanskraal and Lebowakgomo white maize soft porridge increased with increasing levels of the MLP. The addition of 2 and 3% MLP had a significant increase in the lutein, zeaxanthin and 9-cis- β-cryptoxanthin contents of Lebowakgomo white maize soft porridge. A significant increase in the β-carotene and total provitamin A contents were observed from the addition of 1-3% MLP. On the other hand, the zeaxanthin, β-cryptoxanthin and provitamin A contents of Hammanskraal white maize soft porridge significantly increased as 2 and 3% MLP were added to the porridge. A significant increase in the lutein content was observed from the addition of 1-3% MLP. Similarly, other studies have reported an increase in carotenoid composition of Moringa-based foods with increasing levels of Moringa. Glover-Amengor *et al*. (2017) reported an increase in β-carotene (from 0.02-1.28 mg/100g) in a porridge sample (composite white maize, groundnut and white cow pea meal); Abioye and Aka (2015) reported a very high increase in the levels of β-carotene (from 121.67to 1058.33 µg/100g) in *ogi* (fermented cereal porridge made from maize and sorghum). From these findings, it is evident that the carotenoid composition in Moringa based foods is influenced by the variety of Moringa, in conjunction with other ingredients.

Although adding MLP significantly increased the total provitamin A content of both Lebowakgomo and Hammanskraal WMM porridge, the increase was not sufficient to meet the Recommended Dietary Allowance (RDA) (500 mg) of vitamin A for 7-12 month old children (Institute of Medicine (IOM), 2005; IOM, 2006). This suggests that there is a need to include other vitamin A-rich ingredients in complementary foods in order to meet the RDA of vitamin A, while taking into consideration the Tolerable Upper Intake Level (UL) (600 mg) for 7-12-month-old children. Nevertheless, the increase in the lutein, zeaxanthin, 9-cis-β-cryptoxanthin β-carotene and provitamin A contents of Lebowakgomo porridge and zeaxanthin, β-carotene, provitamin A and lutein contents of Hammanskraal porridge are encouraging. It indicates that MLP has the potential for improving the provitamin A carotenoid composition of complementary WMM porridge, which has been reported lacking in this study. Increased MLP substitution levels could also yield a higher value for carotenoids. The improved levels of carotenoids in white maize soft porridge could contribute to improved health as carotenoids are essential in performing biochemical roles which are required for general wellbeing. Vitamin A deficiency, for example, leads to vitamin A disorders including night blindness and increased risk of infection (Clagett-Dame and Knuston 2011).

Table 5.5: Carotenoid composition of Hammanskraal and Lebowakgomo Moringa based complementary soft porridge compared to the control, white maize soft porridge (µg/g, dry weight basis [DW])

	Lutein	Zeaxanthin	β-Cryptoxanthin	13-cis-BC	β-Carotene	9-cis-BC	Total Pro-vitamin A
Maize meal							
Lebowakgomo	0.04±0.00)	0.21±0.01	0.12±0.00	0.26±0.00	0.26±0.01	0.26±0.01	0.83±0.02
Hammanskraal	0.04±0.00	0.18±0.00	0.10±0.00	0.23±0.00	0.23±0.00	0.23±0.00	0.73±0.00
Lebowakgomo SP							
1% Moringa	0.12±0.02c	0.74±0.10c	0.13±0.00cd	0.27±0.01c	0.34±0.01c	0.28±0.01cd	1.00±0.03c
2% Moringa	0.26±0.02d	1.70±0.10d	0.13±0.00cd	0.29±0.01c	0.50±0.01d	0.31±0.01d	1.16±0.03d
3% Moringa	0.30±0.02d	2.18±0.10d	0.14±0.00d	0.28±0.01c	0.50±0.01d	0.29±0.01d	1.14±0.03d
Control	0.04±0.02c	0.21±0.10c	0.11±0.03c	0.25±0.01c	0.25±0.01e	0.25±0.01c	0.81±0.03e
Hammanskraal SP							
1% Moringa	0.10±0.00c	0.51±0.07c	0.13±0.00c	0.26±0.01c	0.30±0.01c	0.27±0.01c	0.89±0.02cd
2% Moringa	0.17±0.00d	1.00±0.07d	0.13±0.00c	0.28±0.01c	0.37±0.01d	0.29±0.01c	0.99±0.02d
3% Moringa	0.22±0.00e	1.29±0.07d	0.14±0.00c	0.27±0.01c	0.39±0.01d	0.28±0.01c	1.01±0.02d
Control	0.05±0.00f	0.22±0.07c	0.12±0.00c	0.28±0.01c	0.27±0.01c	0.25±0.01c	0.87±0.00c

SP= Soft porridge; BC= β-Cryptoxanthin
Mean±standard deviation
Values in bold within same column are significantly different at $p<0.05$ (Independent samples t-test).
Values within the same column with different letters are significantly different at $p<0.05$ (Tukey test).

5.2.2 Effect of Moringa leaf powder on the antioxidant activity and phytochemical composition of complementary white maize soft porridge

The effect of MLP on the antioxidant activity and the phytochemical content of white maize soft porridge are shown in Table 5.6.

Table 5.6: The antioxidant activity, total phenolic and flavonoid content of Hammanskraal and Lebowakgomo Moringa based complementary soft porridge compared to the control, white maize soft porridge

	Antioxidant activity (µmol TE/g DW)	**Phenolic content (mg/g GAE)**	**Flavonoid content H_2O (ug/g CTE)**	**Flavonoid content MeOH (ug/g CTE)**
Moringa leaf powder				
Lebowakgomo	1.06±0.07	**0.81±0.05**	**13.54±3.16**	6.31±0.59
Hammanskraal	1.12±0.05	**0.55±0.03**	**5.96±0.61**	2.53±2.87
Maize meal				
Lebowakgomo	**1.17±0.01**	0.11±0.01	0.93±0.15	0.43±0.07
Hammanskraal	**1.13±0.01**	0.11±0.03	2.43±0.94	0.37±0.03
Lebowakgomo SP				
1% Moringa	0.41±0.01cd	0.13±0.02cd	14.78±1.66c	0.52±0.30c
2% Moringa	0.41±0.02cd	0.14±0.02cd	23.69±2.43d	0.58±0.30c
3% Moringa	0.43±0.00d	0.15±0.02d	27.51±2.77d	0.56±0.33c
Control	0.39±0.01c	0.10±0.01c	11.49±2.62c	0.47±0.27c
Hammanskraal SP				
1% Moringa	0.43±0.00f	0.12± 0.02e	15.48±19.95e	0.37±0.15e
2% Moringa	1.16±0.01e	0.12±0.01e	19.59±4.76e	0.42±0.25e
3% Moringa	1.17±0.00e	0.14±0.01e	27.54±3.10e	0.46±0.06e
Control	0.39±0.01f	0.11±0.00e	13.56±2.81e	0.33±0.12e

SP= Soft porridge
GAE= Gallic acid equivalents
CTE= Rutin equivalents
Mean ± standard deviation
Values in bold within same column are significantly different at $p<0.05$ according to the Independent Samples t-test.
Values within the same column with different letters are significantly different at $p<0.05$ according to the Tukey test.

Extracts from Lebowakgomo MLP had significantly higher amounts of total phenolic compounds than extracts from Hammanskraal MLP. The water extracts from MLP had higher flavonoid content than aqueous 50% methanol extracts.

The antioxidant activity, total phenolic and flavonoid values obtained in the current study are not comparable to those reported in the literature. The variations could be influenced by the extraction method (Siddhuraju and Becker 2003; Vongsak *et al.* 2013), agro-climatic conditions (Siddhuraju and Becker 2003; Iqbal and Banger 2006), plant tissue type (Singh *et al.* 2013) and leaf development stage (Sreelatha and Padma 2009). Siddhuraju and Becker (2003) reported that methanol extracts from freeze-dried MLP had a total phenolic content of 89-123 mg GAE/g and flavonoid content of 59-140 mg QE/g. Vongsak *et al.* (2013) reported that ethanol extracts of dried MLP contained 23-132.3 mg GAE/g of total phenolic compounds and 9-62 mgQE/g of flavonoid content. Sobhy *et al.* (2015) observed high antioxidant activity (46.77 ug/ml) in MLP when water was used as an extraction solvent, compared to methanol (33.11 ug/ml) and ethanol (44.10 ug/ml).

Extracts from Lebowakgomo WMM had significantly higher antioxidant activity than extracts from Hammanskraal WMM. Both WMM samples had similar amounts of total phenolic compounds and flavonoid content. The total phenolic and flavonoid contents in the WMM samples obtained in this study could be attributed to the removal of bran and germ during the milling of maize. Phytochemicals have reportedly been in concentrated amounts in the outer layer (bran) and germ of the maize kernel (Oboh *et al.* 2010).

The antioxidant activity, total phenolic and flavonoid content of the Moringa-added porridges increased as the concentration of MLP was increased. Based on the DPPH assay, it was found that methanol extracts from Lebowakgomo and Hammanskraal Moringa added porridges showed a scavenging effect ranging from 0.41-0.43 µmol TE/g, DW and 0.43-1.17 µmol TE/g DW, respectively. Extracts from Lebowakgomo Moringa added porridge samples exhibited significantly higher antioxidant activity and higher total phenolic content when 3% of MLP was added to the porridge. Extracts from Hammanskraal Moringa-added porridge, to which 2% or 3% Moringa had been added, exhibited significantly higher antioxidant activity.

There was no significant increase in the total phenolic content of the Hammanskraal Moringa added-porridge when 1, 2 or 3% of MLP was added. The addition of 2 or 3% MLP to Lebowakgomo white maize soft porridge significantly increased the flavonoid content of water extracts from the porridge, whilst the corresponding addition of MLP had no effect on the flavonoid content of water extracts from the Hammanskraal porridge. The addition of 1, 2 or 3% MLP did not have a significant effect on the flavonoid content of methanol extracts.

The results of this study show a correlation between total phenolic content and antioxidant activity of extracts from the maize porridges; the higher the phenolic content, the higher the scavenging effect. Similarly, other studies have reported correlations between phenolic content and antioxidant activity. For instance, a significant correlation was observed between phenolic content and antioxidant activity from selected fruits, vegetables, grain products (Velioglu *et al.* 1998), wild berries and cultivated berries (Bunea *et al.* 2011) The increased antioxidant ability with increased phenolic content reported in this study is encouraging. Additionally, the increased flavonoid content in Moringa-added porridges with increased MLP would likely significantly increase the antioxidant properties of the MAPs, because flavonoids have been reported to act as powerful antioxidants by scavenging free radicals (Gulcin *et al.* 2011). Plant derived antioxidants, including phenolic compounds (particularly flavonoids) have been reported essential in the body's defence system against oxygen free radicals and other oxidants, which play an important pathological role in human disease (Lin and Tang 2007). In the early stages of a child's life, phenolics are essential for providing antioxidant protection against the development of disease complications induced by oxygen free radicals (Granot and Kohen 2004).

5.8 Conclusion

The findings of the study show that the addition of Lebowakgomo MLP to WMM had a significant contribution towards improved ash, calcium, potassium, protein, threonine, glutamine, provitamin A, lutein, zeaxanthin, B-Cryptoxanthin, B-Carotene and 9-cis-BC contents. In Hammanskraal, the addition of MLP to WMM made a significant contribution towards improved iron, manganese, phenylalanine, provitamin A, lutein, zeaxanthin, and B-Carotene contents. The antioxidant activity, total phenolic and flavonoid content of the WMM soft porridge increased as the concentration of MLP was increased. The fact that adding MLP significantly improved the calcium, iron, protein and provitamin A carotenoids content of WMM soft porridge is encouraging; this may potentially contribute towards the alleviation of PEM, vitamin A, calcium and iron deficiencies, which have been reported globally as serious health problems. The increased antioxidant activity, total phenolic and flavonoid contents with increased MLP addition could assist the body's defence system against oxygen free radicals and other oxidants that can play an important pathological role in human disease in the early stages of a child's life.

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CHAPTER 6 : ACCEPTANCE OF A MORINGA-ADDED COMPLEMENTARY MAIZE SOFT PORRIDGE BY MOTHERS IN HAMMANSKRAAL, GAUTENG PROVINCE AND LEBOWAKGOMO, LIMPOPO PROVINCE, SOUTH AFRICA

6.1 Abstract

A recipe for a soft, white maize porridge [traditional complementary food (TCF)] used by mother's from Hammanskraal and Lebowakgomo was modified by substituting maize meal with Moringa leaf powder at different levels, 1, 2 and 3% (w/w). Sixty mothers were sampled separately from Hammanskraal and Lebowakgomo communities, and evaluated the acceptability of the samples of the modified, traditional complementary food using a 5-point facial hedonic scale. Focus group discussions were conducted to assess mother's perceptions of adding Moringa leaf powder (MLP) in traditional complementary foods. Sensory evaluation results showed that the acceptance of each of the two traditional complementary foods decreased as the level of MLP increased. Mother's indicated in the focus group discussions that Moringa-based soft porridges had a bitter taste, which would not be suitable for children. Only the Lebowakgomo MTCF containing 1% of Moringa was rated similar in overall acceptability to the corresponding TCF (control). Nevertheless, all mothers expressed willingness to use Moringa in complementary foods, provided they would be trained on how to process it. Varying product formulation and processing methods may contribute to increased acceptance of Moringa-based foods. Overall, Moringa appears to have the potential for use in complementary foods.

6.2 Introduction and background

The World Health Organization (WHO) recommends that children receive nutritious and safe complementary foods after six months of life to achieve optimal growth and development (WHO 2013). Unfortunately, a review of dietary surveys in South Africa from 2000 to 2015 revealed that South African households have limited dietary diversity (Mchiza *et al.* 2015). Consequently, caregivers have reportedly been relying on unfortified white maize, together with energy rich ingredients such as sugar and margarine, when preparing complementary foods (Kruger and Gericke 2003; Faber and Benadé 2007; Nuss and Tanumihardjo 2010; Goosen *et al.* 2014). This is primarily because most of the families especially in rural areas cannot afford diversified diets (Tshabalala 2014). Unfortunately, cereal grains are limited in several nutrients, including protein and micronutrients. Hence, the high rates of child malnutrition in rural areas of the country (South Africa) (Tathiah *et al.* 2013). The consumption of cheaper, complementary foods with a longer satiety effect such as white maize meal and sugar resulted in severely food insecure and underweight children in Limpopo and Gauteng provinces (Ntila *et al.* 2017). Children in Lebowakgomo, Limpopo province (87%) and Hammanskraal, Gauteng province (78%) were reported to be severely food insecure. Additionally, Lebowakgomo children (23.6%) and Hammanskraal children (17.9%) were severely underweight (Ntila *et al.* 2017).

In South Africa, interventions aimed at improving food and nutrition security such as the vitamin A supplementation programme and dietary diversification among low economic status populations are not sustainable. These interventions tend to promote dependency on government institutions. The Department of Health provides routine and therapeutic doses of vitamin A to children who present with clinical signs of vitamin A deficiency and the Department of Agriculture provides agricultural inputs such as seeds to rural communities (Iversen *et al.* 2012a; Iversen *et al.* 2012b). The utilization of nutrient-dense foods which are locally available, affordable and culturally acceptable would be a more sustainable strategy for addressing child malnutrition among limited resource communities (Adedodun *et al.* 2010). The sub-Saharan African region is well endowed with wild and domesticated food plants that have several beneficial properties, including good nutritional and medicinal properties (Makkar *et al.* 2007; Mahajan *et al.* 2007).

Moringa is one of these plants with good nutritional and medicinal properties. The leaves of the Moringa plant are the most nutritious and have more beneficial potential than other parts of the plant (Bennett *et al.* 2003; Fahey 2005; Soliva *et al.* 2005; Lako *et al.* 2007). The leaves are a rich source of minerals and various phenolics (Bennett *et al.* 2003; Siddhuraju and Becker 2003; Lako *et al.* 2007), alkaloids, amino acids and proteins, and vitamins, including vitamin A precursors, especially beta-carotene (Sarwatt *et al.* 2002; Soliva *et al.* 2005; Anwar *et al.* 2007; Lako *et al.* 2007). Thus, Moringa leaves appear to be a good candidate for incorporation into complementary foods to enhance their nutritional quality.

Whilst there are a number of publications on the origin, morphology and chemical composition (Fahey 2005; Lako *et al.* 2007; Arabshahi-D *et al.* 2007), there is scantpublished data on the utilisation of Moringa to enhance the nutritional value of complementary foods. Similarly, there is no published data on mother’s perceptions on the use of Moringa in complementary foods. The aim of the current study was to assess the acceptance of a soft, white maize porridge which was modified by substituting maize meal with Moringa leaf powder.

6.3 Methodology

6.3.1 Focus Group Discussions

The same procedure described earlier in section 4.3.3.2 for conducting FGDs was followed. The discussions were conducted to establish the most commonly used complementary food recipes and assess whether mothers knew of and utilised Moringa, and their perceptions on the inclusion of Moringa in complementary foods. The most common method of preparation was then used to develop a standardised soft maize porridge recipe (after two cooking trials) (Appendix I). This recipe was used to prepare samples for sensory evaluation.

6.3.2 Sensory evaluation

6.3.2.1 Pilot study

In order to detect and correct any methodological errors related to preparation of the soft maize porridges and the wording of the questionnaire, a pilot study of the sensory evaluation was conducted before the main sensory evaluation session. Ten mothers per study area were recruited on a voluntary basis to participate in the sensory evaluation, key informants from both study areas assisted with recruiting mothers of children aged 7-12 months old in their communities. Sensory evaluation pilot study participants were requested not to participate in the main study. The outcome of the pilot study was a standardized porridge recipe which was established after several cooking trials and the sensory evaluation questionnaire was modified accordingly.

6.3.2.2 Sensory evaluation panelists

Mothers from Lebowakgomo (n=60) were recruited on a voluntary basis from the survey participants to evaluate the sensory attributes of soft porridges prepared using MLP and maize sourced from Lebowakgomo community and supermarket, respectively. Similarly, 60 mothers from Hammanskraal were also recruited on a voluntary basis from survey participants to evaluate the sensory attributes of soft maize porridges prepared with MLP and maize meal sourced from Hammanskraal community and supermarket, respectively.

6.3.2.2 Preparation of complementary food samples

As established in section 4.7.3 the most common complementary food fed to 7-12-month-old children was a soft porridge, which was prepared from maize meal and water. Hammanskraal

Moringa-added soft porridge samples were prepared using WMM (Super-sun, Premier manufacturer, South Africa) purchased from local commercial markets around Hammanskraal, and MLP was sourced from Phedisanang Moringa project in Hammanskraal. Similarly, Lebowakgomo Moringa-added soft porridge samples were prepared using WMM (Magnifisan super, VKB milling manufacturer, South Africa), purchased from local commercial markets around Lebowakgomo, and MLP was sourced from Sedikong Sa Lerato Moringa Farm, Limpopo Province, South Africa. The two Moringa-producing projects were funded by the South African Department of Science and Technology (DST) and mentored by the Agricultural Research Council (ARC) to comply with the South African Government for Good Agricultural Practices (GAPs). Fresh Moringa leaves were processed into powder at an agro-processing facility at ARC, Roodeplaat, South Africa. Fresh leaves were harvested from 12-week-old plants, uniformly dried under the shade (25 ± 2°C) for 72 hours, and then processed into powder using a milling machine.

A standard recipe for preparing traditional complementary soft porridge (which did not contain Moringa) was sourced from Hammanskraal and Lebowakgomo community, and used as a control. The recipe was as follows: 500 ml of water was heated to boiling point and 120 g of WMM was combined with 250 ml of water in a bowl to make a smooth paste. The paste was then added to the boiling water and stirred until smooth. The mixture was left to cook for 20 minutes. To prepare test samples of Moringa-added soft porridges, maize meal was mixed with MLP at 1, 2 and 3% w/w substitution levels. The porridges were prepared on site (Hammanskraal and Lebowakgomo) on the day of the survey by mothers from the study areas. The researcher was present on site to ensure that that the porridges were correctly prepared. This ensured that the porridges were prepared in the same manner as the study participants (mothers) normally prepared traditional soft porridges for their children. The women who assisted with processing the soft porridges were excluded from the study investigations related to the porridges they had prepared.

Sample coding, serving order and sensory evaluation set-up

To reduce bias associated with the labeling of samples, a table of random numbers was used to assign each sample a unique three-digit code. The samples were served in randomised order from left to right. Randomisation of the serving order was done using a Table of Random Permutations of Nine. To prevent the panelists from influencing each other’s responses, the sensory evaluation panelists were made to sit far apart. All participants were provided with a glass of water, four plastic teaspoons, serviettes, four small dishes containing each soft porridge type, and four sensory evaluation questionnaires written in Sepedi. The English version (Appendix J) of the sensory evaluation questionnaire was translated into Sepedi (Appendix K). The sensory evaluation questionnaire was in the form of a five-point facial hedonic scale (1=very bad; 5=very good) in order to accommodate illiterate individuals. After the evaluation of the sensory attributes, the participants were given the preference test questionnaires and requested to circle the sample number whichthey preferred the most. These questionnaires were translated from English (Appendix L) to Sepedi (Appendix M).

Before starting the sensory evaluation, participants were required to fill in a participation information form sheet, a letter requesting participation and a consent form. The documents were translated from English (Appendix N, Appendix O, and Appendix P) to Sepedi (Appendix Q, Appendix R, and Appendix S). Trained field workers provided an explanation of the participation information form, the letter requesting participation and the consent form in Sepedi to ensure that participants understood everything before signing the forms. After the forms were signed, field workers provided an explanation of the sensory evaluation questionnaire and preference test questionnaire. The panellists were asked to rate the acceptability of each sensory attribute of the soft porridges by marking an 'X' on the face which best suited the sensory acceptability of each sample. After rating the samples, the participants were asked to write down all the samples they had evaluated and then circle the sample they preferred the most. Illiterate participants were further assisted by field workers if they required more assistance to fill out the questionnaire.

6.4 Data quality and Control of bias

In each study area, the same pot size, measuring jug, measuring cup, and the same type of ingredients and quantity thereof were used to prepare different varieties of soft porridges. The nutritional analysis of the samples was conducted in duplicate using standard methods. All panellists were served with the same quantity of soft porridge (12.5ml). Sample serving, and labelling were randomised; panellists were seated far from each other and were not allowed to communicate during the sensory evaluation session. Data from the sensory evaluation were captured into a spreadsheet and cross-checked to ensure that all the data were entered correctly. Data from the focus group discussions were translated and cross-checked by a Pedi speaking person, for accuracy.

6.5 Data analysis

The Statistical Package for Social Sciences (IBM SPSS), version 21 for Windows, was used to analyse quantitative data. The data were analysed using descriptive statistics and the Dunnet test. A p value of < 0.05 was considered statistically significant. Focus group discussion recordings were transcribed and then translated into English immediately after each session. The transcripts were then subjected to content analysis, to identify and interpret key concepts and themes from the discussions. For each theme, supporting verbatim quotes were included.

6.6 Ethical considerations

The ethical approval to conduct the study was obtained from the University of KwaZulu-Natal, Humanities and Social Science Research Ethics Committee (HSS/1244/015D) (Appendix F). Approval to conduct the study in Hammanskraal was obtained from Tshwane Municipality issued by the ward councillor (Appendix G). Approval to conduct the study in Lebowakgomo was obtained from Lebowakgomo Municipality issued by the Head of Extension (Appendix H). Before commencing the study, participants were asked to sign a participation information form, a letter requesting participation and a consent form. The consent form was clearly explained in Pedi to ensure full understanding of what the study entailed.

6.7 Results and discussion

6.7.1 Mother's perceptions of the use of Moringa in complementary foods

Hammanskraal mothers had limited knowledge on how to use Moringa as they had only heard about its benefits from locals in the community (Table 6.1). However, mothers from Lebowakgomo were well informed about Moringa and had used it for various benefits before the current study. Nevertheless, because of the known benefits, mothers from both study communities expressed willingness to use Moringa in complementary foods, provided they were well trained on how to process and incorporate it into complementary foods.

Table 6.1: Mothers' knowledge, current utilisation and perceptions of incorporating Moringa into complementary foods

Question	Study area	Theme	Concept	Quotes
Have you heard about Moringa?	Hammanskraal	Medicinal benefits	Beliefs	*"Yes, we have heard that people use Moringa to lose weight and to control high blood pressure."* *"We have heard that Moringa helps children with sores in the chest and children who pee at night."*
	Lebowakgomo	Medicinal benefits	Beliefs	*"Moringa is well known and widely used in this community, there is no age restriction for Moringa usage in the area"* *"Moringa is used when children have rash, you smear it on the face & the rash will disappear, it is good for ringworms"* *"Moringa can remove stomach cramps, clean the womb to improve fertility, stops menstruation pains, helps stop kids from urinating at night, boost immune system of HIV patients, helps cure flu, energy booster, increases appetite for food, revives menstruation after menopause, neutralise bile, heals sore feet, boost sexual activity of women"*
How do you utilize Moringa?	Hammanskraal	Social aspect	Beverage	*"We have never used Moringa before as we do not have knowledge of how to use it. We have heard that some mothers add it to water for their children to drink."*
	Lebowakgomo	Utilization	Vegetable Beverage Seasoning	*"Moringa is cooked as morogo and consumed as a relish with pap by old people"* *"We use Moringa when cooking spinach for children aged 6-12 years"* *"Consumed as tea by old people and children (1 years or less). We make it to be weak if it is to be consumed by children as Moringa has a bitter taste which is not suitable for children."*

Question	Study area	Theme	Concept	Quotes
				"Moringa acts as a unique spice in foods."
Would you use Moringa in complementary foods for children?	Hammanskraal	Nutrition campaign knowledge and information	Education and training	*"You cannot use something you do not know. If we are well-informed about measurements, we can use it for our children as Moringa is said to have many benefits."*
	Lebowakgomo	Nutrition education	Education and training	"*We would love to, but we do not know how to process food with Moringa in a way that is suitable for children less than a year old, as these kids do not consume lots of food that we incorporate Moringa with."*

The limited knowledge of the potential benefits of Moringa seems to have contributed to the preference of the traditional white maize soft porridge (control) over the Moringa-added porridge by these mothers. These findings suggest the need for raising awareness and providing information about the nutritional and potential health-promoting properties of Moringa, as well as training the target communities on how to process and use Moringa in complementary foods. Indeed, during the focus group discussions (FGDs), the mothers from both Hammanskraal and Lebowakgomo indicated willingness to use Moringa in foods, including the complementary soft porridges, if they were trained on how to process Moringa into suitable foods for children. Furthermore, mothers from Lebowakgomo liked the Moringa-added soft porridge more than the mothers from Hammanskraal. This was probably because they were more familiar with Moringa, as they were well-informed about the plant and had previously utilized it (before the current study for various benefits.

The Lebowakgomo community used Moringa leaves as a relish and seasoning in foods for adults; only Moringa tea was consumed by both adults and children (1-year-old or less). However, the tea was diluted with water to reduce the bitterness, as the taste was considered unsuitable for children. The study communities believed Moringa had healing properties, and as a result, Moringa was used in the purported treatment of several health conditions as indicated in Table 6.1. Similarly, in Uganda and Nigeria respectively, Moringa leaves were consumed as tea and a vegetable relish (Kasolo *et al.* 2010; Oyewole *et al.* 2014). In addition, the leaves were used to treat skin diseases, HIV-related symptoms, flu and boost the immune system (Kasolo *et al.* 2010). However, these authors did not report on the use of Moringa to increase food appetite, revive menstruation after menopause, heal sore feet, boost women's sexual drive and neutralize bile as was reported by mothers from Lebowakgomo in the current study.

6.7.2 Sensory evaluation

Figure 6.1 shows soft porridge samples prepared at different levels of Moringa as an additive to the usual WMM, and the control. Hammanskraal Moringa-added porridges were noticeably greener than those from Lebowakgomo because MLP sourced from Hammanskraal had a strong green colour.

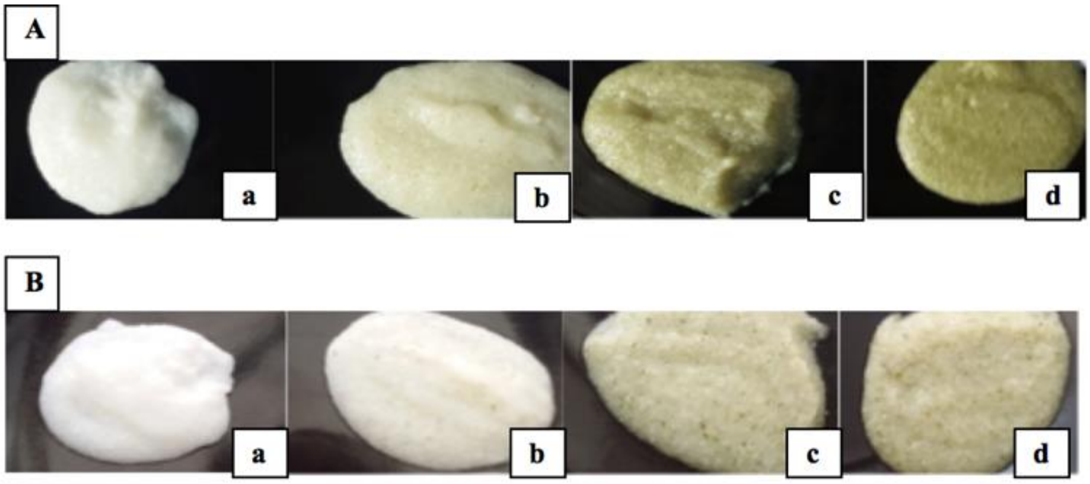

Figure 6.1: Hammanskraal (A) and (B) Lebowakgomo soft porridges with ifferent levels of MLP. Levels: (a) Control without Moringa, (b) 1%, (c) 2% and (d) 3% Moringa as an additive to the normal WMM

The taste, texture, aroma and colour acceptability of all Hammanskraal Moringa-based soft porridges were significantly different ($p < 0.05$) from the control (Table 6.2). Moringa-based porridges were less acceptable compared to the control without Moringa. Nevertheless, in Lebowakgomo, the taste, texture, aroma and colour acceptability of 1% Moringa soft porridge did not significantly affect the overall acceptability of the soft porridge as it was similar to the control.

Table 6.2: Sensory acceptability of Moringa-added soft porridges, compared with soft porridge without Moringa (control)

Soft porridge type	Taste	Texture	Aroma	Colour	Overall acceptability
Hammanskraal					
Control	3.9±1.1	3.8± 1.1	3.7± 1.1	3.8± 1.0	3.9± 1.1
1% Moringa	**2.6± 1.2**	**2.5± 1.2**	**2.8± 1.2**	**2.8± 1.3**	**2.7± 1.2**
2% Moringa	**2.5± 1.4**	**2.6± 1.4**	**2.7± 1.3**	**2.8± 1.3**	**2.9± 1.4**
3% Moringa	**3.0± 1.0**	**3.1± 1.1**	**2.9± 1.0**	**3.2± 1.1**	**3.0± 1.1**
Lebowakgomo					
Control	3.8± 1.1	3.7± 1.1	3.9± 1.0	4.1± 1.0	4.1± 1.1
1% Moringa	**3.2± 1.1**	3.5± 1.2	3.7± 1.1	3.8± 0.8	3.8± 1.0
2% Moringa	**3.1± 1.2**	3.5± 1.2	3.4± 1.1	**3.6± 1.3**	**3.6± 1.1**
3% Moringa	**3.0± 1.4**	**3.1± 1.3**	**2.9± 1.2**	**3.0± 1.2**	**3.2± 1.2**

Mean±standard deviation
Values in bold are significantly different to the control ($p < 0.05$)

The results from the preference test showed that the control porridge was the most preferred in Hammanskraal while 2% Moringa soft porridge was the most preferred in Lebowakgomo (Table 6.3 and Table 6.4).

Table 6.3: Percentage of Hammanskraal panellists who gave the different ratings for the sensory attributes evaluated

Attribute	Rating	Control	1% Moringa	2% Moringa	3% Moringa
Taste	Very bad	6.7	20.0	30.0	10.0
	Bad	6.7	33.3	33.3	16.7
	Neutral	10.0	23.3	6.7	43.3
	Good	46.7	16.7	16.7	23.3
	Very good	30.0	6.7	13.3	6.7
Texture	Very bad	3.3	23.3	26.7	3.3
	Bad	10.0	30.0	33.3	23.3
	Neutral	16.7	23.3	10.0	43.3
	Good	43.3	20.0	16.7	16.7
	Very good	26.7	3.3	13.3	13.3
Aroma	Very bad	3.3	16.7	20.0	13.3
	Bad	13.3	23.3	26.7	16.7
	Neutral	16.7	33.3	26.7	50
	Good	43.3	20	16.7	10.0
	Very good	23.3	6.7	10.0	10.0
Colour	Very bad	3.3	13.3	13.3	6.7
	Bad	10.0	36.7	40.0	16.7
	Neutral	10.0	16.7	10.0	40.0
	Good	53.3	20.0	23.3	23.3
	Very good	23.3	13.3	13.3	13.3
Overall acceptability	Very Bad	6.7	20.0	16.7	6.7
	Bad	3.3	23.3	36.7	26.7
	Neutral	10.0	30.0	6.7	36.7
	Good	53.3	20.0	20.0	20.0
	Very good	26.7	6.7	20.0	10.0
Preference test		60.0	3.3	20.0	16.7

Table 6.4: Percentage of Lebowakgomo Panellists who gave the different ratings for the sensory attributes evaluated

Attribute	Rating	Control	1% Moringa	2% Moringa	3% Moringa
Taste	Very bad	5.0	10.0	8.3	18.3
	Bad	6.7	11.7	31.7	23.3
	Neutral	25	28.3	15.0	18.3
	Good	28.3	41.7	33.3	20.0
	Very good	35	8.3	11.7	20.0
Texture	Very bad	5	5.0	8.3	10.0
	Bad	6.7	8.3	11.7	25.0
	Neutral	25	33.3	20	20.0
	Good	36.7	41.7	43.3	26.7
	Very good	26.7	11.7	16.7	18.3
Aroma	Very bad	1.7	5.0	5	11.7
	Bad	8.3	5.0	13.3	28.3
	Neutral	23.3	30.0	30.0	30.0
	Good	31.7	33.3	33.3	20.0
	Very good	35.0	26.7	18.3	10.0
Colour	Very bad	1.7	3.3	10.0	13.3
	Bad	6.7	1.7	10.0	23.3
	Neutral	11.7	20	13.3	26.7
	Good	38.3	60	40	28.3
	Very good	41.7	15	26.7	8.3
Overall acceptability	Very Bad	3.3	3.3	5.0	5.0
	Bad	6.7	6.7	8.3	25.0
	Neutral	11.7	18.3	30.0	31.7
	Good	26.7	41.7	26.7	18.3
	Very good	51.7	30	30.0	20.0
Preference test		35	16.7	36.7	7

The significantly lower taste acceptability of all Moringa soft porridges may be attributed to the bitter taste of Moringa, as indicated by the mothers in the FGDs. The use of different ingredients (maize meal and MLP) in each study area could have also affected the recipe, and hence the different sensory attribute ratings (Table 6.3 and Table 6.4). However, regardless of the use of different ingredients in each study area, the results suggest that the bitter taste of Moringa is retained irrespective of the fact that other ingredients were included in the soft porridge. In addition, it was observed that the incorporation of Moringa into the soft porridges resulted in unfamiliar odours. Therefore, there is a need to mask the bitter taste and unfamiliar odour of Moringa-added soft porridge. This could be achieved through recipe modification, for an example, by adding fruit extracts or by substituting Moringa powder with Moringa extracts in the porridges.

The findings indicate that the overall acceptance of soft porridges decreased as the levels of Moringa were increased. Only the overall acceptability of 1% Lebowakgomo soft porridge was high and similar to the control. Similarly, other studies have found that samples with low Moringa levels were considered most acceptable. For instance, rice crackers with up to 2% Moringa were acceptable as a control in a study conducted by Manaois *et al.* (2013). Flat noodles with the lowest substitution level (5%) were found to be most acceptable, compared to a higher Moringa substitution level (Abilgos and Barba 1999). A similar case was reported for cookies (De la Mar 2012). Additionally, high amounts of Moringa extracts negatively affected the sensory acceptability of pineapple and carrot juice (Otu *et al.* 2013). The decrease in overall acceptability with increasing levels of Moringa seemed to be associated with an increasing level of alteration in the taste, texture, aroma and colour of the altered product. It is likely that the bitter taste in the Moringa-added soft porridges contributed the most to the decreased overall acceptability of the Moringa-added soft porridges. Nevertheless, the mothers of this study indicated willingness to use Moringa in complementary foods provided they were trained on how to process it into foods suitable for children.

6.8 Conclusion

The findings of this study indicate that soft porridge containing 1% (w/w) of Moringa was as acceptable as the traditional soft porridge (control) to mothers from Lebowakgomo. The low acceptability of porridge samples containing higher levels (2 and 3%) of Moringa was mainly due to their unacceptable taste and aroma. In Hammanskraal, the control was more acceptable than Moringa-added soft porridges. Unlike mothers from Hammanskraal, Lebowakgomo mothers knew Moringa and had previously utilised it for various benefits before this study was conducted. Nevertheless, mothers from both communities demonstrated willingness to use Moringa in complementary foods if they were trained on how to process it into foods that are suitable for children aged 7-12-months; the current bitter taste experienced was considered not suitable for children. These findings suggest that Moringa-based soft porridge could be used as a complementary food in the areas of South Africa selected for the current study, however, the bitter taste could negatively affect its utilization. The optimization of product formulation and processing methods may contribute to increased acceptance of Moringa-added complementary foods.

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CHAPTER 7 : CONCLUSIONS AND RECOMMENDATIONS

The main conclusions and recommendations of the study are discussed in this chapter. The aim of this study was to assess the potential of *Moringa oleifera* (LAM.) leaves for use in complementary foods to combat child food and nutrition insecurity amongst South African rural and peri-urban communities. The objectives of the study were: (i) To assess the food and nutrition security and the nutritional status of children receiving complementary foods (7-12 months); (ii) To investigate child feeding practises and establish a recipe for a popular traditional cereal-based complementary food; (iii) To modify a recipe of a popular traditional cereal-based complementary food by substituting the main ingredient with Moringa leaf powder at different levels *viz.* 1,2 and 3% (w/w); (iv) To determine the effect of adding Moringa leaf powder on the nutritional quality, antioxidant activity and phytochemical content (total phenolics and flavonoids) of the popular traditional cereal-based food; (v) To assess the mothers' perceptions and sensory acceptability of the Moringa-added traditional cereal-based complementary food.

7.1 Conclusions

This work has provided useful baseline data on topics in which data was lacking in South Africa: the food and nutrition security status of children receiving complementary foods (7-12 months old), in addition, to the nutritional quality and mothers acceptability of a Moringa-added complementary soft porridge.

The results indicate high rates of severely food insecure (access) children in both Hammanskraal and Lebowakgomo, which contributed to the high prevalence of underweight and severely underweight children. Overall, the children's diets (complementary foods) were characterized by inadequacy in both quantity and quality. Thus, sustainable interventions aimed at addressing food and nutrition insecurity are recommended in both rural and peri-urban communities with a similar socio-economic status. Such interventions should place focus on improving basic factors (access to resources and environmental technology), underlying factors (maternal and child care, sanitation, health services, and nutrition education) and immediate factors (physical and economic access to nutrient rich foods).

The results showed that the addition of Lebowakgomo MLP to WMM made a significant contribution towards the improved content of ash, calcium, potassium, protein, threonine, glutamine, provitamin A, lutein, zeaxanthin, β-cryptoxanthin, β-Carotene and 9-cis- β-cryptoxanthin. Adding MLP to Hammanskraal porridge significantly contributed towards improved iron, manganese, phenylalanine, provitamin A, lutein, zeaxanthin, and β-carotene contents. Generally, the antioxidant activity, phenolic and flavonoid content of the MAPs increased as the concentration of MLP was increased. Although the addition of MLPsignificantly improved the calcium, protein and provitamin A carotenoids composition of white maize soft porridge, the increase in the calcium content was not sufficient to meet the Adequate Intake (AI) (270 mg) of calcium per day for 7-12-month-old children. The levels of protein in all MAP were lower than the Recommended Dietary Allowance (RDA) of 11g, and the increase in overall provitamin A content was insufficient to meet the Recommended Dietary Allowance (RDA) of 500 mg. Nevertheless, the shortfall in calcium, protein and provitamin A can be supplemented by other calcium, protein and provitamin A rich complementary food sources in children's diets such as dairy products, meat products and green vegetables, respectively.

The reported iron content in Moringa-added porridges were above the Recommended Dietary Allowance (RDA) (11 mg) for 7-12-month-old children, but below the UL (400 mg), while the reported zinc contents were higher than the UL (5 mg), This raises concerns in terms of the risk associated with overdosing zinc levels especially in children's diets. Thus, there is a need to investigate the bioavailability of nutrients in MAPs, especially zinc levels, as the contents were higher than the Tolerable Upper Intake Level.

The findings indicate that the overall acceptance of soft porridges decreased as the levels of Moringa were increased. Unlike mothers from Hammanskraal, Lebowakgomo mothers knew Moringa and utilized it for various benefits before this study was conducted. Hence, the soft porridge containing 1% (w/w) of Moringa was as acceptable as the traditional soft porridge (control) to mothers from Lebowakgomo. The low levels of acceptability of porridge samples containing higher levels (2 and 3%) of Moringa were mainly due to their unacceptable taste and aroma; the bitter taste was considered not suitable for children. Nevertheless, mothers from both communities demonstrated a willingness to use Moringa in complementary foods if they were trained on how to process it into foods that are suitable for children aged 7-12-months.

The findings of this study indicate a number of areas where action can be taken to improve the food and nutrition security of children receiving complementary foods in the studied communities, and other similarly disadvantaged communities in the country. The reported baseline information on the food access and nutritional status of children receiving complementary foods (7-12 months old), an area where local data is lacking, can be used to plan food and nutrition interventions aimed at improving diets and reducing health conditions related to poor nutrition. The nutritional quality of a Moringa-added complementary soft porridge has not been reported on previously. It appears that the addition of Moringa leaf powder in complementary white maize soft porridge has the potential to improve the nutritional quality of the porridge. This may contribute towards the alleviation of protein-energy malnutrition, vitamin A, calcium and iron deficiencies, which have been reported globally as serious health problems. Additionally, the increased antioxidant activity, and total phenolic and flavonoid content that arise from increased Moringa leaf powder addition could contribute to the body's defence system against oxygen free radicals and other oxidants that can play an important pathological role in human disease in the early stages of a child's life. The acceptance of a Moringa-added complementary soft porridge seems to have not been investigated previously. The results indicating willingness of the mothers to use Moringa in complementary foods are encouraging as they highlight an opportunity to introduce Moringa when preparing complementary white maize soft porridge. Thus, there is need for raising awareness and provision of information about the nutritional and potential health-promoting properties of Moringa as well as training the target communities on how to process and use Moringa in foods. This can be achieved through the implementation of education and training initiatives. Additionally, the optimization of product formulation and processing methods may contribute to increased acceptance of Moringa-added complementary foods.

7.2 Study critique and recommendations

7.2.1 Study critique

- This study was conducted in only two Pedi communities of South Africa, therefore, the study findings cannot be used to draw conclusions (generalization) on rural and peri-urban populations from a wider geographical region.
- Food and nutrition security is complex and multidimensional with a range of factors that impact food access, availability, utilisation, and stability. Thus, there is a need to integrate various tools when measuring food and nutrition security to account for all factors. Unfortunately, due to limited financial resources, this study used only four of the several tools available *viz.*, the CFIAS, IDDS, unquantified food consumption frequency survey, and anthropometric indices (WAZ).

- The potential influence of environmental factors and agricultural practices on the nutritional composition of MLPs used in this study was not determined even though these factors are known to influence the nutritional composition of plants.

7.2.2 Recommendations for future studies

- The bioavailability of nutrients in Moringa added porridges and the safety of incorporating MLP into white maize meal should be determined in future studies.
- The effect of environmental factors, agricultural practises and processing methods of Moringa should be determined in future studies, as these factors may influence nutritional composition.
- Future studies should incorporate MLP with other cereal-based complementary foods and determine the nutritional quality and mothers' acceptability of the final product. The chosen cereal-based recipes should be those that are popular in the study area.
- Future studies should identify and determine the presence of commonly perceived antinutritive factors in MLP.

APPENDICES

APPENDIX A: PUBLICATIONS FROM THIS WORK

Published

1. Sithandiwe Ntila, Muthulisi Siwela, Unathi Kolanisi, Hafiz Abdelgadir and Ashwell Ndhlala. In press. An Assessment of the Food and Nutrition Security Status of Weaned 7–12 Months Old Children in Rural and Peri-Urban Communities of Gauteng and Limpopo Provinces, South Africa. *International Journal Environmental Research and Public Health* 2017, 14, 1004; doi:10.3390/ijerph14091004.

Accepted

2. Sithandiwe Ntila, Muthulisi Siwela, Unathi Kolanisi, Hafiz Abdelgadir, and Ashwell R. Ndhlala. Acceptance of a Moringa-Added Complementary Soft Porridge by Caregivers in Hammanskraal, Gauteng Province and Lebowakgomo, Limpopo Province, South Africa. Revised version submitted. *South African Journal of Clinical Nutrition.*

Under-review

3. Sithandiwe Ntila, Muthulisi Siwela, Unathi Kolanisi, Hafiz Abdelgadir and Ashwell Ndhlala. The effect of Moringa leaf powder on the nutritional and phytochemical composition of complementary white maize soft porridge. *Nutrients*.

APPENDIX B: SURVEY QUESTIONNAIRE IN ENGLISH

All the information provided here will be treated as **STRICTLY CONFIDENTIAL**.

Name of interviewer …………………………………………………………………………….

Date: ……………………………………………………………………………………….

Area……………………………………………………………………………………………

SECTION A: SOCIO-ECONOMIC DEMOGRAPHICS

1. Mothers Age |__||__|

2. How many months is your child?........................

3. What is the weight of your child?.........................

4. What is the gender of your child?

1=Female	2=Male

5. Mothers Marital Status

1=Single	2=Married	3=Divorced	4=Widowed

6. Mothers Level of education

1=No Formal education	2=Primary	3=Secondary	4=Tertiary

7. Mothers Employment status

1=Employed full time	2=Employed part time	3=Unemployed	4=Pensioner

8. Household income per month?

Below R800	R801 – R1500	R1501-R3500	Above R3500

9. Total size of household________

10. Indicate the number of people per age category

7-12months	1-5 years	6-12 years	13-19 years	20-35years	36- 59 years	Greater than 59

11. Please indicate the source of water for your household;

1=Household Tap water	2=Communal tap	3=Both

12. Do you have a vegetable garden in your household? If no, please proceed to question 12.

0=No	1=Yes

a) Please indicate the hectares of land for the vegetable garden

1= less than 1ha	2=1-2ha	3= 3-4ha	4= Greater than 4ha

b) Please indicate the source of water for irrigation

1= household Tap	2=Community tap	2=rain harvesting	3= River	4= Other (specify)

c) If yes, please indicate whether the produce is for the FF;

1= Household consumption	2=Cash income	3=Both

13. Is your household involved in any fruit production? If no, please proceed to question 13.

0=No	1=Yes

a) Please indicate whether the produce is for the FF;

1= Household consumption	2=Cash income	3=Both

14. Do you have any livestock in your households? If no, please proceed to question 14.

0=No	1=Yes

a) Please indicate the type of livestock;

1=Chickens	2= cattle's	3=goats	Other (Specify)

b) please indicate whether the produce if for the FF;

1= Household consumption	2=Cash income	Traditional ceremonies	3=Other (Specify)

15. Do you receive any child feeding practises information? If no, please proceed to section B.

0=No	1=Yes

16. If yes, please indicate the source of receiving child nutrition information

1=Radio	2= Television	3= public health facilities	4=Other (Specify)

Breast feeding

1. **Are you breast feeding you child?**

0=No	1=Yes

a) If you answered No to question 1, what do you feed your baby to substitute breast milk?

1=Formula milk	2= Animal milk	4=Other (Specify)

b) If you answered No to question 1, when did you stop breast feeding?

1=Never started	2= less than 3 months after birth	3= 3-5 months after birth	4=6 months after birth	5=Other (Specify)

c) If you answered No to question 1, why are you not breast feeding your baby?

1=Insufficient milk	2= Age appropiate	3= I do not have time	4=Medical reasons	5=Other (Specify)

d) If you answered yes to question 1, when did you start breast feeding?

1=less than 1 hour after birth	2= 1 hour after birth	3= 1 day after	4=More than a day after birth	5=Other (Specify)

e) If you answered yes to question 1, please specify the breast feeding category.

1=Exclusive breastfeeding	2= Predominant breastfeeding	3= Partial breast feeding

f) Are there any problems encountered during breast feeding?

1=None	2= Soreness of nipple	3= Child reluctant to suckle	4=I do not have enough breast milk	5=Other (specify)

Complementary feeding

2. **Did you feed your baby any foods other than breast milk or formula milk in the first 6 months of life? If yes, please answer the ff questions. if no, please proceed tom question 3**

0=No	1=Yes

a) If you answered yes to question 2, please indicate when did you start?

1=less than1 month	2= from 1-2months	3= from 3-4months	4= from 5-6months

b) If you answered yes to question 2, please indicate why?

1=Milk insufficient	2= Mothers desire	3= I had to go back to work	4=Child was unwilling to suckle	5=Medical complications	6=Other

c) If you answered yes to question 2, please indicate where the food was acquired?

1= food prepared for the whole household	2= prepared at household level for the child only using local foods	3= purchased from commercial markets	4=purchased from local markets	5=Other

d) If you answered yes to question 2, please indicate the first solid foods introduced

1= Maize meal soft porridge	2= commercial Ready to eat bottled baby foods	3= mashed fruits and vegetables	4=Meat and meat products	5= Other (Specify)

3. **After 6 months of life did you start to provide foods which will complement breastfeeding or formula milk?**

0=No	1=Yes

a) When exactly did you start giving your child complementary foods

1= Exactly at 7 months	2= 7-8 months	3= After 8-9months	4= from 9 months

b) If you started providing complementary foods after 8-9 months, please indicate why?

1= My breast milk was enough	2= Not aware of food type which I should feed my baby	3= I don't have money to purchase	4=I did not know when to start	5=Other

c) Which type of complementary foods are given to your child?

1= Specially prepared foods	2= usual family foods modified to make them easy to eat	3= commercially available foods	4=Other (Specify)

d) Please indicate the first solid foods provided

1= Maize meal soft porridge	2= commercial Ready to eat bottled baby foods	3= mashed fruits and vegetables	4=Meat and meat products	5= Other (Specify)

e) Number of meals of complementary foods provided a day

1= 0-2 meals	2= 3-4 meals	3= 9-11 meals

SECTION B: CHILDREN'S FOOD INSECURITY ACCESS SCALE (CFIAS)

Recall questions for mothers: each of the questions in the following table is asked with a recall period of four weeks (30 days).

no	Occurrence questions	Response options	Code
1	In the past four weeks, did you worry that your child would not have enough food?	0 = No (skip to Q2) 1=Yes	….|___|
1a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	….|___|
2	In the past four weeks, was your child not able to eat the kinds of foods you preferred because of a lack of resources?	0 = No (skip to Q3) 1=Yes	….|___|
2a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	….|___|
3	In the past four weeks, did you have to feed your child a limited variety of complementary foods due to a lack of resources?	0 = No (skip to Q4) 1=Yes	….|___|
3a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	….|___|
4	In the past four weeks, did you have to feed your child some complementary foods that you really did not want your child to eat because of a lack of resources to obtain other types of food?	0 = No (skip to Q5) 1=Yes	….|___|
4a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks)	….|___|

		3 = Often (more than ten times in the past four weeks)	
5	In the past four weeks, did you have to feed your child a smaller meal than you felt your child needed because there was not enough food?	0 = No (skip to Q6) 1=Yes	….|___|
5a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	….|___|
6	In the past four weeks, did you have to feed your child fewer meals in a day because there was not enough food?	0 = No (skip to Q7) 1=Yes	….|___|
6a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	….|___|
7	In the past four weeks, was there ever no food to feed your child because of lack of resources (physical or financial means) to get food?	0 = No (skip to Q8) 1=Yes	….|___|
7a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	….|___|
8	In the past four weeks, did your child go to sleep at night without consuming any complementary foods because there were no resources to get food?	0 = No (skip to Q9) 1=Yes	….|___|
8a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	….|___|
9	In the past four weeks, did your child go a whole day and night without	0 = No (questionnaire is finished)) 1=Yes	….|___|

	eating any complementary foods expect for breast milk because there was not enough food?		
9a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	….|___|

SECTION C: Dietary intake for children aged 7-12 months; Food frequency and 24hr recall

1. **Usual intake of food items (food frequency).**

NB to Mothers: Please indicate how often the FF foods are given to your child.

Food	**Most days**	**Once a week**	**Seldom (rarely)**	**Never**
Cereals/starches				
Bread				
Maizemeal porridge- Soft				
Maizemeal porridge- Stiff				
Maizemeal porridge- Fermented				
Cooked porridge other, than maizemeal				
Infant cereal				
Rice				
Potato				
Dairy products				
Fresh milk				
Milk powder				
Yoghurt				
Breast milk				
Animal foods				
Red meat				
Chicken				
Fish				
Eggs				
Legumes				
Beans				
Peanut butter				
Vegetables				
Butternut				
Carrots				
Dark-green leafy vegetables				
Cabbage				
Tomato				
Fruits				
Banana				
Orange				
Apple				
Miscellaneous				
Sugar				
Sweets				
Biscuits				
Savory snacks				
Carbonated drinks				
Juice				
Tea				
Coffee				

2. **Individual Diet Diversity Score (IDDS) for children aged 7-24 months during the 24-hour recall period.**

NB for Mothers: Please recall whether you fed your child the following foods in the past 24hours.

Food	**Yes**	**No**
Cereals/starches		
Bread		
Maizemeal porridge- Soft		
Maizemeal porridge- Stiff		
Maizemeal porridge- Fermented		
Cooked porridge other, than maizemeal		
Infant cereal		
Rice		
Potato		
Dairy products		
Fresh milk		
Milk powder		
Yoghurt		
Breast milk		
Animal foods		
Red meat		
Chicken		
Fish		
Eggs		
Legumes		
Beans		
Peanut butter		
Vegetables		
Butternut		
Carrots		
Dark-green leafy vegetables		
Cabbage		
Tomato		
Fruits		
Banana		
Orange		
Apple		
Miscellaneous		
Sugar		
Sweets		
Biscuits		
Savory snacks		
Carbonated drinks		
Juice		
Tea		
Coffee		

APPENDIX C: SURVEY QUESTIONNAIRE IN SEPEDI

Tshedimošo ka moka ye e tla tšweletšwa mo e tla swarwa ka **hlokomelo le šedi e kgolo**.

Leina la monyakišiši:……………………………………………………………………….

Letšatši:…………………………………………………………………………………….

Lefelo:………………………………………………………………………………………

KAROLO A: Dipalopalo tša boemo bja bophelo (tša leago le moruo)

17. Mengwaga ya mohlokomedi |__||__|

18. Ngwana wa lena o na le kgwedi tše kae?........................

19. Ngwana wa lena o kala bokae?.........................

20. Ngwana wa lena ke mong?

1=Mosetsana	2=Mošemane

21. Maemo a lenyalo

1=Ga ka nyalwa	2=Nyetšwe	3=Hladile	4=Mohlologadi

22. Maemo a thuto a mohlokomedi

1=Ga go thuto ya maleba	2=Sa Digotlane	3=Se se phagamego	4=sa thuto ya godimo

23. Maemo a mošomo a mohlokomedi

1=Hirilwe goya goile	2=Hirilwe lebakanyana	3=Ga ke šome	4=Maikhutšong ka bogolo

24. Letseno la lapa la kgwedi?

Ka fase ga R800	R801 – R1500	R1501-R3500	Go feta R3500

25. Palomoka ya maloko a lapa________

26. Re lemoše palo ya maloko go yaka mengwaga

7-12 ya dikgwedi	1-5 mengwaga	6-12 mengwaga	13-19 mengwaga	20-35 mengwaga	36- 59 mengwaga	Ka godimo ga 59

27. Hle re botše ka fao le hwetšago meetse;

1=Pomping ya ka gae	2=Pomping ya setšhaba	3=Bobedi

28. Le na le tšhemo ya merogo ka gae? Ge eba aowa, hle tshelela go potšišo ya 13

0=Aowa	1=Ee

a) Ka kgopelo re lemoše ka bonabo bja tšhemo ya gago ka dihectara

1= ka fase ga 1ha	2=1-2ha	3= 3-4ha	4= ka godimo ga 4ha

b) Ka kgopelo, re lemoše ka fao le hwetšago meetse a go nošetša

1= pompi ya ka gae	2=pompi ya setšhaba	2=meetse a pula	3= Noka	4= Yengwe (Hlatholla)

c) Ge ele Ee, kgopela le lemoše ge le tšweletša go FF;

1= go ja ka gae	2=letseno la tšhelete	3=Bobedi

29. Go na le ba lapa bao ba šeditšego tšweletšo ya dienywa? Ge eba aowa, hle tshelela go potšišo ya 14.

0=Aowa	1=Ee

a) Hle lemoša ge eba dienywa tše di tšweletšwago ke tša FF;

1= go ja ka gae	2= letseno la tšhelete	3=Bobedi

30. Le na le diruiwa ka gae? Ge eba aowa, hle tshelela go potši tshelela go potšišo ya 1o ya 15.

0=Aowa	1=Ee

a) Hle lemoša mohuta wa leruo;

1=Dikgogo	2= Dikgomo	3=Dipudi	Tše dingwe (Hlatholla)

b) Hle lemoša ge eba leruo le ke la FF;

1= Go ja ka gae	2=Letseno la tšhelete	Merero ya setšo	3=Yengwe (Hlatholla)

31. Le humana tshedimošo, efe kapa efe, ka phepo ya bana? Ge eba aowa, hle tshelela go karolo B.

0=Aowa	1=Ee

32. Ge eba Ee, hle lemoša moabi wa tshedimošo ka phepo ya bana

1=Seyalemoya	2= Thelebišene	3= Ba tša maphelo a setšhaba	4=Yengwe (Hlatholla)

Go nyantšha letswele

4. Le nyantšha ngwana letswele?

0=Aowa	1=Ee

a) Ge karabo ya potšišo 1 ele aowa, le fepa ngwana eng legatong la maswi a letswele?

1=Maswi a bana	2= Maswi a phoofolo	3=A mangwe (Hlatholla)

b) Ge karabo ya potšišo 1 ele aowa, le lesitše neng go nyantšha?

1= Ga senke ke thome	2= Kgwedi tše 3 morago ga pelego	3= Kgwedi tše 3-5 morago ga pelego	4= Kgwedi tše 6 morago ga pelego	5= Yengwe (Hlatholla)

f) Ge karabo ya potšišo 1 ele aowa, ke ka lebaka la eng le sa nyantšhe ngwana?

1=Hlaetšo ya maswi	2= Ditumo goba dikganyogo tša mme	3= Ga kena nako	4= Mabaka a maphelo	5= Le lengwe (Hlatholla)

g) Ge karabo ya potšišo 1 ele ee, le thomile neng go nyantšha ngwana?

1= ka fase ga iri e tee morago ga pelego	2= Iri e tee morago ga pelego	3= Ka morago ga letšatši	4=Morago ga matšatši	5= Yengwe (Hlatholla)

h) Ge karabo ya potšišo 1 ele ee, hle hlatholla mokgwa woo wa go nyantšha.

1= Go nyantšha fela	2= Go nyantšha ga ntšhi kudu	3= E sego go nyantšha fela

f) Go na le mathata ao le itemogelang ona ge le nyantšha?

1=Ga ago	2= Bohloko mo matsweleng	3= Ngwana ga ana kganyogo	4=Hlaetšo ya maswi	5=le lengwe (Hlatholla)

Tlaleletšo ya phepo

5. **A be le fepa ngwana dijo tše dingwe ntle le maswi a letswele goba a bana mo dikgweding tše tshela tša mathomo? Ge eba ee, hle araba diputšišo tše di latelago. Ge eba karabo ke aowa, hle tshelela go potšišo 3.**

0=Aowa	1=Ee

a) Ge o arabile ee go potšišo 2, hle laetša gore o thomile neng?

1=ka fase ga kgwedi e tee	2= Go tloga 1-2 ya dikgwedi	3= Go tloga 3-4 ya dikgwedi	4= Go tloga 5-6 ya dikgwedi

b) Ge o arabile ee go potšišo 2, hle laetša lebaka?

1=Hlaetšo ya maswi	2= Kganyogo ya mme	3= Go boela mošomong	4=Ngwana obe a sena kganyogo ya go nyanya	5=Hlakahlakano ya tša maphelo	6=Le lengwe

c) Ge o arabile ee go potšišo 2, hle laetša gore dijo di hweditšwe kae?

1= Dijo tša lapa ka moka	2= di apeilwe ka gae di apeelwa ngwana fela	3= di rekilwe mabenkeleng	4=rekilwe mebarakeng a mo gae	5=le lengwe

d) Ge o arabile ee go potšišo 2, hle laetša dijo tša go tia tše o thomilego ka tšona?

1= Motepa wa mabele a lefela	2= dijo tša go rekwa di lokišeditšweng ruri ka mabotlolong	3=Merogo goba dienywa tša go tubiwa	4=Nama le ditšweletšwa tša nama	5= Ye ngwe (Hlatholla)

6. **Morago ga dikgwedi tše tshela tša bophelo, a le thomile go fa ngwana dijo tša go tlaletša go nyantšha letswele goba maswi a bana?**

0=Aowa	1=Ee

a) Botse le thomile neng go fa ngwana dijo tša tlaleletšo ya phepo?

1= Ka dikgwedi tše 7 thwii	2= ka dikgwedi tše 7-8	3= Morago ga kgwedi tše 8-9	4= Morago ga kgwedi tše 9

b) Ge o thomile go diriša dijo tša tlaleletšo ya phepo ka dikgwedi tše 8-9, hle hlatholla ka lebaka?

1= Maswi aka a letswele abe a lekane	2= Go hloka tsebo ka mehuta ya dijo yeo nka efago ngwana'ka	3= Ga kena tšhelete ya go reka	4=E ke sa tsebe gore ke thome neng	5=Engwe

c) Ke mohuta ofe wa dijo tša tlaleletšo ya phepo yeo di fiwago ngwana wa lena?

1= Dijo tša go lokišwa ka mokgwa wa go ikgetha	2= Dijo tša lapa empa tšeo di nolofaditšwego go swanela ngwana	3= Dijo tša mabenkeleng kgoparara	4=Tše dingwe (Hlatholla)

d) Hle laetša dijo tša go tia tšeo le thomilego ka tšona

1= Motepa wa mabele a lefela	2= Dijo tša go rekwa di lokišeditšwe ruri ka mabotlolong	3= Merogo goba dienywa tša go tubiwa	4= Nama le ditšweletšwa tša nama	5= Ye ngwe (Hlatholla)

i) Nomoro ya dijo tša tlaleletšo ya phepo mo letšatšing

1= 0-2 ya dijo	2= 3-4 ya dijo	3= 9-11 ya dijo

KAROLO B: HLAELELO YA KHUMANEGO YA DIJO GO BANA

Biletša dipotšišo go bahlokomedi: Yengwe le yengwe ya dipotšišo tše di latelago e botšišwa ka kgopolo ya lebaka la dibeke tše nne (Matšatši a 30).

no	Dipotšišo tša go hlaga	Kgetho go dikarabo	Code
1	Mo dibekeng tše nne tša go feta, a le kile wa hlobaela gore ngwana wa lena aka se hwetše dijo tše lekanetšego?	0 = Aowa (Tshelela go Q2) 1=Ee	….|___|
1a	E hlagile ga kae?	1 = Ga nnyane (Ga tee goba ga bedi go dibeke tše nne tša go feta) 2 = Nako yengwe (Ga raro goya go lesome mo go dibeke tše nne tša go feta) 3 = Ga ntšhi (Go feta makga a lesome go dibeke tše nne tša go feta)	….|___|
2	Mo dibekeng tše nne tša go feta, a ngwana ga a kgona go ja dijo tšeo motswadi a mo lakaletšago tsona, ka baka la go hlaetša ga motswadi?	0 = Aowa (Tshelela go Q3) 1=Ee	….|___|
2a	E hlagile ga kae?	1 = Ga nnyane (Ga tee goba ga bedi go dibeke tše nne tša go feta) 2 = Nako yengwe (Ga raro goya go lesome mo go dibeke tše nne tša go feta) 3 = Ga ntšhi (Go feta makga a lesome go dibeke tše nne tša go feta)	….|___|
3	Mo dibekeng tše nne tša go feta, a le kile la gapeletšega go ješa ngwana mehuta e menyane ya dijo tša tlaleletšo ya phepo ka baka la go hlaetša?	0 = Aowa (Tshelela go Q4) 1= Ee	….|___|
3a	E hlagile ga kae?	1 = Ga nnyane (Ga tee goba ga bedi go dibeke tše nne tša go feta) 2 = Nako yengwe (Ga raro goya go lesome mo go dibeke tše nne tša go feta) 3 = Ga ntšhi (Go feta makga a lesome go dibeke tše nne tša go feta)	….|___|
4	Mo dibekeng tše nne tša go feta, a le kile la gapeletšega go ješa ngwana mehuta ya dijo tša tlaleletšo ya phepo yeo le be le sa nyake a dija, eupša ka baka la go hlaetša la se hwetše mehuta e mengwe?	0 = Aowa (Tshelela go Q5) 1= Ee	….|___|
4a	E hlagile ga kae?	1 = Ga nnyane (Ga tee goba ga bedi go dibeke tše nne tša go feta) 2 = Nako yengwe (Ga raro goya go lesome mo go dibeke tše nne tša go feta) 3 = Ga ntšhi (Go feta makga a lesome go dibeke tše nne tša go feta)	….|___|
5	Mo dibekeng tše nne tša go feta, a le kile la gapeletšega go ješa ngwana dijo tše ese di lekanego seatla, eupša ka baka la go hlaelelo ya dijo?	0 = Aowa (Tshelela go Q6) 1= Ee	….|___|

5a	E hlagile ga kae?	1 = Ga nnyane (Ga tee goba ga bedi go dibeke tše nne tša go feta) 2 = Nako yengwe (Ga raro goya go lesome mo go dibeke tše nne tša go feta) 3 = Ga ntšhi (Go feta makga a lesome go dibeke tše nne tša go feta)	….|___|
6	Mo dibekeng tše nne tša go feta, a le kile la gapeletšega go ješa ngwana dijo tša ka fase ga palo ya letšatši, eupša ka baka la go hlaelelo ya dijo?	0 = Aowa (Tshelela go Q7) 1= Ee	….|___|
6a	E hlagile ga kae?	1 = Ga nnyane (Ga tee goba ga bedi go dibeke tše nne tša go feta) 2 = Nako yengwe (Ga raro goya go lesome mo go dibeke tše nne tša go feta) 3 = Ga ntšhi (Go feta makga a lesome go dibeke tše nne tša go feta)	….|___|
7	Mo dibekeng tše nne tša go feta, a le kile la hloka dijo tša ngwana ka baka la go hlaetša (tshelete goba seemong) ya dijo?	0 = Aowa (Tshelela go Q8) 1= Ee	….|___|
7a	E hlagile ga kae?	1 = Ga nnyane (Ga tee goba ga bedi go dibeke tše nne tša go feta) 2 = Nako yengwe (Ga raro goya go lesome mo go dibeke tše nne tša go feta) 3 = Ga ntšhi (Go feta makga a lesome go dibeke tše nne tša go feta)	….|___|
8	Mo dibekeng tše nne tša go feta, ngwana o ile a robala ase a fiwa dijo tša tlaleletšo ya phepo ka baka la go hloka ditlabakelo tša go hwetša dijo?	0 = Aowa (Tshelela go Q9) 1= Ee	….|___|
8a	E hlagile ga kae?	1 = Ga nnyane (Ga tee goba ga bedi go dibeke tše nne tša go feta) 2 = Nako yengwe (Ga raro goya go lesome mo go dibeke tše nne tša go feta) 3 = Ga ntšhi (Go feta makga a lesome go dibeke tše nne tša go feta)	….|___|
9	Mo dibekeng tše nne tša go feta, ngwana o ile a fetša letšatši ka moka a se aja dijo tša tlaleletšo ya phepo goba maswi a letswele ka baka la go hlaetša dijo?	0 =Aowa (Bofelo bja lenaneopotšišo) 1= Ee	….|___|
9a	E hlagile ga kae?	1 = Ga nnyane (Ga tee goba ga bedi go dibeke tše nne tša go feta) 2 = Nako yengwe (Ga raro goya go lesome mo go dibeke tše nne tša go feta) 3 = Ga ntšhi (Go feta makga a lesome go dibeke tše nne tša go feta)	….|___|

KAROLO C: Dijo tša phepo ya bana ba dikgwedi tše 7-12; Kgafetšo-kgafetšo ya dijo le Kgopolo ya diiri tše 24.

3. **Dijo tše di jewago ka setlwaedi (Kgafetšo-kgafetšo ya dijo).**

Kelo Hloko go bahlokomedi: Hle lemoša gore ke makga a ma kae ao dijo tša Kgafetša di fiwago ngwana wa lena.

Dijo	Bontši bja Matšatši	Ga tee mo bekeng	Morago ga sebaka	Ga senke
Cereals/starches				
Borotho				
Motepa wa bupi bja mafela				
Bogobje bja bupi bja mafela				
Ting ya bupi bja mafela				
Bogobje bja mabelethoro				
Cereal tša bana				
Rice				
Matsapane				
Ditšweletšwa tša lebese/maswi				
lebese				
Maswi a lerole				
Yoghurt				
Lebese la letswele				
Diphoofolo tša dijo				
Nama e hubedu				
Kgogo				
Hlapi				
Mae				
Legumes				
Dibonkisi				
Tokomane/botoro ya dimake				
Merogo				
Lephotse				
Carrots				
Merogo ya matlakala a matala-tala				
Khabetšhe				
Tamati				
Dienywa				
Panana				
Namune				
Apola				
Hlakahlakano				
Swikiri				
Dimonomonane/malekere				
Dikuku				
Dimonamonane tša letswai				
Dinomapholi				
Juice				
Tee				
Kofi				

4. **Meputso ya go fapafapana ga phepo/dijo (IDDS) tša bana ba kgwedi tše 7-24 mo diiring tše 24 tša go feta.**

Kelo Hloko go bahlokomedi: Hle gopodišiša ge ekaba o file ngwana dijo tše di latelago mo diiring tše 24 tša go feta.

Dijo	**Ee**	**Aowa**
Cereals/starches		
Borotho		
Motepa wa bupi bja mafela		
Bogobje bja bupi bja mafela		
Ting ya bupi bja mafela		
Bogobje bja mabelethoro		
Cereal tša bana		
Rice		
Matsapane		
Ditšweletšwa tša lebese/maswi		
lebese		
Maswi a lerole		
Yoghurt		
Lebese la letswele		
Diphoofolo tša dijo		
Nama e hubedu		
Kgogo		
Hlapi		
Mae		
Legumes		
Dibonkisi		
Tokomane/botoro ya dimake		
Merogo		
Lephotse		
Carrots		
Merogo ya matlakala a matala-tala		
Khabetšhe		
Tamati		
Dienywa		
Panana		
Namune		
Apola		
Hlakahlakano		
Swikiri		
Dimonomonane/malekere		
Dikuku		
Dimonamonane tša letswai		
Dinomapholi		
Juice		
Tee		
Kofi		

APPENDIX D: FOCUS GROUP DISCUSSION GUIDE IN ENGLISH
Focus group discussion guide

A. child feeding practices

Explore caregiver's perceptions on child feeding practices

- Perceived benefits/ non-benefits of breastfeeding?
- Initiation of complementary feeding?
- What types of complementary foods are made for children?
- How are they prepared? (Observe recipes and hygiene practices)
- Are there special foods made with leafy vegetables?

B. Decision influencing the selection and purchasing of complementary foods

Observe whether children aged 7-12 months have their own special grocery (different from household food basket).

- What is the criteria for selecting perceived appropriate complementary food?
- Do they purchase commercial complementary foods? What are the challenges?
- What informs their decisions when buying complementary foods?
- What are the key determinants that guide their complementary foods purchases?

C. Knowledge on Moringa plant

- **Mothers** perception on the plant?
- The value of the plant to **Mothers**?
- Observe any special medicine/foods prepared for children using Moringa.

D. Willingness to use Moringa leaves in complementary food preparation

Would you be eager to use Moringa as a major ingredient when preparing complementary foods for your child?

- What are the concerns?
- Why are they willing?
- What dishes could be made with Moringa leaves and why those specific dishes?

E. Willingness to produce and process Moringa

What are the perceived reasons for this willingness?

F. Willingness to purchase Moringa food based complementary products if they could be commercialised

Why do they think they would buy it?

- Perceived advantages or disadvantages over commonly purchased complementary foods?
- How much would they pay for it and why

APPENDIX E: FOCUS GROUP DISCUSSION GUIDE IN SEPEDI

Hlahlo ya Sehlopha sa Baahlaahli

G. Mekgwa ya go fepa bana

Nyakishiso ya pono ya moledi/mohlokomedi go mekgwa ya go fepa bana

- Mmono wa dipoelo tse botse/mpe tsa go nyantsha letswele?
- Go thoma ga tekatekanyetso ya go fepa?
- Ke dijo tsa mohuta ofe tsa go lekalekanya phepo ya bana?
- Di apewa/lokiswa bjang? (Ela hloko ya metswako le hlweko)
- Go na le dijo tse di kgethegilego tsa go ba le merogo ya matlakala?

H. **Sephetho sa go huetsa kgetho le theko ya dijo tsa phepo**

Lekola gore bana ba dikgwedi tsa magareng ga supa le lesomepedi ba rekelwa dijo tsa go ikgetha tsa bona (tsa go fapana le tsa ba bagolo ka gae).

- Ke mokgwa ofe wo o somiswago go kgetha dijo tseo di bonalago okare di tlaleletsa phepo?
- Ba reka dijo tsa go tlaleletsa phepo mo mabenkeleng kgoporara? Ekaba dihlohlo ke eng?
- Ba hlahla ke eng ge ba reka dijo tsa go tlaleletsa phepo?
- Ke dife ditshupo tsa go hlahla go reka ga bona dijo tsa go tlaleletsa phepo?

I. Tsebo ya semela sa Moringa

- Mmono wa moledi go semela se?
- Boleng bja semela se go moledi?
- Lekola sehlare goba dijo tse di kgethegilego tsa go direlwa bana tse di na le Moringa

J. Kamogelo ya go dirisa matlakala a Moringa ka gare ga dijo tsa tlaleletso ya phepo

- A o ka amogela go dirisa semela sa Moringa bja ka motswako mogolo ge o lokisa dijo tsa phepo ya tlaleletso go bana?
- Dingongorego e ka ba dife?
- Go reng ba dumela?
- Ke dijo dife tse di ka hlakantshwago le matlakala a Moringa, gape lebaka ke lefe la go a hlakanya le dijo tseo?

K. Maikemisetso a go bjala le go tsweletsa Moringa

Ekaba mabaka afe a maikemisetso a se?

L. Maikemisetso a go reka dijo tsa tlaleletso ya phepo tsa goba le Moringa ge di ka rekiswa mabenkeleng kgoparara

Nkane ba nagana gore batla di reka?

- Mmono wa dipoelo tse botse goba tse mpe wa dijo tse tlwaelegilego tsa go tlaleletsa phepo?
- Ba ka lefela bokae le gona lebaka ele lefe?

APPENDIX F: ETHICS APPROVAL LETTER FROM UKZN

UNIVERSITY OF KWAZULU-NATAL

INYUVESI YAKWAZULU-NATALI

8 February 2016

Ms Sithandiwe Khoza 209500150
School of Agriculture, Earth and Environmental Sciences
Pietermaritzburg Campus

Dear Ms Khoza

Protocol reference number: HSS/1244/015D
Project Title: The potential of Moringa oleifera leaf powder for use in complementary foods to combat malnutrition in children aged 7 to 12 months

Full Approval – Full Committee Reviewed Protocol

In response to your application received 3 September 2015, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL**.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

Dr Shenuka Singh (Chair)
Humanities & Social Scinces Research Ethics Committee

/pm

Cc Supervisor: Dr Unathi Kolanisi
Cc Academic Leader Research: Professor Onisimo Mutanga
Cc School Administrator: Ms Marsha Manjoo

Humanities & Social Sciences Research Ethics Committee
Dr Shenuka Singh (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 3587/8350/4557 Facsimile: +27 (0) 31 260 4609 Email: ximbap@ukzn.ac.za / snymanm@ukzn.ac.za / mohunp@ukzn.ac.za
Website: www.ukzn.ac.za

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APPENDIX G: APPROVAL LETTER FROM HAMMANSKRAL MUNICIPALITY

CITY OF TSHWANE

Councillor A.K Phahlane
Ward 13
Room 208 | 2nd Floor | Temba Council Offices | 4244 Jubilee Road | Temba | 0407
Private Bag X 1019/Temba | 0407
Cell: 083 9501 339
Email:AlfredP@Tshwane.gov.za | www.tshwane.gov.za

My ref:
Your ref:
Contact person: Khala Phahlane
Section/Unit: Ward Councillor

Tel: 083 9501 339
Fax:
Email:AlfredP@tshwane.gov.za
Date 14 October 2015

Dr Unathi Kolanisi

Re: Permission to conduct research in Hammanskraal community.

We welcome and permit your student from the University of Kwazulu-Natal Ms. SL Khoza (student no. 209500150) to conduct her research studies in our community.

We further commit to help her with whatever assistance she may need

Should further clarity regarding the matter be sought please do not hesitate to contact the ward Councillor Concern.

Thanking you in anticipation.

Regards

Cllr. A.K. Phahlane

[illegible]
[illegible]
Office of the Speaker

APPENDIX H: APPROVAL LETTER FROM LIMPOPO

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

Department of agriculture, Lebowakgomo

Private bag X28

Chuenespoort

0745

Date: 10 May 2016

Dear Dr Kolanisi

Re: Permission to conduct research in Lebowakgomo

This letter serves to confirm that your student Ms SL Khoza has been granted permission to conduct her study in Lebowakgomo. Mrs Maureen Chaba (0729163130/0823813666) has been assigned to assist the student with organising relevant study participants and showcasing different moringa projects in Lebowakgomo.

Yours Sincerely

Dr Zwane

Contact: 082 808 7173/ 015 287 6017

Email: Zwanefrank@gmail.com

APPENDIX I: STANDARDIZED COMPLEMENTARY WHITE MAIZE SOFT PORRIDGE RECIPE

Soft porridge (four servings)

Ingredients

1. 750ml of water
2. 120g of white maize meal

Method

1. Heat 500ml of water to a boiling point
2. Combine 120g of white maize meal with 250ml of water in a bowl to make a smooth paste.
3. Add the smooth paste to the boiling water
4. Continue to stirre until the mixture is well combined
5. Let the mixture cook for 20 minutes

APPENDIX J: SENSORY EVALUATION QUESTIONNAIRE IN ENGLISH
Participant number: ---------------------------------

Sample number: -------------------------------------

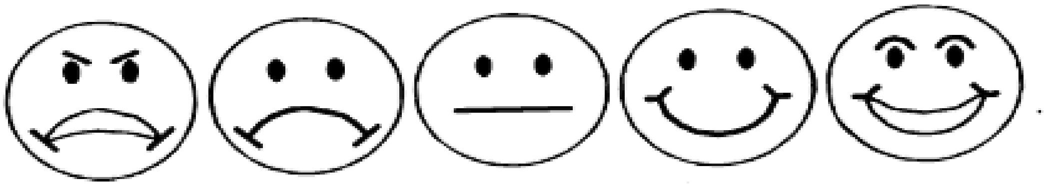
Gender: ---

Date of birth: |__||__||__||__|

Instructions

- Please assess the food sample in front of you. Then indicate how you feel about the taste, smell, colour, mouth feel and the overall acceptability by placing **X** over the face indicating your liking.
- Please rinse your mouth with water before starting. You may rinse again at any time during the test if you need to.
- If you have any questions, please ask and you may test the sample as many times as you like

TASTE



Very bad Bad Average Good Very good

TEXTURE

Very bad Bad Average Good Very good

AROMA

Very bad Bad Average Good Very good

COLOUR

Very bad Bad Average Good Very good

OVERALL ACCEPTABILITY

Very bad Bad Average Good Very good

APPENDIX K: SENSORY EVALUATION QUESTIONNAIRE IN SEPEDI

Leina la motšeakarolo: ---------------------------------

Nomoro ya sample: -------------------------------------

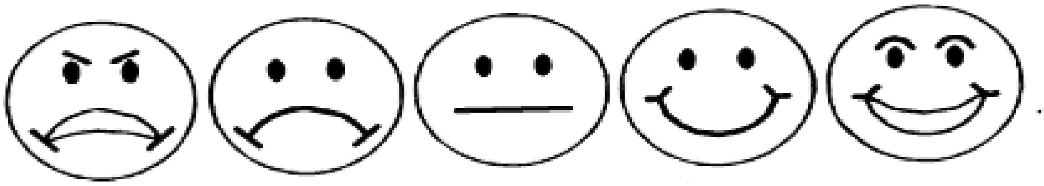
Bong: ---

Tšatši la matswalo: |__||__||__||__|

Ditaelo

- Ka kgopelo lekola dijo tse di lego mo pele ga gago. Lemoša ka o ikwago mabapi le tatso, monkgo, mmala, ka ganong le kakaretso ya go amogelega ga sona ka go swaya ka **X** mo sefahlegong/seswantšhong sa go laetsa maikutlo a gago.
- Kgopelo ke ya gore o tšokotše molomo wa gago ka meetse pele o thoma. O ka buseletsa go tšokotša ka meetse nako engwe le engwe ge go hlokagala.
- Ge o nale dipotšišo, re kgopela o butšiše le gona o dumeletšwe go lekola dijo tše makga a mmalwa go ya ka fao o ratago.

TATSO



Ye mpe kudu　Ye mpe　Magareng　Bose　Bose kudu

SEBOPEGO

Se mpe kudu　Se mpe　Magareng　Botse　Botse kudu

MONKGO

O mobe kudu　O mobe　Magareng　Bose　Bose kudu

MMALA

O mobe kudu | O mobe | Magareng | Bose | Bose kudu

KAMOGELO KAKARETŠO

Ye mpe kudu | Ye mpe | Magareng | Botse | Botse kudu

APPENDIX L: PREFERENCE TEST IN ENGLISH

Participant number: ---------------------------------

Gender: --

Age:|__||__|

Instructions

Please rinse your mouth with water before starting.

Please taste the two food samples in the order given, from left to right.

Please write all the samples you tested in the space provided.

Please circle the number of the sample that you prefer.

________ ________ ________ _______

Thank you for taking part in this study

APPENDIX M: PREFERENCE TEST IN SEPEDI

Nomoro ea sehlopha: ---------------------------------

Tekano: ---

Lilemo:|__||__|

Instructions

Ka kopo hlakola molomo oa hau ka metsi pele u qala.

Ka kopo latsoa li-sampuli tse peli tsa lijo ka taelo e fanoeng, từ trái để phải.

Ka kopo ngola mehlala eohle eo u e lekiloeng sebakeng se fanoeng.

Ka kopo, potoloha nomoro eo u e khethang.

_________ _________ _________ ________

Kea u leboha ka ho kenya letsoho thutong ena.

APPENDIX N: PARTICIPATION INFORMATION SHEET IN ENGLISH

Participant information sheet

Dear Caregiver

We are requesting your consent to participate in the tasting of fortified complementary foods. The reason for this study is to gather information on the acceptability. The complementary food contains high amounts of energy, proteins and nutrients which are lacking in many of the children's diet. In South Africa, there is a high rate of malnutrition, in particular under-nutrition which results from not eating enough food to meet energy and micronutrient needs. This contributes to high rates of child illnesses, growth failure and deaths in the country. In order to help minimize the effect of malnutrition, the Moringa-based complementary foods can be introduced to the diet of the malnourished child. However, the acceptability of this product in South African children is not known, and this is important as people usually eat food that is acceptable and liked by them.

This research will be conducted by Sithandiwe Khoza, a PhD student in the Discipline of Food Security at the University of KwaZulu-Natal, under the guidance of Dr Kolanisi. Your participation is requested for one session of 30-45 minutes. During this time, you will be provided with an unlabelled sample and be asked to evaluate it using a standard scale. The following principles will be followed in order to ensure that your rights are protected:

- Participation is voluntary;
- Participation will cost you nothing
- Tape recorder will be used, and pictures will be capture during the session;
- You can withdraw at any time with no consequences; and
- All information will be kept confidentially and in line with the standard of the UKZN research ethics committee;

Should you have any questions about the research, please contact Dr U. Kolanisi at 033 260 6342 or Kolanisi@ukzn.ac.za. Thank you for your cooperation and hope you will agree to participate in the study. If you consent, please sign the attached consent form

Sincerely

-------------------- ------------------------

Dr Kolanisi Sithandiwe Khoza

I ………………………………………….(name of caregiver) hereby declare that I understand the above information and that I was given an opportunity to ask questions if there was anything that was not clear. I understand the aim of the study and the benefits it holds, as well as the way in which the study will be conducted. Furthermore, I understand that there will be no risk or discomforts from participating in the study and that I may withdraw from the study at any time without any consequences.

Signed……………………… (Caregiver) Date……………………………

Additional consent, where applicable

I hereby provide consent to:

Audio-record my interview / focus group discussion YES / NO

Video-record my interview / focus group discussion YES / NO

Use of my photographs for research purposes YES / NO

______________________	______________________
Signature of Participant	**Date**
______________________	______________________
Signature of Witness	**Date**
(Where applicable)	
______________________	______________________
Signature of Translator	**Date**
(Where applicable)	

APPENDIX O: LETTER REQUESTING PARTICIPATION IN ENGLISH

LETTER REQUESTING PARTICIPATION

I, the undersigned, ______________________________(Full Name) participant, Tel: ___________________,

Have been fully informed of:

- It is my responsibility to report prior to participation to the investigators any allergies I may have;
- The purpose of this study;
- That my participation is voluntary;
- That I can withdraw at any time;
- That a tape recorder will be used & pictures will be captured during the session;
- That participation will cost me nothing; and
- That all information given will be kept confidential.

I agree to:

Sensorial test the quality of complementary foods and participate in a focus group discussion.

This consent form was explained to me by _____________________ (Full Name), in ______________________ (language) and I confirm that I have understood.

I _________________________________ (full name) agree to voluntarily take part in this research project.

_________________________ ______________________

(Participants signature or mark) (Witness)

Signed at: ___________________________ on ______/__________/_____ 2015.

Additional consent, where applicable

I hereby provide consent to:

Audio-record my interview / focus group discussion YES / NO

Video-record my interview / focus group discussion YES / NO

Use of my photographs for research purposes YES / NO

_____________________ _____________________

Signature of Participant **Date**

_____________________ ______________________

Signature of Witness **Date**

(Where applicable)

_____________________ ______________________

Signature of Translator **Date**

(Where applicable)

APPENDIX P: CONSENT FORM FOR CAREGIVERS IN ENGLISH

Consent form for caregivers

My name is sithandiwe Linda Khoza and I am a full-time student at the University of KwaZulu-Natal registered for PhD (food security). I would like you to participate in a study evaluating the acceptance of complementary food products. Therefore, you will be required to evaluate complementary foods and further rate each the foods using a simple picture scale indicating your views on the taste, texture, smell, colour and overall acceptability.

It is essential to know that:

- All the data collected from this study will remain confidential and will only be used for the purpose of this project. All participants will remain anonymous.
- Participation in this study is voluntary, participants are free to leave the study any time they wish, without any negative consequences.
- There are no potential benefits from participating in this study. No participants will receive any payments or financial reimbursements for participating in this research project.
- Audio recordings and pictures will be captured during the session
- All information will be kept confidentially and will only be used for the purpose of this study.
- All information will be destroyed when it is no longer needed.
- For any further information with the study, you may contact Dr Kolanisi who is the supervisor of the study at 033 260 6342 or kolanisi@ukzn.ac.za

Declaration:

I ________________________________ (full name and surname) hereby confirm my understanding of the questionnaire and I understand the purpose of this research project and how the information will be collected. I consent to participating in the research project.

I understand that participation is voluntary, and I can leave the study if I desire.

_________________________ _________________________

Signature (Caregiver) Date

Additional consent, where applicable

I hereby provide consent to:

Audio-record my interview / focus group discussion YES / NO

Video-record my interview / focus group discussion YES / NO

Use of my photographs for research purposes YES / NO

____________________ ____________________

Signature of Participant **Date**

____________________ ____________________

Signature of Witness **Date**

(Where applicable)

____________________ ____________________

Signature of Translator **Date**

(Where applicable)

Humanities & Social Sciences Research Ethics Committee (HSSREC)

Dr Shenuka Singh (chair)

Westville Campus, Govan Mbeki Building

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Telephone: +27 (0)31 260 3587/8350/4557 Facsimile: +27 (0)31 260 4609

Email: ximbap@ukzn.ac.za / snymanm@ukzn.ac.za

Website: www.ukzn.ac.za

APPENDIX Q: PARTICIPATION INFORMATION SHEET IN SEPEDI

Letlakala la tshedimošo ya motšeakarolo

Mohlokomedi yo a rategago

Re kgpela tumello ya lena go tšea karolo mo go lekoleng ga tatso ya dijo tša goba le Moringa. Lebaka la dinyakišišo tše ke go kgoboketša tshedimošo ka go amogelega ga dijo tša go tswakwa le Moringa tšeo di dirišwago go tlaleletša phepo ya bana. Dijo tše tša tlaleletšo ya phepo di na le dipalo tša godimo tša mafolofolo, le diaga mmele tšeo di hlaelelago mo phepong ya bana ba bantši. Mo Afrika Borwa, go na le palo ya godimo ya phepompe, kudu kudu phepo ye e hlaelelago yeo e hlolwago ke go ja dijo tše nnyane ka phepo goba ka palo yeo e hlokegago ka letšatši. Se se baka palo ya godimo ya malwetši a bana, go se gole gabotse le mahu ka mo nageng. Gore re kgone go fokotša phepompe, dijo tšeo di tswakilwego le Moringa tša tlaleletšo ya phepo ya bana, di ka thomišwa. Fela kamogelo ya bana ba Afrika Borwa go dijo tša go tswakwa le Moringa ga e tsebwe, ebile se se bohlokwa ka ge batho ba eja dijo tšeo di amogelegago ebile di ratwa ke bona.

Dinyakišišo tše di tla be di dirwa ke Sithandiwe Khoza, yoo elego moithuti yo a phagamego ka lefapheng la Polokego ya Dijo kua Unibesithi ya KwaZulu-Natal (UKZN), ka fase ga hlahlo ya Dr Kolanisi. Gokgathatema ga lena go hlokega lekga le tee la go kaba metsotso ye 30 goya go ye 45. Mo nakong yeo, le tla fiwa dijo tšeo di sa ngwalwago. Le tla kgopelwa go di lekola le diriša sehlahli sa go swana. Go tla obamelwa tše di latelago go kgonthiša gore ditokelo tša gago di a šireletšwa:

- Kgathotema ke ya biokgafo;
- A go lefelwe selo go tšea karolo;
- Segatiša mantšu le dinepe di tla tšewa ge gole gare go ahlaahlwa;
- Le ka ikgogela morago ntle le ditlamorago tše mpe; gape
- Tshedimošo ka moka yeo e tlago go tšewa fa e tla bolokwa ga botse ebile e tla dirišwa go dinyakišišo tša projeke ye fela go ya ka melao ya komiti ya maitshwaro a dinyakišišo ya UKZN;

Mabapi le kgopelo ya tshedimošo e nabilego, le ka ikgokaganya le Dr Kolanisi yoo elego mofahloši le mohlahli wa dinyakišišo tše mo go 033 260 6342 goba kolanisi@ukzn.ac.za. Re leboga tšhomišano ya lena gape re holofela gore le tla dumela go tšea karolo. Ge le dumela, swaying lengwalo ya tumelo leo le momagantšwego le letlakala le.

Ba lena,

--------------------   ------------------------

Dr Kolanisi   Sithandiwe Khoza

Nna ________________________________ (Leina la mohlokomedi) ke kgonthišiša kwešišo yaka ya tshedimošo yaka godimo, ebile ke filwe monyetla wa go botšišsa ge kebe ke na le kgakanego. Ke kwešiša mohola wa dinyakišišo tša projeke ye le gore tshedimošo e tla kgoboketšwa bjang. Go feta fao, ke kwešiša gore go kgatha tema gaka fa ga go mpeye kotsing ebile nka tlogela go tšea karolo mo dinyakišišong tše nako efe goga efe ntle le ditlamorago.

__________________________   ________________________

Leswao (Mohlokomedi)   Letšatšikgwedi

Tumelelo ya tlaleletšo, mo go Hlokegago

Ke dumelela tše di latelago:

Go gatišwa ga lentšu laka ka nako ya dinyakišišo / sehlopheng sa baahlaahli	Ee / Aowa
Go gatišwa ga di tiragalo tsa dinyakišišo / sehlopheng sa baahlaahli	Ee / Aowa
Go dirišwa ga dinepe/diswantšho tša ka mo projekeng	Ee/ Aowa

______________________ ______________________

Leswao la mokgathatema **Letšatšikgwedi**

______________________ ______________________

Leswao la hlatse **Letšatšikgwedi**

(mo go hlokegago)

______________________ ______________________

Leswao la toloki **Letšatšikgwedi**

(mo go hlokegago)

APPENDIX R: LETTER REQUESTING PARTICIPATION IN SEPEDI

LENGWALO LA GO KGOPELA GOTŠEAKAROLO

Nna, mosaeni ka fase, _____________________________(Leina ka botlalo) mokgathatema, Mogala: __________________,

Ke tsebišitšwe go tlalang seatla gore:

- Ke maikarabelo aka go tsebiša, pele ga gokgathatema, banyakišiši ka dijo tšeo ke di ilago ka baka la ge di sa kwane le mmele waka goba maphelo aka;
- Mohola wa dinyakišišo tše;
- Go kgatha tema gaka ke ka boikgafo ba go hloka tefo;
- Nka lesa goba go ikgogela morago nako efe goba efe;
- Go tla dirišwa segatiša mantšu le dinepe di tla tšewa ge rele gare re kgatha tema;
- Gokgathatema gaka go ka se ntefiše selo; le
- Tshedimošo yaka e tla swarwa bja ka sephiri.

Ke dumela go:

Lekola (ka goja, bona, labella, le go dupa) boleng bja dijo le go tšea karolo go sehlopha sa Baahlaahli.

Lengwalo le la tumello ke le hlaloseditše ke ____________________ (Maina aka botlalo), ka _____________________ (leleme) ebile ke kgonthišiša gore ke kwešišitše.

Nna ________________________________ (Maina ka botlalo) ke dumelelana le go tšea karollo mo projeke ye.

________________________ ______________________

(Leswao la motšeakarolo) (Hlatse)

E swailwe mo: ___________________________ ka ______/__________/_____ 2015.

Tumelelo ya tlaleletšo, ge go hlokega

Ke dumelela tše di latelago:

Go gatišwa ga lentšu laka ka nako ya dinyakišišo / sehlopheng sa baahlaahli	Ee / Aowa
Go gatišwa ga di tiragalo tsa dinyakišišo / sehlopheng sa baahlaahli	Ee / Aowa
Go dirišwa ga dinepe/diswantšho tša ka mo projekeng	Ee/ Aowa

_____________________ _____________________

Leswao la mokgathatema **Letšatšikgwedi**

_____________________ ______________________

Leswao la hlatse **Letšatšikgwedi**

(mo go hlokegago)

_____________________ ______________________

Leswao la toloki **Letšatšikgwedi**

(mo go hlokegago)

APPENDIX S: CONSENT FORM IN SEPEDI

Lengwalo la tumelelo go ya go Bahlokomedi

Leina laka ke Sithandiwe Linda Khoza. Ke moithuti wa thuto ya godimo ya bongaka ka mangwalo (ke lebeletše tšhireletšo ya dijo) ka Unibesithi ya KwaZulu-Natal. Nka thabela go kgatha tema ga lena mo dinyakišišong tša go lekola kamogelo ya mehuta ya dijo tša tlaleletšo ya phepho go bana. Ka fao, ge le dumela le tla kgopelwa gore le lekole dijo tša tlaleletšo le go hlahloba sejo se sengwe le se sengwe le diriša tekanyo yeo e tšweletšwago ka seka sa ditshwantšho. Le tla diriša diswantšho tšeo go hlatha pono ya lena mo go takatso, tebello, monkgo, mmala le kamogelo kakaretšo ya sejo seo.

Go bohlokwa go tseba gore:

- Tshedimošo ka moka yeo e tlago go tšewa fa e tlaba sephiri ebile e tla dirišwa fela go dinyakišišo tša projeke ye fela. Batšeakarolo ka moka e tlaba bo hlokaina.
- Go kgathatema dinyakišišong tše ke boikgafo ba ntle le tefo, empa bakgathatema ba ka ikgogela morago ntle le ditlamorago tše mpe.
- Ga go meputso yeo e ka bago gona go batšeakarolo. Ka fao, ga go motšeakarolo yo a tlago hwetša tšhelete goba mpho ya ditebogo gotšwa projekeng ye ya dinyakišišo.
- Segatiša mantšu le dinepe di tla tšewa ge gole gare go ahlaahlwa.
- Tshedimošo ka moka yeo e tlago go tšewa fa e tla bolokwa ga botse ebile e tla dirišwa go dinyakišišo tša projeke ye fela.
- Tshedimošo ka moka e tla senywa morago ga go dirišwa goba ge e feletšwe ke mošomo.
- Mabapi le kgopelo ya tshedimošo e nabilego, le ka ikgokaganya le Dr Kolanisi yoo elego mofahloši le mohlahli wa dinyakišišo tše mo go 033 260 6342 goba kolanisi@ukzn.ac.za

Boitlamo:

Nna _________________________________ (Maina ka botlalo le sefane) ke kgonthišiša kwešišo yaka ya lenaneopotšišo le, mmogo le mohola wa dinyakišišo tša projeke ye le gore tshedimošo e tla kgoboketšwa bjang. Ke fana ka tumelelo ya go kgathatema gaka mo dinyakišišong tše.

Ke kwešiša gore go kgatha tema gaka fa ke boikgafo bo senago tefo ebile nka tlogela go tšea karolo mo dinyakišišong tše nako efe goga efe.

__________________________ __________________________

Leswao (Mohlokomedi) Letšatšikgwedi

Tumelelo ya tlaleletšo, mo go Hlokegago

Ke dumelela tše di latelago:

Go gatišwa ga lentšu laka ka nako ya dinyakišišo / sehlopheng sa baahlaahli Ee / Aowa

Go gatišwa ga di tiragalo tsa dinyakišišo / sehlopheng sa baahlaahli Ee / Aowa

Go dirišwa ga dinepe/diswantšho tša ka mo projekeng Ee/ Aowa

_____________________ _____________________

Leswao la mokgathatema **Letšatšikgwedi**

_______________________ _______________________

Leswao la hlatse **Letšatšikgwedi**

(mo go hlokegago)

_______________________ _______________________

Leswao la toloki **Letšatšikgwedi**

(mo go hlokegago)

Humanities & Social Sciences Research Ethics Committee (HSSREC)

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