IMPROVING THE NUTRITIONAL COMPOSITION OF IDENTIFIED POPULAR HOME-PREPARED COMPLEMENTARY FOODS IN SELECTED RURAL AND URBAN AREAS OF KWAZULU-NATAL, SOUTH AFRICA

by

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BSc Diet, PGDip Diet (UKZN)

Dissertation submitted in fulfilment of the academic requirements for the degree

MASTER OF SCIENCE IN DIETETICS

Dietetics and Human Nutrition

School of Agricultural, Earth and Environmental Sciences

College of Agriculture, Engineering and Science

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Pietermaritzburg

South Africa

October 2023

UNIVERSITY OF KWAZULU-NATAL

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ABSTRACT

Background: Timely introduction of nutritious complementary foods and the continuation of breastfeeding is vital for optimal growth and development in infants. However, not all infants are breastfed adequately or fed appropriate complementary food. Consequently, children under five years of age remain affected by childhood malnutrition. The South African government has employed several strategies to improve child health and reduce childhood malnutrition. Unfortunately, there are still high mortality and morbidity rates in children under five due to undernutrition. Therefore, effective and sustainable strategies to improve the nutritional content of home-prepared complementary foods are needed using the commonly used complementary foods. These strategies can include using accessible indigenous crops such as *Moringa oleifera*, which contains essential nutrients- protein, amino acids, vitamins and minerals required for child growth and development.

Aim: To determine the popular home-prepared complementary food fed to infants in KZN and investigate the effect of incorporating *Moringa oleifera* leaf powder (MOLP) on the physical quality and nutritional composition of the popular home-prepared complementary food.

Objectives: (i) To identify the popular home-prepared complementary foods fed to children among selected rural and urban population groups in KZN; (ii) To assess the nutritional composition of the selected home-prepared complementary foods consumed by children living in selected rural and urban population groups in KZN; (iii) To determine how the identified home-prepared complementary foods can be modified through the incorporation of MOLP to improve their nutritional composition; (iv) To determine the effect of MOLP on the physical quality of the identified home-prepared complementary foods; and (v) To determine the effect of MOLP on the nutritional composition of home-prepared complementary foods.

Study design: A mixed-method study design was employed. Phase one of the study was a cross-sectional, descriptive and quantitative investigation, and phase two was a laboratory-based investigation under controlled conditions.

Methods: Purposive sampling was used to select the study participants from the MACE and SONKE cohorts. Stratified sampling was used to group participants according to the geographic location of the community where the study participants resided (either rural or urban) and the children's age groups (2 - <3; 3 - <4, and 4 - <5 years).

This study was conducted during COVID-19 alert level one lockdown restrictions in SA, where face-to-face contact with participants was restricted. Therefore, telephonic interviews were used for data collection using a standardised questionnaire to identify popular home-prepared complementary foods and complementary food recipes used by the caregivers. At the end of the first phase of the study, popular home-prepared complementary foods were selected for modification. During phase two of this study, the popular home-prepared complementary food (white maize porridge and pumpkin) was substituted with varying amounts (1%, 2% and 3% w/w) of MOLP. Thereafter, the effect of MOLP on the physical quality and nutritional composition was analysed using standard methods.

Results: Although this study indicated that a significant number of infants (n=23; 47.9%) started complementary foods from the age of 6-7 months. Many infants (n=16; 33.3%) were introduced to solids before the age of six months. Most of the caregivers (n=29; 60.4%) started feeding infants complementary foods in the form of white maize porridge. The three most popular home-prepared complementary foods used were pumpkin (n=26; 54.2%), potato (n=20; 41.7%) and white maize porridge (n=16; 33.3%). Pumpkin was the most commonly grown and/or bought vegetable by caregivers (n=28; 58.3%) for complementary feeding. Twenty-six (54.2%) of the caregivers consumed indigenous crops. Additionally, many caregivers have not heard of moringa (n=32, 66.7%) or consumed moringa (n=18; 37.5%). The colour of MOLP-added home-prepared complementary food became darker as the level of MOLP substitution increased. The addition of MOLP to popular home-prepared complementary food increased the protein content. The total mineral content (ash), fat, calcium, iron and potassium content generally increased as the MOLP substitution level increased.

Conclusions: Starchy foods were the popular home-prepared complementary foods given to infants in this study. These foods can increase the risk of childhood undernutrition as they are deficient in protein, minerals and vitamins. The results of this study show that MOLP improves the nutritional composition of popular home-prepared complementary foods, therefore, has the potential to reduce the incidence of childhood undernutrition. However, the acceptability of the modified complementary food needs to be evaluated.

PREFACE

The data described in this dissertation were collected in KwaZulu-Natal Province, Republic of South Africa, from April 2022 to November 2022. Experimental work was carried out while registered at the School of Agricultural, Earth and Environmental Sciences, University of KwaZulu-Natal, Pietermaritzburg, under the supervision of Dr Laurencia Govender and Prof Muthulisi Siwela.

This dissertation, submitted for the degree of Master of Science in Dietetics in the College of Agriculture, Engineering and Science, University of KwaZulu-Natal, Agricultural, Earth and Environmental Sciences, Pietermaritzburg campus, represents original work by the author and has not otherwise been submitted in any form for any degree or diploma to any University. Where use has been made of the work of others, it is duly acknowledged in the text.

Signed: [redacted] Date: 17 October 2023

Ms Hlengiwe Sinenhlanhla Charmaine Sokhela (MSc Candidate)

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

Signed: [redacted]__________ Date: 17 October 2023

Dr Laurencia Govender (Main Supervisor)

Signed: [redacted]__________ Date: 17 October 2023

Prof Muthulisi Siwela (Co-Supervisor)

DECLARATION OF ORIGINAL WORK

- I, **Hlengiwe Sinenhlanhla Charmaine Sokhela**, declare that the research reported in this dissertation, except where otherwise indicated, is my original research.
- This dissertation has not been submitted for any degree or examination at any other university.
- This dissertation does not contain other persons' data, pictures, graphs or other information unless specifically acknowledged as being sourced from other persons.
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  1. Their words have been rewritten, but the general information attributed to them has been referenced.
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Signature: [redacted] Date: 17 October 2023

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DECLARATION OF PUBLICATION

The following publication forms part of the research presented in this study (Chapter 2) and has been accepted and published by the journal.

Publication 1

Sokhela H, Govender L, Siwela M (2023). Complementary Feeding Practices and Childhood Malnutrition in South Africa: The Potential of Moringa Oleifera Leaf Powder as a Fortificant: A Narrative Review. ***Nutrients*** 15, 2011: https://doi.org/10.3390/nu15082011.

Author contributions

HS conceived the paper with LG and MS. HS collected and analysed data and wrote the manuscript. HS and MS contributed valuable comments to the manuscript.

ACKNOWLEDGEMENTS

I want to express my profound appreciation to the following individuals who contributed to this study's completion. I could not have undertaken this journey without you.

- Firstly, I would like to thank God for the strength and courage to reach the finish line. This journey was long and challenging, but it was worth it.
- The University of KwaZulu-Natal for granting me fee remission for the first year of my master's degree.
- The Halley Stott Foundation for providing funding for my Masters degree.
- A special thanks to all involved in the OrCHID project (MACE and SONKE) and for funding from the OrCHID project for running expenses.
- Dr Laurencia Govender, for your continued intangible support, guidance and patience throughout this journey. I would not have made it this far without you. Thank you.
- Professor Muthulisi Siwela, for always sharing your expertise to make my Master's study successful.
- Mrs Elsie Correia, for availing the food science kitchen to conduct product development and for assisting with the colour analysis.
- Dr Gill Henry for assistance with the questionnaire validation and statistical analysis.
- Mr Thokozani Nkosi for assisting with freeze-drying the food samples.
- I want to thank all participants from the OrCHID project (MACE and SONKE) for participating in this study.
- Mrs Buyisiwe Mabaso and Mrs Nobuhle Mkhize, for always being supportive work supervisors and encouraging me to peruse with my Masters degree.
- My family, for always being supportive and understanding when I needed time away from them to complete my studies.

DEDICATION

To my two daughters, Zime and Kuye, this Masters degree is dedicated to both of you. It must motivate both of you always to put in the effort to achieve your goals. It should remind you that you must always work hard, not give up, and when you feel stuck, you must ask for help and finish every task you start.

If it is to be, it is up to you.

Love, Mum.

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ABBREVIATIONS

FAO	: Food and Agriculture Organisation
GMP	: Growth Monitoring and Promotion
KZN	: KwaZulu-Natal
MACE	: Mother and Child in Environment
MOLP	: *Moringa Oleifera* leaf powder
OrCHID	: Optimal Child Growth and Development
PEM	: Protein Energy Malnutrition
SA	: South Africa
UKZN	: University of KwaZulu-Natal
UNICEF	: United Nations Children's Fund
VAD	: Vitamin A Deficiency
VAS	: Vitamin A Supplementation
WHO	: World Health Organization

CHAPTER 1
INTRODUCTION TO THE PROBLEM AND ITS SETTING

1.1 Importance of the study

At a global level, child malnutrition remains one of the major public health concern [Food and Agriculture Organisation (FAO), International Fund for Agricultural Development, United Nations Children's Fund, World Food Programme and World Health Organization (WHO) 2020)] In 2021, worldwide, 149.2 million children under five years were stunted, 45.4 million were wasted, and 38.9 million were overweight (Development Initiatives 2021). In 2016, 27.4% of South African children under five years were stunted, 2.5% were wasted, and 13.3% were overweight (UNICEF, WHO & World Bank Group 2021). Stunting remains the most prevalent form of malnutrition globally (UNICEF, WHO & World Bank Group 2016). Stunting is a form of undernutrition and is an indication of chronic malnutrition (UNICEF, WHO & World Bank Group 2021). It is caused by insufficient intake of nutrients from food for a prolonged period (UNICEF, WHO & World Bank Group 2021). The World Health Organization recommends exclusive breastfeeding for the first six months of life and the need for introducing complementary feeding at six months of food containing sufficient amounts of energy, macro and micronutrients (WHO 2013).

Inadequate intake of the recommended energy and nutrients during complementary feeding can be attributed to the low socio-economic status of caregivers of the affected children (WHO 2013; WHO 2021). South Africa (SA) has a high unemployment rate, and economically disadvantaged or unemployed communities rely on social grants for livelihood (Statistics South Africa 2021). According to Statistics South Africa, loss of income resulting from the COVID-19 pandemic may lead to increased food insecurity in SA, thus leading to an increased prevalence of malnutrition, especially among vulnerable population groups (Statistics South Africa 2021). In SA, the programs focused on improving child health to address childhood malnutrition include breastfeeding promotion, food fortification, national school nutrition, integrated nutrition, growth monitoring and promotion. Despite these interventions, malnutrition, particularly undernutrition, continues to increase (UNICEF, WHO & World Bank Group 2021). Therefore, to reduce malnutrition in developing regions such as SA, more research needs to be conducted on affordable and sustainable strategies that can be used to improve the nutritional composition of the home-prepared complementary foods used by low-economic-status communities.

In developing countries, including SA, maize meal is the most common complementary food item given to infants (Sayed & Schönfeldt 2020). Unfortunately, if foods given to infants are not fortified, they are low in essential nutrients such as iron, folic acid, protein, and vitamin A (Sayed & Schönfeldt 2020; Shiriki, Igyor & Gernah 2015). Thus, fortifying popular complementary foods with essential macro- and micronutrients at the household level can reduce the risk of child malnutrition among low-income communities (Sayed & Schönfeldt 2020). Using locally available, accessible, and affordable food items to fortify popular complementary foods prepared at the household level would be cost-effective and sustainable compared to the industrial fortification of commercial foods (Pretorius & Schönfeldt 2012). Abundant and nutrient-rich edible wild and domesticated plants that are locally available and would be a highly suitable option for fortifying home-prepared complementary foods in low-income communities in developing countries such as SA. Among these nutrient-rich edible plants in *Moringa oleifera*, which is indigenous to India and grows prolifically in various regions (Gopalakrishnan, Doriya & Kumar 2016; Moyo, Masika, Hugo & Muchenje 2011).

Currently, Moringa leaves are being processed into value-added products, such as *Moringa oleifera* leaf powder (MOLP), for use as a commercial food fortificant and nutraceutical (Moyo *et al* 2011). *Moringa oleifera* leaf powder has been found to be rich in several nutrients, including protein, minerals and vitamins (Gopalakrishnan *et al* 2016; Kasolo, Bimenya, Ojok, Ochieng & Ogwal-Okeng 2010). Fortification with MOLP can improve the protein and iron content of home-prepared complementary foods and thereby contribute to the alleviation of childhood malnutrition (Govender & Siwela 2020; Shah, Jhade & Chouksey 2016). However, before MOLP can be considered for use as a fortificant for complementary foods, there is a need to identify popular home-prepared complementary foods which are suitable for incorporation of MOLP. Currently, there is a paucity of data on the nutritional composition of home-prepared complementary foods that are popular in rural and urban areas of KZN. There is a need to fill the information gap to facilitate food-based nutrition intervention programs, such as home-based fortification of complementary foods. Thus, this study aims to identify popular home-prepared complementary foods in KZN and determine whether they could be modified to improve their nutritional composition by incorporating MOLP.

1.2 Statement of the research problem (research question)

In SA, malnutrition in children under five years remains a concern as it leads to increased child mortality and morbidity rates (WHO 2021). Infants should be exclusively breastfed for the first six months, and after that, there should be a safe introduction of solids with sufficient nutrients and continued breastfeeding beyond six months (WHO 2021). When these recommendations are implemented, they can prevent childhood malnutrition and malnutrition-related deaths (WHO 2021). Although the SA government has implemented various programs to combat malnutrition; different forms of malnutrition such as childhood undernutrition, are still prevalent. A significant number of infants and children are not receiving sufficient nutrients from the food they consume. Poor knowledge of breastfeeding and complementary feeding and limited availability and affordability of complementary foods with adequate nutrients lead to poor complementary feeding practices resulting in childhood malnutrition (Umugwaneza, Havemann-Nel, Vorster & Wentzel-Viljoen 2021). Overreliance on home-prepared nutrient-deficient starchy complementary foods (mainly maize porridges) seem to be a leading contributor to childhood malnutrition among low-economic status communities in SA. Locally available traditional and indigenous wild and domesticated plants high in essential nutrients could be used to fortify the nutrient-deficient home-prepared complementary foods. Moringa leaves are rich in protein and essential micronutrients (Govender & Siwela 2020). *Moringa oleifera* leaf powder (MOLP) could be a good candidate for fortifying home-prepared complementary foods, but that needs to be scientifically evaluated. Therefore, it is important to conduct research on the complementary feeding practices in SA, more specifically within KZN, and investigate the potential of including MOLP as fortificant to improve the nutritional composition of home-prepared popular complementary foods in selected rural and urban areas of KZN.

1.3 Hypotheses

1.3.1 There are different popular home-prepared complementary foods found in rural and urban areas in KZN, as each area has a different locally available and affordable home-prepared complementary food.

1.3.2 The nutritional composition of home-prepared complementary foods has insufficient essential nutrients.

1.3.3 Fortification of home-prepared complementary foods improves the nutritional composition of home-prepared complementary foods.

1.3.4 Physical quality of home-prepared complementary food changes in terms of texture, structure, and appearance after nutritional content modification.

1.3.5 Modification of popular home-prepared complementary foods improves their nutritional composition, especially the protein content.

1.4 Research objectives

The objectives of this study were:

1.4.1 To identify the most common home-prepared complementary foods fed to children among selected rural and urban population groups in KZN.

1.4.2 To assess the nutritional composition of the selected home-prepared complementary foods consumed by children living in selected rural and urban population groups in KZN.

1.4.3 To determine how the identified home-prepared complementary foods can be modified through the incorporation of MOLP to improve their nutritional composition.

1.4.4 To determine the effect of MOLP on the physical quality of the identified home-prepared complementary foods.

1.4.5 To determine the effect of MOLP on the nutritional composition of home-prepared complementary foods.

1.5 Study Parameters

The parameters of the study were as follows:

1.5.1 The study was restricted to mothers and caregivers of children between the age of two to five years residing in both rural and urban areas of KZN. It was part of the Optimal Child Growth and Development (OrCHID) project under Mother and Child in Environment (MACE) and SONKE cohorts.

1.5.2 The study was restricted to mothers and caregivers who fed their children home-prepared complementary foods. Those who fed commercially prepared complementary foods were excluded.

1.5.3 Due to COVID-19 and the attempts to reduce contact, interviews were conducted telephonically with the study participants.

1.6 Assumptions

The following assumptions were made:

- that all the study participants were honest and truthful when they reported that they fed their children home-prepared complementary foods.
- that the study participants gave accurate recipes of the home-prepared complementary foods.
- that all the participants understood either *isiZulu* or English. These are the local languages spoken in KZN.

1.7 Definition of terms

Complementary foods: These are food items given in addition to breastfeeding to infants from the age of six months to improve their nutrients and energy intake (WHO 2000). For the purpose of this study, data was reported on complementary feeding practices up to 36 months.

Caregiver: A family member who regularly looks after a child (Hermanns & Mastel-Smith 2012). In this study, a caregiver will refer to either the mother or the grandmother.

Fortification: The process of adding essential micronutrients to food to improve its nutritional composition (WHO & FAO 2006).

Malnutrition: The term malnutrition refers to both under and over-nutrition. Malnutrition refers to deficiencies, excess, or imbalances in the intake of essential nutrients and energy (WHO 2013).

***Moringa Oleifera* Leaf powder**: It is a powder made from moringa leaf. The powder contains essential nutrients, and its nutritional content plays an important role in nutrition purposes. *Moringa Oleifera* Leaf powder (MOLP) is rich in minerals, vitamins, protein, iron, folic acid, and other essential nutrients which are important for growth and development (Gopalakrishnan *et al* 2016; Kasolo, Bimenya & Ojok 2010).

Undernutrition: Insufficient intake of energy and/or nutrients to meet the nutritional requirements (WHO 2013).

1.8 Dissertation outline:

This dissertation was written according to the manuscript format of UKZN. This dissertation is laid out as follows:

Chapter 1: Introduction to the problem and its setting

Chapter 2: Complementary feeding practices and childhood malnutrition in South Africa: the potential of *Moringa oleifera* leaf powder as a fortificant: A narrative review

Chapter 3: Methodology

Chapter 4: Results

Chapter 5: Discussion

Chapter 6: Conclusion, study critique and recommendations

1.9 Summary

Despite several interventions being implemented, malnutrition remains a public health concern locally and globally. Malnutrition mainly affects children under five years and is possibly caused by inappropriate complementary feeding. In SA, interventions are being implemented by the government to combat malnutrition. However, these interventions are not equally effective in both rural and urban areas due to various factors such as accessibility to health services, affordability, and feasibility of these interventions. Some of these interventions can reduce malnutrition if implemented feasibly and affordably for a particular population group. Currently, there is a gap in the data on the nutritional composition of home-prepared complementary foods in selected rural and urban areas of KZN. This gap could contribute to the increasing prevalence of malnutrition in children. Thus, this study aims to determine the food used during complementary feeding and how popular home-prepared complementary foods can be modified to improve their nutritional composition.

1.10 References

Development Initiatives (2021). **Global Nutrition Report**. https://globalnutritionreport.org/reports/2021-global-nutrition-report/ (Accessed 10 December 2021).

Food and Agriculture Organisation, International Fund for Agricultural Development, United Nations Children's Fund, World Food Programme , World Health Organizations (2020). **The state of the Food Security and Nutrition in the world –Transforming food systems for food security, improved nutrition and affordable healthy diets for all.** https://www.fao.org/documents/card/en/c/cb4474en (Accessed 02 August 2021).

Gopalakrishman L, Dorya K, Kumar DS (2016). *Moringa Oleifera*: A review on nutritive importance and its medical application. **Food Science and Human Wellness** 5: 49-56.

Govender L, Siwela M (2020). The effects of Moringa Oleifera leaf powder on the physical quality, nutritional composition and consumer acceptability of white and brown breads. **Foods** 9 (1910): 1-17.

Hermanns M, Mastel-Smith B (2012). Caregiving: A Qualitative Concept Analysis. **The Qualitative Report** 17 (38): 1-18.

Kasol JN, Bimenya GS, Ojok L (2010). Phytochemical and uses of Moringa Oleifera leaves in Ugandan rural communities. **Journal of Medicinal Plant Research** 4: 753 – 7.

Moyo B, Masika P J, Hugo A, Muchenje V (2011). Nutritional characterization of Moringa (Moringa oleifera Lam.) leaves. **African Journal of Biotechnology** 10: 12925-12933.

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

Sayed N, Schönfeldt HC (2020). A review of complementary feeding practices in South Africa. **South African Journal of Clinical Nutrition** 33: 36-43.

Shah SK, Jhade D, Chouksey R (2016). Moringa *Oleifera* lam. A study of ethnobotany, Nutrients and pharmacological profile. **Research Journal of Pharmaceutical, Biological and Chemical Sciences** 7: 2158-2165.

Shiriki D, Igyor MA, Gernan DI (2015). Nutritional evaluation of complementary food with Moringa Oleifera leaf powder. **Food and Nutrition Sciences** 6:5.

Statistics South Africa (Stats SA) (2021). **Inequality Trends in South Africa: A Multidimensional Diagnostic of Inequality.** https://www.statssa.gov.za/?s&sitem=statistics&pg=16&paged=39 (Accessed 03 August 2021).

Umugwaneza M, Havemann-Nel L, Vorster HH, Wentzel-Viljoen E (2021). Factors influencing complementary feeding practices in rural and semi-urban in Rwanda: a qualitative study. **Journal of Nutrition Science** 10: e45.

United Nations Children's Fund, World Health Organizations, World Bank Group (2021). **Joint child malnutrition estimates: levels and trends in child malnutrition: Key findings of the 2021 edition**. https://www.who.int/publications/i/item/9789240025257 (Accessed 29 July 2021).

United Nations Children's Fund, World Health Organizations, World Bank Group (2016). **Levels and trends in child malnutrition.** http://www.who.int/malnutrition (Accessed 7 July 2021).

World Health Organizations (2021). **Complementary Feeding**. https://www.who.int/health-topics/complementary-feeding (Accessed 10 July 2021).

World Health Organizations (2000). **Complementary feeding family foods for breastfed children**. https://apps.who.int/iris/handle/10665/66389 (Accessed 12 November 2021)

World Health Organizations (2013). **Guidelines: Updates on the management of severe acute malnutrition In Infants and children**. https://www.who.int/publications-detail-redirect/9789241506328 (Accessed 2 July 2021).

World Health Organization, Food Agriculture Organisation of United Nations (2006). **Guidelines on food fortification with micronutrients.** https://www.who.int/publications-detail-redirect/9241594012 (Accessed 24 May 2021).

CHAPTER 2
COMPLEMENTARY FEEDING PRACTICES AND CHILDHOOD MALNUTRITION IN SOUTH AFRICA: THE POTENTIAL OF *MORINGA OLEIFERA* LEAF POWDER AS A FORTIFICANT: A NARRATIVE REVIEW

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Nutrients-published

Nutrients 2023, 15, 2011. https://doi.org/10.3390/nu15082011

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2.1 Abstract

Poor complementary feeding is a common practice in developing regions, including SA, and is one of the main contributing factors to childhood malnutrition. This paper reviews the literature on complementary feeding practices in SA and the potential of fortifying home-prepared complementary foods with *Moringa oleifera* to improve their nutritional composition. Studies that investigated complementary feeding practices, indigenous crops, nutritional benefits of *Moringa oleifera*, and the use of MOLP as a fortificant both locally and globally were included in this review. In SA, maize meal and commercial cereal are the most commonly used complementary infant foods. The diet consumed by children from vulnerable households commonly has insufficient nutrients. Foods consumed are generally high in starch and low in other essential nutrients, including good-quality protein. Impoverished individuals consume poor-quality foods as they are unable to afford a diversified diet with food from different food groups, such as protein, fruits, and vegetables. In SA, various programs have been implemented to reduce the incidence of childhood malnutrition. However, childhood malnutrition remains on the rise. This shows a need for complementary food-based strategies that can be implemented and sustained at a household level. This can be conducted through the use of accessible indigenous crops such as *Moringa oleifera*. *Moringa oleifera* contains essential nutrients such as proteins, amino acids, vitamins, and minerals. Therefore, it could possibly be used as a home-prepared complementary food fortificant to enhance nutritional composition.

Before complementary foods can be fortified with *moringa oleifera*, popular home-prepared complementary foods must be identified.

Keywords: dietary diversity; food-based interventions; indigenous crops; malnutrition; moringa *oleifera*; weaning foods.

2.2 Introduction

Like other developing regions, SA faces the burden of malnutrition (Chakona & Shackleton 2018) in the form of undernutrition, a public health concern affecting vulnerable population groups, especially children under the age of five years (UNICEF, WHO & World Bank Group 2021). The trend in SA follows that in developing countries (UNICEF, WHO & World Bank Group 2021). In 2020, 22% and 6.7% of children under five years worldwide were stunted and wasted, respectively (UNICEF, WHO & 2021). Similarly, in SA in 2016, 27.4% of children under five years were stunted, 6% were underweight, 2.5% were wasted, and 13% had micronutrient deficiencies (National Department of Health, Statistics South Africa & South African Medical Research Council 2017). Additionally, in KwaZulu-Natal (KZN), a province in SA, it was found that in 2017, stunting affected 28.5% of children under five years (Keding 2016). These statistics show that stunting is the most common form of malnutrition in South African children under five years (Modjadji & Madiba 2019).

Several factors are associated with the escalating rates of malnutrition, especially undernutrition in SA. Still, some major contributing factors are food insecurity, poor feeding practices for infants and young children, childhood illnesses, and poor access to water and sanitation (Madiba, Chelule & Mokgatle 2019). As mentioned earlier, children under five years are the most vulnerable to undernutrition; children must receive adequate nutrition in the first 1000 days of life, as this is a critical period for growth and development (UNICEF 2020a). Not all individuals can afford adequate food during pregnancy and lactation (UNICEF 2020a). Furthermore, complementary feeding can be suboptimal due to poor access to nutritious foods (Mkhize & Sibanda 2020). Poor complementary feeding practices primarily cause childhood malnutrition (Mkhize & Sibanda 2020). The World Health Organization (WHO) recommends initiating complementary feeding at six months to prevent malnutrition and provide adequate energy, protein, and micronutrients. In SA, early introduction of solids before six months and insufficient consumption of protein-rich foods by children between the ages of 6–24 months are common practices that lead to protein-energy malnutrition (PEM) and micronutrient deficiencies (Sayed & Schönfeldt 2020). Therefore, programs and/or strategies must be implemented to address childhood malnutrition.

The government in SA has implemented various programs and/or strategies, such as breastfeeding promotion, growth monitoring and promotion, vitamin A supplementation, and food fortification, to help reduce malnutrition and improve the nutritional status of children (Mkhize & Sibanda 2020). However, these programs have had various challenges that have hindered their implementation or access (OECD 2022). COVID-19 increased the limitation of access to these programs and negatively affected access to basic nutrition and healthcare services (OECD 2022). As a result, malnutrition cases are expected to rise (Heady, Heidkamp, Osendarp, Ruel, Scott, Black, Shekar, Bouis, Flory & Haddad 2020). More feasible home-based strategies are needed to reduce malnutrition, especially during challenging economic times, as was the case during the COVID-19 pandemic (Heady, Heidkamp, Osendarp, Ruel, Scott, Black, Shekar, Bouis, Flory & Haddad 2020). Affordable, accessible, and sustainable strategies are needed to complement existing strategies to reduce malnutrition and improve the nutritional status of vulnerable populations, especially children (Heady *et al* 2020). Therefore, other sustainable and accessible strategies, such as improving the nutritional content of home-prepared complementary foods to combat malnutrition at a household level, are required. Nutrient-rich plant material obtained from accessible, affordable, and locally adapted plant species could be used as a fortificant in home-prepared complementary foods.

Moringa oleifera is native to India and thrives well in tropical and subtropical regions in different parts of the world (Gopalakrishnan, Doriya & Kumar 2016; Moyo, Masika, Hugo & Muchenje 2011). South Africa has suitable land conditions that allow for the growth of this crop. Thus, it is produced in most provinces in SA (Mashamaite, Pieterse, Mothapo & Phiri 2021). It is widely cultivable, as it can grow in less fertile soil, and its growth is rarely affected by drought (Gopalakrishnan, Doriya & Kumar 2016; Moyo *et al* 2011). Several studies have shown that moringa leaves are rich in health-promoting bioactive substances and several nutrients, including protein and micronutrients (Gopalakrishnan, Doriya & Kumar 2016). Therefore, there is a growing interest in promoting the utilization of moringa leaves as a health and nutritional ingredient to address malnutrition and related health conditions. Moringa leaves are processed into *moringa oleifera* leaf powder (MOLP), now widely available in formal and informal markets in SA (Mashamaite *et al* 2021). However, most South Africans are unaware of the health and nutritional benefits of moringa leaves (Moyo *et al* 2011). Global and local studies have been conducted to determine consumer acceptance of moringa in complementary foods. While incorporating MOLP in nutrient-deficient foods improves the nutritional composition (Ntila, Ndhlala, Mashela, Kolanisi & Siwela 2020; Olusanya, Kolanisi, Van Onselen, Ngobese & Siwela 2020), the MOLP might decrease consumer acceptability as it would likely negatively affect the taste, colour, and aroma, as found in previous studies (Ntila *et al* 2020). Therefore, for MOLP to be used as a fortificant by the target community, popular home-prepared complementary foods whose consumer acceptance would not be negatively affected by the incorporation of MOLP should be identified. Therefore, this narrative review aims to provide a comprehensive picture of the complementary feeding practices in SA, specifically within KZN province, and evaluate the potential of including MOLP as a fortificant to improve the nutritional composition of home-prepared complementary foods.

2.3 Methodology

This paper reviewed the literature on complementary feeding practices and home-prepared complementary foods that could be fortified with MOLP to improve their nutritional composition. Studies that investigated complementary feeding practices, indigenous crops, the nutritional benefits of Moringa *oleifera*, and the use of MOLP as a fortificant, both locally and globally, were included in this narrative review. The inclusion criteria used were studies written in English, peer-reviewed studies, government reports, and policies published from 2014 onwards. Only indispensable older literature (e.g., the literature on basic principles, concepts, and facts) and articles between 2007–2022 on complementary feeding practices in SA were also used. Relevant literature sources were obtained using several academic search engines, including PubMed, Science Direct, and Google Scholar. A comprehensive literature search was conducted using the following search words: “complementary feeding”, “dietary diversity”, “food-based interventions”, “homemade complementary foods”, “indigenous crops”, “introduction to solids”, “malnutrition”, “Moringa”, “weaning foods”. Abstracts were read, and manuscripts were selected as per the inclusion criteria.

2.4 Discussion

2.4.1 Malnutrition in children: undernutrition in South Africa

Undernutrition is a form of malnutrition that refers to deficiencies or imbalances in an individual’s daily requirements for energy and essential nutrients from the diet (WHO 2022a). As alluded to earlier, childhood undernutrition can present as stunting, underweight, wasting, and/or micronutrient deficiencies. Undernutrition can be further classified as severe acute malnutrition (SAM), moderate acute malnutrition (MAM), and not acutely malnourished but at risk (NAM but at risk) (WHO 2022a).

Stunting is a chronic form of undernutrition; it increased by 2.5% between 2008–2016 in SA (Modjadji *et al* 2019; UNICEF 2020a; Mkhize *et al* 2020). Furthermore, the second highest percentage (28.5%) of stunting was found in the KZN province in SA, and children residing in rural areas were the most affected by stunting (29%) in comparison to their urban counterparts (26%) (National Department of Health, Statistics South Africa & South African Medical Research Council 2017). Stunting is irreversible after the age of two (Bradford, Beck, Nshimyiryo, Wilson, Mutaganzwa, Havugarurema, Ngamije, Uwamahoro & Kirk 2020; Black, Walker, Fernald, Andersen, DiGirolamo, Lu, McCoy, Fink, Shawar & Shiffman 2017). It has several negative effects, such as poor growth and development and irreversible physical and cognitive damage caused by persistent nutritional deprivation (Nshimyiryo, Hedt-Gauthier, Mutaganzwa, Kirk, Beck, Ndayisaba, Mubiligi, Kateera & El-Khatib 2019; Dukhi, Satorius & Taylor 2017; Matsungo, Kruger, Faber, Rothman & Smuts 2017). This emphasises the need for adequate nutrition in the first 1000 days of life.

The statistics from the latest published South African national study conducted in 2016 indicated that 6% of South African children were underweight. At the same time, wasting affects 2.5% of South African children (UNICEF 2020a). Furthermore, 2.5% of children under five from the KZN province are affected by wasting (National Department of Health, Statistics South Africa & South African Medical Research Council 2017). Wasting is caused by hunger, insufficient intake of adequate quantity and quality of food, and regular incidence of childhood illnesses that affect the nutritional status or a combination of these factors (WHO 2021; Harding, Aguayo & Webb 2018). Wasting can result in childhood mortality if not prevented, identified, or treated accordingly (National Department of Health, Statistics South Africa & South African Medical Research Council 2017), reemphasising the importance of good nutrition, especially during complementary feeding.

Protein-energy malnutrition (PEM) is a form of malnutrition affecting children under five in Africa and other developing countries (Mkhize & Sibanda 2020). Protein-energy malnutrition can be defined as the consumption of a diet by children that contain insufficient protein and energy, which are needed for normal growth and development (UNICEF 1998). In addition to PEM, children may also be affected by micronutrient deficiencies (e.g., iron, zinc, iodine, and vitamin A), which can also cause an irreversible effect on growth and development (Bain, Awah, Geraldine, Kindong, Siga, Bernard & Tanjeko 2013). Protein-energy malnutrition and micronutrient deficiencies manifest early in children between 6–24 months (Bain *et al* 2013). Poor nutrition and infectious diseases can cause PEM and micronutrient deficiencies in children (Nshimyiryo *et al* 2019), showing the importance of optimal nutrition in early childhood.

There are several causes of undernutrition in SA, namely poverty, food insecurity, lack of access to a variety of nutritious foods, inadequate infrastructure, lack of economic resources and access to healthcare facilities, lack of education and knowledge of appropriate feeding practices, and infectious diseases (Motadi, Mbhenyane, Mbhatsani, Mabapa & Mamabolo 2015; Bain *et al* 2013). Globally and in SA, the burden of undernutrition continues to increase despite social and economic development (Siddiqui, Salam, Lassi & Das 2020).

Many vulnerable individuals rely on social grants to purchase food and necessities. Social grants are not sufficient to provide individuals with nutritiously balanced meals. For example, a child support grant in SA is R500/month ($27.54) (Godongwana 2023), and a basic 28-item food basket in SA costs R1148.38 ($63.25) (National Agricultural Marketing Council 2023); this shows that the affordability of foods that contain essential nutrients is far from reach for many vulnerable individuals. Insufficient dietary intake of essential nutrients from foods can cause diseases, leading to childhood undernutrition and even death (Maggini, Pierre & Calder 2018). In SA, consuming a monotonous diet negatively affects the nutritional status of children under five years (Mkhize & Sibanda 2020). A monotonous diet lacks essential nutrients, such as protein, vitamins, and minerals, and is made up mostly of starchy foods (Mkhize & Sibanda 2020; Panda, Lakra & Panda 2019). Therefore, insufficient intake of essential nutrients due to consuming a diet that lacks a variety of food from different food groups may contribute to childhood undernutrition (Mkhize & Sibanda 2020), thus stressing the importance of strategies to assist in reducing and preventing undernutrition.

2.4.2 Strategies in place to combat childhood malnutrition and challenges in the South African context

The interventions currently being implemented in SA to address childhood undernutrition include breastfeeding promotion (Bhutta & Das 2014), growth monitoring and promotion (GMP) programs (Mkhize & Sibanda 2020), vitamin A supplementation programs

(Coutsoudis, Sanders, Dhansay, Van Stuijvenberg & Benn 2019), and food fortification (Mannar & Gallego 2002).

Infants need to be exclusively breastfed for the first six months and thereafter introduced solids, as breastmilk alone is not sufficient to meet the infant's nutritional needs. Breastfeeding is continued with complementary foods for up to two years and beyond (WHO 2021). When comparing breastfeeding rates, it is noteworthy that rural areas have higher rates than urban areas (UNICEF 2022a). However, a common universal practice of mixed feeding has been noted in the first six months due to several factors. In SA, suboptimal breastfeeding rates are influenced by easy access to infant formula (Vitalis, Vilar-Compte, Nyhan & Pérez -Escamilla 2021). Working women do not receive adequate support to continue breastfeeding. Only 12% of countries worldwide provide adequately paid maternity leave, thus resulting in lactating women wanting to return to work to earn income (UNICEF 2021). This, in turn, can lead to the cessation of breastfeeding and the early commencement of complementary foods (UNICEF 2021). This is a risk factor for undernutrition, as early initiation of complementary foods significantly impacts the infant's growth, development, and survival (Katepa-Bwalya, Mukonka, Kankasa, Masaninga, Babaniyi & Siziya 2015), which are assessed during the GMP clinic visits.

Growth monitoring and promotion (GMP) consists of regular growth assessment, where appropriate referrals are made if necessary, e.g., referral to nutrition services if the infant is underweight. The GMP program can potentially reduce childhood undernutrition through early diagnosis and referral to relevant services (Pllifrone, Cunningham, Pandey, Rana, Philbin, Manandhar, Lamsal, Mandal & Deuja 2020). Growth monitoring and promotion programs have various challenges, particularly in developing countries like SA, including limited availability of equipment used for anthropometric assessments, poor recording on growth charts, poor attendance of patients at healthcare facilities for GMP, and remote patients being unable to afford transportation to healthcare centres (Bilal, Moser, Blanco, Spigt & Dinant 2014). Regardless of regular GMP attendance, some caregivers still lack knowledge of appropriate infant feeding practices and/or lack support at the household level to implement the recommended infant and young child feeding practices (Bilal *et al* 2014). Additionally, in SA, healthcare workers face challenges that prevent the implementation of the GMP, such as work overload, vaccine shortages, insufficient staff training on GMP, and inadequate supply of health booklets used to record immunizations and growth trends (Kaldenbach, Engebrestsen, Hasins, Conolly & Horwood 2022). As in other developing countries, in SA, the vitamin A supplementation program is part of the GMP program; infants are routinely supplemented with vitamin A during their GMP clinic visits to prevent deficiencies that can negatively affect growth.

Vitamin A deficiency (VAD) is a major public health problem in low- and middle-income countries (Imdad, Mayo- Wilson, Haykal, Regan. Sidhu, Smith & Bhutta 2022), including SA. Vitamin A deficiency, can cause blindness and increase the risks of childhood death and illness from infections such as measles and diarrheal diseases (Dubock 2019). Addressing VAD can improve disease resistance and reduce mortality in children under five, as vitamin A supplementation supports growth and combats infections (UNICEF 2022b). Although SA has a vitamin A supplementation program, VAD is still a concern, as 44% of children under five years have VAD, which is higher than the statistics from the 1994 South African Health and Examination Survey, which found 33.3% had VAD (Sambu 2020).

This emphasises the need for accessible and sustainable strategies such as food fortification with essential nutrients and existing strategies to reduce undernutrition. Food fortification is the addition of essential micronutrients, such as trace elements, vitamins, and minerals, to processed foods to improve their nutritional quality (Manar & Gallego 2002). Food fortification is used to reduce micronutrient deficiencies such as vitamin A, vitamin B, vitamin D, and iron (Method & Tulchinsky 2015). It is a cost-effective food-based approach that can be used to reduce micronutrient deficiencies (Method & Tulchinsky 2015; Bhagwat. Gulati, Sachdeva & Sankar 2014). Most commonly consumed foods in developing countries are used as vehicles for fortification (Anjali 2015). These include oil and fats, milk, sugar, salt, rice, wheat, and maize (Anjali 2015).

In SA, maize meal and wheat flour are fortified with vitamin A, thiamine, riboflavin, niacin, pyridoxine, folic acid, iron, and zinc (Wakeel, Farooq, Bashir & Ozturk 2018). The public health benefit of food fortification includes prevention and/or correction of micronutrient deficiency and improving nutritional status in a specific population group (FAO, IFAD, UNICEF & WHO 2020). Although fortified foods are available in SA, they are not affordable or accessible to most vulnerable groups, thus increasing their risk for micronutrient malnutrition (Wakeel *et al* 2018). This shows a need for affordable food-based strategies to support existing strategies to reduce undernutrition in early childhood, especially in the complementary feeding phase.

2.4.3 Complementary feeding practices in South Africa

It is important to promote good growth and prevent undernutrition during the first 1000 days of life, which is the period from when the child is conceived to two years of age (De Onis & Branca 2016). As mentioned earlier, infants must be exclusively breastfed for the first six months of life, followed by the introduction of safe, nutritious complementary foods and continue breastmilk (WHO 2022b). According to the WHO, complementary feeding must be timely (introduced not too early or too late), adequate (provide sufficient energy and nutrients as per individual's requirement), safe (hygienic practices must be observed during meal preparations, storage, and feeding), and age-appropriate (WHO 2022b). Complementary food should contain sufficient amounts of energy, macronutrients (protein, fats, and carbohydrates), and micronutrients (e.g., zinc, iron, calcium, folate, and vitamins A, B, and C) needed to ensure that the recommended growth and development are achieved (Abeshu *et al* 2016). Poor complementary feeding practices include giving foods with inadequate nutrients, starting solids too early or too late, and/or infrequent feeding. In SA, children between 6 and 24 months consume a minimal amount of food with protein, which leads to PEM and deficiencies of essential nutrients (Sayed & Schönfeldt 2020). Early introduction of complementary foods can result in poor breastfeeding and infant feeding practices (Abeshu *et al* 2016). Increased choking risks, food allergies, and reduced breast milk intake are the dangers associated with the early introduction of solids (Abeshu *et al* 2016). In SA, the introduction of solids before six months is common (Sayed & Schönfeldt 2020). Late introduction of complementary foods can result in developmental delay and increased risk of malnutrition, leading to stunting, wasting and/or being underweight (Masuke, Msuya, Mahande, Diarz, Stray-Pederse, Jahanpour & Mgongo 2021; Abeshu *et al* 2016).

There are two types of complementary foods: commercial and home-prepared complementary foods (Abeshu *et al* 2016). Commercial complementary food is bought from the supermarket and includes food items such as iron-fortified infant cereal and commercially prepared fruits, vegetables, and meat (Katiforis, Fleming, Haszard, Hape-Cramond, Taylor & Heath 2021; Abeshu *et al* 2016). Home-prepared complementary food is food prepared at a household level by a caregiver using traditional methods (Abeshu *et al* 2016). Commercially fortified foods are often not accessible to vulnerable populations due to affordability. Hence, home-prepared complementary foods are commonly used by vulnerable populations (Abeshu *et al* 2016). In developing countries, complementary foods are often home-prepared from staple crops, as commercial complementary foods are expensive (Oladiran & Emmambux 2022). However, the challenge with home-prepared complementary foods is poor dietary quality (Bernal, Roman, Klerks, Haro-Vicente & Sanchez-Siles 2021). Home-prepared complementary foods in sub-Saharan African countries usually contain starchy staples of poor nutritional quality (Oladiran & Emmambux 2022). In SA, home-prepared maize meal porridge and commercial infant cereal are the most common complementary foods (Sayed & Schönfeldt 2020). In SA, maize meal is the most common first food introduced to infants, but the popularity of commercial infant cereal has also increased over the years (Sayed & Schönfeldt 2020).

In SA, some studies have investigated complementary feeding practices. In 2022, Sayed and Schönfeld (2022) conducted a cross-sectional study using 184 mothers from KZN. The study aimed to ascertain whether the nutrient requirements of 6–11-month-old infants could be met with a food-based approach and to identify which nutrients from food were consumed in insufficient amounts. The results revealed that iron, zinc, and calcium were the nutrients that were not provided in sufficient amounts in the diet of infants from the study group (Sayed & Schönfeldt 2022). Another study conducted by Chakona (2020) of 84 Eastern Cape mothers in their maternal and infant/young child dietary diversity and breastfeeding practices found that 56% of mothers perceived meal porridge as the type of food that should be given to a child for growth. In this study, 35%, 32%, and 12% of mothers perceived vegetables, fruits, and meat as essential for growth. The most commonly used complementary food item given to infants by caregivers (57%) was maize meal porridge (Chakona 2020). A longitudinal study of pregnant women during their second trimester from rural and urban clinics in Western Cape, SA, found that 19% of infants were given complementary foods at four months.

Moreover, the study found there was high consumption of processed meats (56%) and inappropriate foods such as fruit juice (82%), soft drinks (54%), and refined sugar (51%) at one year (Budree, Goddard, Brittain, Cader, Myer & Zar 2017). A descriptive study using a structured questionnaire was conducted by Seonandan and McKerrow (2016) of mothers of infants up to the age of five years and healthcare professionals in 12 state hospitals in KZN province, SA. These authors found 84% of infants below six months of age were introduced to complementary feeding (Seonandan & McKerrow 2016). Similarly, a prospective cohort study of 168 mothers living in KZN found 73% of infants were given complementary foods at 14 weeks (Ghuman, Saloojee & Morris 2009). Likewise, a descriptive and exploratory study conducted in Limpopo of 185 mothers with infants 12 months old and younger in a primary healthcare clinic found 15% of mothers started complementary feeding before two months and

43.2% at three months. The weaning food most of the mothers gave was soft maize meal porridge, which had been introduced before four months of age (Mushapi, Mbhenyane, Khoza & Amey 2008). Additionally, a cross-sectional survey and an unquantified food frequency questionnaire conducted by Cape, Faber and Benade (2007) in KZN found the first solids were maize meal porridge (55%), infant cereal (32%), and ready-to-eat bottled baby foods (9%).

The above studies show that most infants are fed poor-quality complementary foods, with maize meal porridge being the most common complementary food item given to infants. Maize is a staple that most vulnerable households can afford and is consumed by infants as the main complementary food in SA. In SA, maize is fortified with vitamin A, thiamine, riboflavin, niacin, pyridoxine, folic acid, iron, and zinc to prevent deficiencies. It must be consumed in specific amounts to meet the nutritional requirements; it also does not contain all essential nutrients, such as protein, which promotes growth and development. To increase the dietary diversity of maize, it must be eaten with other nutrient-dense food items, such as meat and/or vegetables, which vulnerable populations might not be able to afford. Therefore, home-based strategies that can be used to improve the nutritional composition of home-prepared complementary foods should be considered, such as using MOLP as a fortificant.

2.4.4 The potential use of MOLP as a fortificant

Background

Moringa is a tree native to India. It belongs to the Moringaceae family and is the most cultivated species of the genus moringa (Sujatha 2017). Moringa is widely cultivable in different parts of the world and can thrive in different environmental conditions, such as severe drought and mild frost conditions (Mashamaite *et al* 2021; Tshabalala, Ncube, Moyo, Abdel-Rahman, Mutanga & Ndhlala 2020). *Moringa oleifera* was first introduced in SA to rural communities in the Limpopo province as a cultivable crop. Since then, production and utilization have increased in different parts of SA (Mashamaite *et al* 2021). Moringa has a high nutritional value of both macronutrients and micronutrients (Gopalakrishnan *et al* 2016). Therefore, *Moringa oleifera* could be used as a source of nutrition to combat undernutrition in children (Sujatha *et al* 2017).

Nutritional composition of moringa

Moringa oleifera contains protein, amino acids, vitamins (A, B, and C), and minerals (calcium, phosphorus, and iron), which can be used to combat undernutrition and improve food security through its incorporation into food (Sultana 2020; Bolarinwa, Aruna & Raji 2019). All parts of

Moringa oleifera store essential nutrients (Gopalakrishnan *et al* 2016). The nutritional composition of moringa leaves and leaf powder is presented in Table 2.1 (Olagbemide & Philip 2014; Fuglie 2005). Moringa *oleifera* leaves are usually used as a food ingredient in a powder called MOLP (Alakali, Kucha & Rabiu 2015). Moringa leaves are converted into MOLP by drying fresh moringa leaves (Alakali *et al* 2015). However, drying the moringa leaf into powder affects its nutritional composition (Alakali *et al* 2015). It has been shown that dry moringa leaves and MOLP have a higher concentration of energy, protein, and fat content when compared to fresh moringa leaves; however, the concentration effect does not prevent the possible loss of a certain proportion of specific nutrients during processing (Alakali *et al* 2015).

Table 2.1: The nutrient composition of *Moringa oleifera* fresh leaves, dry leaves, and leaf powder

Nutrients	Fresh Leaves	Dry Leaves	Leaf Powder
Energy (cal)	92	329	205
Protein (g)	6.7	29.4	27.1
Fat (g)	1.7	5.2	2.3
Carbohydrates (g)	12.5	41.2	38.2
Fibre (g)	0.9	12.5	19.2
Vitamin B1 (mg)	0.06	2.02	2.64
Vitamin B2 (ng)	0.05	21.3	20.5
Vitamin B3 (mg)	0.8	7.6	8.2
Vitamin C (mg)	220	15.8	17.3
Vitamin E (mg)	448	10.8	113
Calcium (mg)	440	2185	2003
Magnesium (mg)	42	448	368
Phosphorus (mg)	70	252	204
Potassium (mg)	259	1236	1324
Copper (mg)	0.07	0.49	0.57
Iron (mg)	0.85	25.6	28.3
Sulphur (mg)	-	-	870

All values are in 100 g per plant matter.

Moringa contains essential vitamins (A, B, and C) and minerals (calcium, phosphorus and iron). This includes the SA moringa ecotype (Mashamaite *et al* 2021). Moringa also has high vitamin E and beta-carotene content. It provides seven times more vitamins than oranges, ten times more vitamin A than carrots, seventeen times more calcium than milk, nine times more protein than yoghurt, and twenty-five times more iron than spinach (Gopalakrishnan *et al* 2016). Minerals such as calcium, iron, potassium, copper, and zinc found in moringa are essential in preventing and treating malnutrition and micronutrient deficiencies. These minerals are essential for physiological growth and development (Gopalakrishnan *et al* 2016).

Moringa is a good source of protein and other essential nutrients. Plant-based protein alternatives such as *Moringa oleifera* can be used as a treatment or preventative measure for undernutrition (Matabura & Rweyemamu 2022; Moyo *et al* 2011). Essential amino acids are obtained through the consumption of food items such as eggs, poultry, fish, and red meat. This is a problem for the vulnerable population who cannot afford to purchase meat-based food sources of protein. The amino acid levels of threonine, methionine, isoleucine, lysine, and valine present in moringa leaves are almost identical to those found in meat products (Manary & Callaghan-Gillespie 2020). Plant-based protein from crops such as moringa can be a more affordable and accessible source of protein when compared to animal-based protein (Manary & Callaghan-Gillespie 2020). The protein content (dry matter) of moringa in the form of dry leaves (29.4%) and leaf powder (27.1%) was found to be higher when compared with other plant-based leaves such as Mulberry leaves (20.9%), Anchote leaves (21.6%) and Alfalfa leaves (18.1%) (Islam, Islam, Hossen, Mahtab-ul-Islam. Hasan & Karim 2021).

Utilisation of moringa oleifera leaves as a food source—consumer acceptability

In SA, the government has implemented various activities to support moringa production (Mashamaite *et al* 2021; Zungu, Van Onselen, Kolanisi & Siwela 2020). These activities include the inclusion of moringa on the list of medicinal plants in SA, offering financial support for moringa-based development activities, and allowing research to be conducted on the inclusion of moringa in the daily diet of school-going children (Mashamaite *et al* 2021). The different parts of the moringa plant can be consumed in a number of ways. In SA moringa is consumed as seeds (used as ground nuts and as spices) and leaves (leaf powder is added in salads or cooked as a vegetable or as a moringa tea) (Mashamaite *et al* 2021). Currently, moringa leaves are being processed for use as a commercial food fortificant in the form of MOLP. Various global and local studies have been conducted to determine consumer acceptability and nutritional composition of food items using moringa as a fortificant. This has both advantages and disadvantages. The advantages and disadvantages of using moringa as a fortificant found in different studies between 2014– 2022 are presented in Table 2.2.

According to the research findings presented in Table 2.2, fortification with moringa can improve the protein and other essential nutrient content of foods when it is used as a fortificant. At higher substitution levels, the nutrient profile of the fortified product improves. Based on the fact that the nutritional content improves when moringa is added, consumption could help in reducing undernutrition (Govender & Siwela 2020). However, even if a product has a good nutritional value, it will not positively impact one's health if it is not well accepted. Most studies indicated that a moringa-fortified product's acceptability decreases as the substitution level increases. *Moringa oliefera* leaves contain chlorophyll, giving them a dark green colour (Karim, Kayode, Oyeyinka & Oyeyinka 2015). When MOLP is added to, e.g., white maize porridge, it turns the porridge from a cream-white colour to a greenish colour, which can be undesirable.

Furthermore, moringa can make a product bitter if too much is added, giving the product an unpleasant taste. A review by Boateng *et al*. indicated that the optimal substitution for improved nutritional content and sensory acceptability is 10%. Any substitution higher than 10% has poor consumer acceptability (Boateng, Nortey, Ohemeng, Asante & Steiner-Asiedu 2018). Another study indicated that 5% substitution is the optimal level to use for the fortification of food products (Govender & Siwela 2020). Another way to improve consumer acceptability would be to add another food item to mask Moringa's taste and/or colour.

Effectiveness of moringa as a supplement to prevent childhood undernutrition

In developing countries such as India and Nigeria, moringa has been included in children's and breastfeeding women's diets as an intervention to prevent childhood malnutrition (Mashamaite *et al* 2021; Srikanth, Mangala & Subrahmayam 2014). Table 2.3 indicates studies conducted between 2014–2022 on the effectiveness of moringa as a supplement in preventing and treating child malnutrition. All except for one study showed the positive effects of moringa supplementation. There was weight gain, improved haemoglobin levels, reduced anaemia, and improved overall nutritional status. From the studies presented, the dose and duration of moringa supplementation are important considerations for ensuring nutritional benefits.

Table 2.2: The advantages and limitations of using MOLP as a fortificant in foods that can be used for complementary feeding

Author/s	Aim	Method	Study Area	Vehicle for Fortification	Advantages	Limitations
Olusanya, Kolanisi, Van Onselen, Ngobese & Siwela (2020)	To investigate the effects of MOLP on the nutritional composition of and consumer acceptability of mahewu.	2%, 4%, and 6% *w/w* levels of MOLP were added to the mahewu. Fifty-two untrained panellists participated in the sensory evaluation.	KZN, SA	Mahewu	The total mineral (calcium and iron), fat, and fibber increased.	The colour and aroma acceptability decreased with the addition of MOLP to the mahewu.
Ntila, Ndhlala, Kolanisi, Abdelgadir& Siwela (2019)	To determine the caregiver's acceptability and perception of soft white maize porridge modified with MOLP.	Cross-sectional (sensory evaluation: 60 mothers and focus groups) 1%, 2%, and 3% *w/w* levels of MOLP were added to the soft white maize porridge.	Gauteng and Limpopo, SA	Soft white maize porridge	All caregivers were willing to use Moringa in complementary foods, provided they would be educated on how to process it.	Consumer acceptability decreased as the level of MOLP increased. Caregivers indicated that the MOLP porridge was bitter and would not be accepted by their children.

Author/s	Aim	Method	Study Area	Vehicle for Fortification	Advantages	Limitations
Boateng, Nyarko, Asante & Steiner-Asiedu (2018)	To investigate the acceptability of complementary foods fortified with MOLP.	MOLP was given to infants as part of a *koko* or sprinkled on foods. A total of 36 infant–mother pairs were studied.	Ghana	*Koko* (a fermented maize porridge)	Authors found that Moringa in the cereal blend and sprinkled on food was well accepted by caregivers.	-
Netshiheni, Mashau & Jideani (2018)	To determine the effect *Moringa Oliefera* and termite powder on the nutritional and sensory properties of instant maize porridge.	The inclusion of *Moringa Oliefera* and termite powder in instant maize porridge using different treatments was considered using a completely randomised design. Sixty untrained panellists rated the appearance, texture, taste, aroma, and overall acceptability of fortified instant maize porridges	Venda	Instant maize porridge	Results indicated the fortified porridge had a higher protein content than the unfortified porridge. Zinc, iron, Calcium, and magnesium were also higher in the fortified samples.	The untrained panel rated the control sample as better than the fortified samples.

Author/s	Aim	Method	Study Area	Vehicle for Fortification	Advantages	Limitations
Abioye & Aka (2015)	To identify the effects of Moringa leaf fortification on the nutritional value and consumer acceptability of maize ogi.	Cross-sectional study. The ogi produced from maize was fortified with Moringa leaf substitution levels of 10% and 15%.	Nigeria	Maize-ogi	Improvement in nutritional and sensory quality. Increased protein, mineral content, and crude fibre. Ten percent Moringa substitution in maize-ogi is the optimal substitution for consumer acceptance.	Swelling capacity decreased with an increase in the level of Moringa substitution. The sensory properties of the 15% substitution were not comparable to the unfortified sample.

Table 2.3: Studies on the effectiveness of Moringa as a supplement in the prevention and treatment of undernutrition in children

Author/s	Materials and Methods	Aim	Area	Subjects	Main Findings
Brar, Haugh, Robertson, Owuor, Waterman, Fuchs & Attia (2022)	Systematic review	To assess the impact of Moringa leaf supplementation in humans and animals on the outcomes of iron level, vitamin A status, the measures of growth, and/or breastmilk production.	-	One-hundred forty-eight unique studies, 33 were included (7 human studies and 26 animal studies).	In humans, Moringa at higher (14–30 g/day), not lower (<10 g/day) doses improved haemoglobin (Hgb) in children with iron deficiency anaemia; Moringa (0.5 g/day) also increased breastmilk volumes.
Yadav, Gaur & Bansal (2022)	Randomised controlled trial	To assess the effect of Moringa Oliefera leaf powder supplementation on children with Severe Acute Malnutrition (SAM) during facility-based care and home-based care.	Gwalior District of Central India	One hundred children in the age group of 7–59 months admitted between November 2019 and October 2020 who fulfilled the World Health Organization (WHO) recommended criteria for identification of severe acute malnutrition were included in the study.	The use of MOLP supplementation resulted in an improved weight gain and Reduction in severe wasting at the end of two months.
Manzo, Hallarou, Halidou, Maiga, Bahwere, Salimata, Castetbon,Wilmet-Dramaix & Donnen (2021)	Randomised double-blind clinical trial	To analyse the impact of supplementation of *Moringa Oliefera*.	Niger	Four hundred children with moderate acute malnutrition (MAM) aged 6 to 59 months were admitted to outpatient nutritional recovery centres.	There was no difference in average weight gain or mid-upper arm circumference and size between the children who were supplemented with Moringa and those who were not supplemented with Moringa.

Author/s	Materials and Methods	Aim	Area	Subjects	Main Findings
Shija, Rumisha, Oriyo, Kilima & Massaga, (2019)	Community-based interventional study	To investigate the effect of moringa *oleifera l*eaf powder supplementation in reducing anaemia among children younger than two years.	Kisarawe District, Tanzania	Ninety-five anaemic children were followed for six months.	Increasing the amount and time of using *Moringa Oliefera* supplementation significantly reduced cases of anaemia.
Srikanth, Mangala & Subrahmanya(2014)	The nutritional intervention was given in moringa *oleifera* leaf powder 15 g twice daily for two months. Reassessment of the nutritional status was done following the intervention.	To identify children with Protein Energy Malnutrition. To give nutritional intervention in the form of *Moringa Oleifera* powder to the children for two months. To reassess the nutritional status after the nutritional intervention at the end of two months.	Rural Area in Bangalore, India	Sixty children with grade I and grade II protein energy malnutrition.	Seventy percent of children with grade II PEM improved to grade I, and 60% with grade I PEM showed significant ($p < 0.01$) improvement in their nutritional status.

2.5 Conclusions

This narrative review aimed to discuss malnutrition in the form of undernutrition in children, the strategies in place in SA to combat childhood malnutrition and its challenges, complementary feeding practices in SA, specifically within KZN, and the possibility of including MOLP as a fortificant to improve the nutritional composition of home-prepared complementary foods. Despite different programs implemented by the government in SA to combat malnutrition, children under five years are still affected by malnutrition. Poor complementary feeding practices in SA are common and are the main contributing factor to childhood malnutrition. In SA, popular complementary foods are maize and commercial cereals. However, vulnerable populations have access to maize fortified with only some nutrients and lacking in other essential nutrients such as protein. This is needed for infant growth, as deficiency can result in malnutrition, which can have an irreversible effect, as discussed earlier in this review.

There is a need to implement home-based food strategies to improve the nutritional composition of popular home-prepared complementary foods. A possible food-based approach could be to incorporate MOLP into popular home-prepared complementary foods. Moringa is a nutrient-dense plant that can potentially improve children's nutritional status, especially in the complementary feeding phase. However, moringa has been associated with several undesirable sensory properties, thus hindering its consumer acceptability. Therefore, there is a need for further investigation to develop a suitable fortified complementary food with optimal substitution and improved nutritional composition. Before this can be done, home prepared complementary foods suitable for the incorporation of MOLP should be identified for the target population. Further research needs to be conducted to improve the physical appearance and taste of moringa-fortified foods to improve consumer acceptability. Moreover, studies could look at adding more than one food item to mask the colour and enhance the taste. The next chapter presents the research methodology.

2.6 References

Abeshu MA, Lelisa A, Geleta B (2016). Complementary feeding: Review of recommendations, feeding practices, and adequacy of homemade complementary food preparations in developing countries–lessons from Ethiopia. **Frontiers Nutrition** 3: 41.

Abioye V, Aka M (2015). Proximate composition and sensory properties of Moringa fortified maize-ogi. **Journal of Nutrition and Food Sciences** 12: 1–4.

Alakali J, Kucha C, Rabiu I (2015). Effect of drying temperature on the nutritional quality of Moringa oleifera leaves. **African Journal of Food Science** 9: 395–399.

Anjali V (2015). Food fortification: A complementary strategy for improving micronutrient malnutrition (MNM) status. **Food Science Research Journal** 6: 381–389.

Bain LE, Awah PK, Geraldine N, Kindong NP, Siga Y, Bernard N, Tanjeko AT (2013). Malnutrition in Sub–Saharan Africa: Burden, causes and prospects. **Pan Africa Medical Journal** 15: 120.

Bernal MJ, Roman S, Klerks M, Haro-Vicente JF, Sanchez-Siles LM (2021). Are Homemade Commercial Infant Foods Different? A Nutritional Profile and Food Variety Analysis in Spain. **Nutrients** 13: 777.

Bhagwat S, Gulati D, Sachdeva R, Sankar R (2014). Food fortification as a complementary strategy for the elimination of micronutrient deficiencies: Case studies of large scale food fortification in two Indian States. **Asia Pacific Journal of Clinal Nutrition** 23: S4–S11.

Bhutta ZA, Das JK (2014). Interventions to address maternal and childhood undernutrition: Current evidence. **International Nutrition Achieving Millennium Goals and Beyond** 78: 59–69.

Bilal SM, Moser A, Blanco R, Spigt M, Dinant GJ (2014). Practices and challenges of growth monitoring and promotion in Ethiopia: A qualitative study. **Journal of Health, Population and Nutrition** 32: 441.

Black MM, Walker SP, Fernald LC, Andersen CT, DiGirolamo AM, Lu C, McCoy DC, Fink G, Shawar YR, Shiffman J (2017). Early childhood development coming of age: Science through the life course. **Lancet** 389: 77–90.

Boateng L, Nortey E, Ohemeng AN, Asante M, Steiner-Asiedu M (2018). Sensory attributes and acceptability of complementary foods fortified with Moringa oleifera leaf powder. **Nutrition and Food Science** 49: 393–406.

Boateng L, Nyarko R, Asante M, Steiner-Asiedu M (2018). Acceptability of complementary foods that incorporate Moringa Oleifera leaf powder among infants and their caregivers. **Food and Nutrition Bulletin** 39: 137–148.

Bolarinwa IF, Aruna TE, Raji AO (2019). Nutritive value and acceptability of bread fortified with moringa seed powder. **Journal of the Saudi Society of Agricultural Sciences** 18: 195–200.

Bradford J, Beck K, Nshimyiryo A, Wilson K, Mutaganzwa C, Havugarurema S, Ngamije P, Uwamahoro A, Kirk CM (2020). Nutritional evaluation and growth of infants in a Rwandan neonatal follow-up clinic. **Maternal Child Nutrition** 16: e13026.

Brar S, Haugh C, Robertson N, Owuor PM, Waterman C, Fuchs GJ, Attia SL (2022). The impact of Moringa oleifera leaf supplementation on human and animal nutrition, growth, and milk production: A systematic review. **Phytotherapy Research** 36: 1600–1615.

Budree S, Goddard E, Brittain K, Cader S, Myer L, Zar HJ (2017). Infant feeding practices in a South African birth cohort—A longitudinal study. **Maternal Child Nutrition** 13: e12371.

Chakona G (2020). Social circumstances and cultural beliefs influence maternal nutrition, breastfeeding and child feeding practices in South Africa. **Nutrition Journal** 19: 47.

Chakona G, Shackleton CM (2018). Household food insecurity along an agro-ecological gradient influences children's nutritional status in South Africa. **Frontiers Nutrition** 4: 72.

Coutsoudis A, Sanders D, Dhansay MA, Van Stuijvenberg M, Benn C (2019). Is it time for South Africa to end the routine high-dose vitamin A supplementation programme? **South African Medical Journal** 109: 907–910.

De Onis M, Branca F (2016). Childhood stunting: A global perspective. **Maternal Child Nutrition** 12: 12–26.

Dubock A (2019). **Golden rice: To combat vitamin A deficiency for public health. In Vitamin A**. IntechOpen: London, UK.

Dukhi N, Sartorius B, Taylor M (2017). Stunting in children (0–59 months): What is the current trend in South Africa? **Early Child Development Care** 187: 1874–1886.

FAO, IFAD, UNICEF, WHO (2020). The State of Food Security and Nutrition in the World 2020. Transforming Food Systems for Affordable Healthy Diets. https://books.google.co.za/books?hl=en&lr=&id=09zyDwAAQBAJ&oi=fnd&pg=PR1&dq=The+State+of+Food+Security+and+Nutrition+in+the+World+2020#v=onepage&q=The%20State%20of%20Food%20Security%20and%20Nutrition%20in%20the%20World%202020&f=false (Accessed 21 May 2021).

Fuglie LJ (2005). The Moringa Tree: A local solution to malnutrition. **Church World Serv. Senegal** 5: 75–83.

Ghuman, MR, Saloojee H, Morris G (2009). Infant feeding practices in a high HIV prevalence rural district of KwaZulu-Natal, South Africa. **South African Journal of Clinical Nutrition** 22: 74–79.

Godongwana E (2023). **Budget 2023 Budget Speech; National Treasury Department**. RSA: Pretoria, South Africa.

Gopalakrishnan L, Doriya K, Kumar DS (2016). Moringa oleifera: A review on nutritive importance and its medicinal application. **Food Science and Human Wellness** 5: 49–56.

Govender L, Siwela M (2020). The effect of Moringa oleifera leaf powder on the physical quality, nutritional composition and consumer acceptability of white and brown breads. **Foods** 9: 1910.

Harding KL, Aguayo VM, Webb P (2018). Factors associated with wasting among children under five years old in South Asia: Implications for action. **PLoS ONE** 13 : e0198749.

Headey D, Heidkamp R, Osendarp S, Ruel M, Scott N, Black R, Shekar M, Bouis H, Flory A, Haddad L (2020). Impacts of COVID-19 on childhood malnutrition and nutrition-related mortality. **Lancet** 396: 519–521.

Imdad A, Mayo-Wilson E, Haykal MR, Regan A, Sidhu J, Smith A, Bhutta ZA (2022). Vitamin A supplementation for preventing morbidity and mortality in children from six months to five years of age. Cochrane Database **Systematic Reviews** 11: 7.

Islam Z, Islam S, Hossen F, Mahtab-ul-Islam K, Hasan M, Karim R (2021). Moringa Oleifera is a prominent source of nutrients with potential health benefits. **International Journal of Food Science** 2021: 6627265.

Kaldenbach S, Engebretsen IM, Haskins L, Conolly C, Horwood C (2022). Infant feeding, growth monitoring and the double burden of malnutrition among children aged 6 months and their mothers in KwaZulu-Natal, South Africa. **Maternal Child Nutrition** 18: e13288.

Katepa-Bwalya M, Mukonka V, Kankasa C, Masaninga F, Babaniyi O, Siziya S (2015). Infants and young children feeding practices and nutritional status in two districts of Zambia. **International Breastfeed Journal** 10: 5.

Katiforis I, Fleming EA, Haszard JJ, Hape-Cramond T, Taylor RW, Heath ALM (2021). Energy, sugars, iron, and vitamin B12 content of commercial infant food pouches and other commercial infant foods on the New Zealand market. **Nutrients** 13: 657.

Karim O, Kayode R, Oyeyinka S, Oyeyinka A (2015). Physicochemical properties of stiff dough 'amala'prepared from plantain (Musa Paradisca) flour and Moringa (Moringa oleifera) leaf powder. **Hrana Zdr. Boles. Znan.-Strucˇni Cˇ asopis Nutr. Dijetetiku** 4: 48–58.

Keding G (2016). Nutrition transition in rural Tanzania and Kenya. **Hidden Hunger** 115: 68–81.

Madiba S, Chelule PK, Mokgatle MM (2019). Attending informal preschools and daycare centers is a risk factor for underweight, stunting and wasting in children under the age of five years in underprivileged communities in South Africa. **International Journal of Environmental Research Public Health** 16:2589.

Maggini S, Pierre A, Calder PC (2018). Immune function and micronutrient requirements change over the life course. **Nutrients** 10(10): 1531.

Manary M, Callaghan-Gillespie M (2020). Role of optimized plant protein combinations as a low-cost alternative to dairy ingredients in foods for prevention and treatment of moderate acute malnutrition and severe acute malnutrition. **Global Landscape Nutrition Challenges in Infants and Children** 93: 111–120.

Mannar V, Gallego EB (2002). Iron fortification: Country level experiences and lessons learned. **Journal of Nutrition** 132: 856S–858S.

Manzo ML, Hallarou ME, Halidou MD, Maiga DA, Bahwere P, Salimata W, Castetbon K, Wilmet-Dramaix M, Donnen P (2021). Effect of Moringa supplementation in the management of moderate malnutrition in children under 5 receiving ready-to-use supplementary foods in Niger: A randomized clinical trial. **Global Scholarly Communication Advanced Research Reviews** 8: 071–086.

Mashamaite CV, Pieterse PJ, Mothapo PN, Phiri EE (2021). Moringa oleifera in South Africa: A review on its production, growing conditions and consumption as a food source. **South African Journal Science** 117: 1–7.

Masuke R, Msuya SE, Mahande JM, Diarz EJ, Stray-Pedersen B, Jahanpour O, Mgongo M (2021). Effect of inappropriate complementary feeding practices on the nutritional status of children aged 6-24 months in urban Moshi, Northern Tanzania: Cohort study. **PLoS ONE** 16: e0250562.

Matsungo TM, Kruger HS, Faber M, Rothman M, Smuts CM (2017). The prevalence and factors associated with stunting among infants aged 6 months in a peri-urban South African community. **Public Health Nutrition** 20: 3209–3218.

Maponya N, Van Rensburg ZJ, Du Plessis-Faurie A (2021). Understanding South African mothers' challenges to adhere to exclusive breastfeeding at the workplace: A qualitative study. **International Journal of Nursing Sciences** 8: 339–346.

Matabura VV, Rweyemamu LM (2022). Formulation of plant-based food and characterisation of the nutritional composition: A case study on soy-moringa beverage. **Journal of Food Science Technology** 59: 3794–3805.

Method A, Tulchinsky TH (2015). Commentary: Food Fortification: African Countries Can Make More Progress. **Advances in Food Technology and Nutrition Sciences Open Journal** 1: 22–28.

Modjadji P, Madiba S (2019). The double burden of malnutrition in a rural health and demographic surveillance system site in South Africa: A study of primary schoolchildren and their mothers. **Bio Medical Central Public Health** 19: 1087.

Motadi SA, Mbhenyane XG, Mbhatsani HV, Mabapa NS, Mamabolo RL (2015). Prevalence of iron and zinc deficiencies among preschool children ages 3 to 5 y in Vhembe district, Limpopo province, South Africa. **Nutrition** 31: 452–458.

Moyo B, Masika PJ, Hugo A, Muchenje V (2011). Nutritional characterization of Moringa (Moringa oleifera Lam.) leaves. **African Journal of Biotechnology.**

Mkhize M, Sibanda M (2020). A review of selected studies on the factors associated with the nutrition status of children under the age of five years in South Africa. **International Journal of Environmental Research Public Health** 17:7973.

Mushaphi LF, Mbhenyane XG, Khoza L, Amey A (2008). Infant feeding practices of mothers and nutritional status of infants in Vhembe District in the Limpopo Province. **South African Journal of Clinical Nutrition** 21: 36–41.

National Agricultural Marketing Council (NAMC) (2023). **NAMC Food Basket:28 Selected Food Items Prices.** https://www.namc.co.za/wp-content/uploads/2023/03/Final-Food-Basket-Price-Monthly-Report-March-2023-003.pdf (Accessed 7 March 2023).

National Department of Health (nDoH), Statistics South Africa, South African Medical Research Council (SAMRC) (2017). **South Africa Demographic and Health Survey 2016: Key Indicators; Health and Vital Statistics Division**: Pretoria, South Africa: Government Printer.

Netshiheni KR, Mashau ME, Jideani AIO (2018). Nutritional and sensory properties of instant maize porridge fortified with Moringa oleifera leaves and termite (Macrotermes falciger) powders. **Nutrition and Food Science** 49: 654–667.

Ntila S, Ndhlala A, Mashela P, Kolanisi U, Siwela M (2020). Supplementation of a complementary white maize soft porridge with Moringa oleifera powder as a promising strategy to increase nutritional and phytochemical values: A research note. **South African Journal of Botany** 129: 238–242.

Ntila S, Ndhlala AR, Kolanisi U, Abdelgadir H, Siwela M (2019). Acceptability of a moringa-added complementary soft porridge to caregivers in Hammanskraal, Gauteng province and Lebowakgomo, Limpopo province, South Africa. **South African Journal of Clinical Nutrition** 32: 51–57.

Nshimyiryo A, Hedt-Gauthier B, Mutaganzwa C, Kirk CM, Beck K, Ndayisaba A, Mubiligi J, Kateera F, El-Khatib Z (2019). Risk factors for stunting among children under five years: A cross-sectional population-based study in Rwanda using the 2015 Demographic and Health Survey. **BioMed Central Public Health** 19: 175.

OECD (2022). **The Territorial Impact of COVID-19: Managing the Crisis across Levels of Government.** https://www.oecd.org/coronavirus/policy-responses/the-territorial-impact-of-covid-19-managing-the-crisis-across-levelsof-government-d3e314e1/ (Accessed 16 September 2022).

Oladiran DA, Emmambux NM (2022). Locally available African complementary foods: Nutritional limitations and processing technologies to improve nutritional quality—A review. **Food Review International** 38: 1033–1063.

Olagbemide PT, Philip C (2014). Proximate analysis and chemical composition of raw and defatted Moringa oleifera kernel. Adv**. Life Science Technologies** 24: 92–99.

Olusanya RN, Kolanisi U, Van Onselen A, Ngobese NZ, Siwela M (2020). Nutritional composition and consumer acceptability of Moringa oleifera leaf powder (MOLP)-supplemented mahewu. **South African Journal of Botany** 129: 175–180.

Panda SK, Lakra K, Panda SC (2019). Dietary diversity among women in the reproductive age group in urban field practice area, Vimszr, Burla. **International Journal of Biological and Medical Research** 3: 9–14.

Pollifrone MM, Cunningham K, Pandey Rana P, Philbin MM, Manandhar S, Lamsal, KP, Mandal RN, Deuja V (2020). Barriers and facilitators to growth monitoring and promotion in Nepal: Household, health worker and female community health volunteer perceptions. **Maternal Child Nutrition** 16: e12999.

Sambu W (2020). **Child Nutrition. South African Child Gauge 2020. Child Nutrition.** http://www.ci.uct.ac.za/sites/default/files/image_tool/images/367/Child_Gauge/South African_Child_Gauge_2020/CG2020_CC_child%20nutrition.pdf (Accessed on 27 July 2022).

Sayed N, Schönfeldt HC (2022). The use of linear programming to determine whether breastfed infants can achieve a nutritionally adequate complementary feeding diet: A case study of 6–11-month-old infants from KwaMashu, KwaZulu-Natal, South Africa. **South African Journal Clinical Nutrition** 35: 100–107.

Sayed N, Schönfeldt HC (2020). A review of complementary feeding practices in South Africa. **South African Journal of Clinical Nutrition** 33: 36–43.

Seonandan P, McKerrow N (2016). A review of infant and young child feeding practice in hospital and the home in KwaZulu-Natal Midlands. **South African Journal of Clinical Nutrition** 29: 111–115.

Shija AE, Rumisha SF, Oriyo NM, Kilima SP, Massaga JJ (2019). Effect of Moringa Oleifera leaf powder supplementation on reducing anemia in children below two years in Kisarawe District, Tanzania. **Food Science Nutrition** 7: 2584–2594.

Siddiqui F, Salam RA, Lassi ZS, Das JK (2020). The intertwined relationship between malnutrition and poverty. **Frontiers Public Health** 8: 453.

Sujatha B, Patel P (2017). Moringa oleifera–nature’s gold. **Imperial Journal of Interdisciplinary Research** 3: 1175– 179.

Sultana S (2020). Nutritional and functional properties of Moringa oleifera. **Metabolism Open** 8:100061.

Srikanth V, Mangala S, Subrahmanyam G (2014). Improvement of protein energy malnutrition by nutritional intervention with Moringa oleifera among Anganwadi children in rural area in Bangalore, India. **International Journal of Scientific Study** 2: 32–35.

Tshabalala T, Ncube B. Moyo H, Abdel-Rahman E, Mutanga O, Ndhlala A (2020). Predicting the spatial suitability distribution of Moringa oleifera cultivation using analytical hierarchical process modelling. **South African Journal Botany** 129: 161–168.

Umugwaneza M, Havemann-Nel L, Vorster HH, Wentzel-Viljoen E (2021). Factors influencing complementary feeding practices in rural and semi-rural Rwanda: a qualitative study. **Journal of Nutrition Science** 10: e45.

United Nations Children's Fund (2022a). **Breastfeeding—A Mother's Gift, for Every Child**. https://www.unicef.org/media/48046/file/UNICEF_Breastfeeding_A_Mothers_Gift_for_Every_Child.pdf (Accessed 27 June 2022).

United Nations Children's Fund (2020a). **South African Nutrition Brief.** https://www.unicef.org/southafrica/sites/unicef.org.southafrica/files/2020-07/ Nutrition-brief-2020.pdf (Accessed 16 March 2022).

United Nations Children's Fund (UNICEF) (1998). **The State of the World's Children 1998**. https://www.unicef.org/media/84766/file/SOWC-1998.pdf (Accessed 31 August 2022).

United Nations Children's Fund (UNICEF) (2020b). **UNICEF/WHO/The World Bank Group** Joint **Child Malnutrition Estimates: Levels and Trends in Child Malnutrition: Key Findings of the 2020 Edition**; New York, NY, USA: UNICEF.

United Nations Children's Fund (2022b). **Vitamin A Deficiency in Children**. https://data.unicef.org/topic/nutrition/vitamin-a-deficiency/ (Accessed 3 March 2022).

United Nations Children's Fund (2021). **Why Family-Friendly Policies Are Critical to Increasing Breastfeeding Rates Worldwide**. https://www.unicef.org/turkiye/en/press-releases/why-family-friendly-policies-are-critical-increasing-breastfeeding-rates-worldwide (Accessed 17 September 2021).

United Nations Children's Fund, World Health Organizations, World Bank Group (2021). **Joint child malnutrition estimates: levels and trends in child malnutrition: Key findings of the 2021 edition**. https://www.who.int/publications/i/item/9789240025257 (Accessed 29 July 2021).

Vitalis D, Vilar-Compte M, Nyhan K, Pérez-Escamilla R (2021). Breastfeeding inequities in South Africa: Can enforcement of the WHO Code help address them? –A systematic scoping review. **International Journal Equity Health** 20: 114.

Wakeel A, Farooq M, Bashir K, Ozturk L (2018). **Micronutrient malnutrition and biofortification: Recent advances and future perspectives. In Plant Micronutrient Use Efficiency.** Elsevier: Amsterdam, The Netherlands.

World Health Organizations (2021). **Breastfeeding.** https://www.who.int/health-topics/breastfeeding (Accessed 27 April 2021).

World Health Organizations (2000). **Complementary feeding family foods for breastfed children.** https://apps.who.int/iris/handle/10665/66389 (Accessed 12 May 2021)

World Health Organizations (2022b). **Infant and Young Child Feeding.** https://www.who.int/data/nutrition/nlis/info/infant-and-youngchild-Feeding (Accessed 8 January 2022).

World Health Organizations (2022a). **Malnutrition**. https://www.who.int/news-room/fact-sheets/detail/malnutrition (Accessed 12 January 2022).

Yadav H, Gaur A, Bansal SC (2022). Effect of Moringa Oleifera Leaf Powder Supplementation in Children with Severe Acute Malnutrition in Gwalior District of Central India: A Randomised Controlled Trial. **Journal of Clinical and Diagnostic Research** 16: 9–14.

Zungu N, Van Onselen A, Kolanisi U, Siwela M (2020). Assessing the nutritional composition and consumer acceptability of Moringa oleifera leaf powder (MOLP)- based snacks for improving food and nutrition security of children. **South African Journal of Botany** 129: 283–290.

CHAPTER 3
METHODOLOGY

3.1 Introduction

Chapter 3 describes the methods used in this study. This chapter will cover the following aspects of the study methodology: background information on the study site and participants, study design, materials and methods, data quality control and reduction of bias, statistical analysis and ethical considerations.

3.2 Background information on the study site and participants

3.2.1 Study site

Participants for this study were recruited from the sample population for the study entitled "Optimal Child Growth and Development (OrCHID)", which is composed of two cohorts, namely women and child project, which is referred to as SONKE, and Mother and Child in Environment (MACE). The OrCHID study is located in urban and rural settings in KZN, SA. The MACE cohort is located in low-socio-economic communities in eThekwini (Durban) district (urban area), and the SONKE cohort is located in uMkhanyakude and uMgungundlovu districts (rural areas). Figure 3.1 is a South African map depicting the location of KZN, and Figure 3.2 is a map depicting eThekwini, uMkhanyakude and uMgungundlovu districts in KZN.

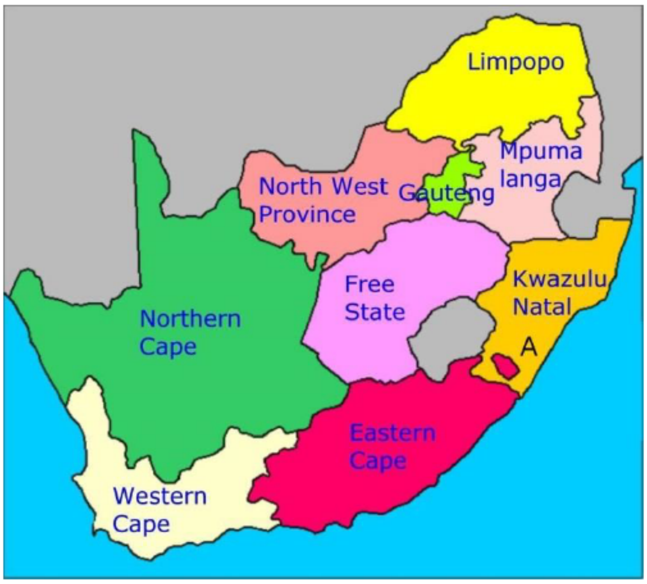

Figure 3.1: A map of South Africa, KwaZulu-Natal province (A)

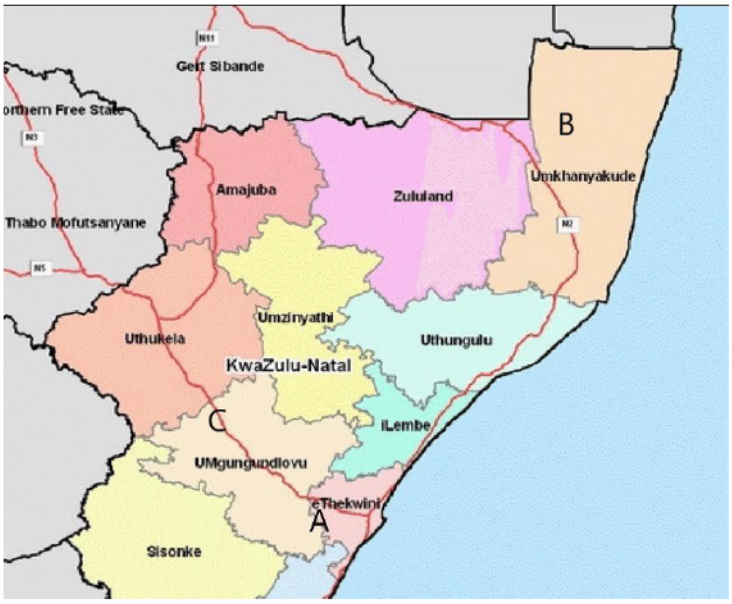

Figure 3.2: A map of the KwaZulu-Natal province showing eThekwini (A), uMkhanyakude (B) and uMgungundlovu (C) district

The KwaZulu-Natal (KZN) province has the second largest population amongst the nine provinces of SA. It has an estimated population of 11.54 million people (Statistics South Africa 2022). The KZN province has a multicultural mix of people, and the principal languages spoken are *IsiZulu*, English and Afrikaans (Akpa-Inyang, Ojewole & Chima 2022). *eThekwini* is a district in KZN that was established in 1880, and the city of Durban, within this district, is the third largest of the cities in SA (Statistics South Africa 2022). According to the SA National Department of cooperative governance and traditional affairs (COGTA), *uMkhanyakude* is the northernmost of the eleven districts of the KZN province in SA (COGTA 2020). At 12 818 km^2 and with a population totaling approximately 625 846, uMkhanyakude is the second largest district in the KZN province and is a very rural district that remains affected by malnutrition in children under five years old (COGTA 2020). uMgungundlovu district is the home of Pietermaritzburg, the capital city of KZN, it is located approximately 80 km from *eThekwini* (COGTA 2020). *uMgungundlovu* district has a total population of 1 095 865 people and an extent of 9 603 m^2 (COGTA 2020). Approximately 54.6% of the population in uMgungundlovu has no source of income (COGTA 2020). This can be a contributing factor to childhood malnutrition in uMgungundlovu district.

3.2.2 Study participants

The participants of this study were enrolled in the OrCHID study, which included participants from the MACE (urban area) and SONKE (rural area) cohort studies. This study was restricted to caregivers of children between the ages of two and five years who fed their children home-prepared complementary foods. The SONKE cohort had participants from two years onwards. There were no under two year old children in that component of the study. Due to COVID-19, no new participants were enrolled in the MACE cohort. In order to compare data from the same age groups in the rural and urban areas, caregivers who had children between two and five were included in the study. Those who fed commercially prepared and/or bought complementary foods were excluded from the study.

3.2.3 Sampling procedure

The study participants were conveniently recruited from the existing participants in the OrCHID project. Only participants between the ages of two and five from the MACE and SONKE cohorts were recruited to participate. A list of the study participants from the MACE and SONKE cohort studies meeting the inclusion criteria of this study was compiled on the excel spreadsheet. The list included the caregiver's details (name, surname, contact number) and children's details (name, surname, gender, and date of birth). Stratified sampling was used to group participants. Stratified sampling is a method of division of a population into smaller groups based on their similar characteristics (Martinez-Mesa, Gonzalez-Chica, Duquia, Bonamigo & Bastos 2016). In this study, the participants were grouped according to the population area (either rural or urban) and the children's age groups (2 - <3; 3 - <4, and 4 - <5 years).

3.3 Study design

This study used a cross-sectional, descriptive, quantitative and laboratory experiment study design.

3.3.1 Phase one - Determining popular home-prepared complementary foods and their nutritional composition

This study was conducted during COVID-19 alert level one lockdown restrictions in SA, where face-to-face contact with participants had to be restricted (SA Government 2022). Therefore, telephonic interviews were used for data collection using a standardized questionnaire to identify popular home-prepared complementary food and complementary food recipes used by the caregivers. Phase one of this study used a cross-sectional, descriptive and quantitative research methods.

Cross-sectional and descriptive method

This study used cross-sectional research methodology to determine objective one (to identify the popular home-prepared complementary foods fed to children among selected rural and urban population groups in KZN). Cross-sectional research methodology looks at data at a single point in time (Wang & Cheng 2020). In this study, the participants were interviewed at one point in time during the telephonic interview using a standardised questionnaire, and the interview was not repeated over time. The advantages of a cross-sectional study are that it is inexpensive and easy to conduct (Wang & Cheng 2020). Cross-sectional studies are also known as descriptive research; they describe the characteristics of a sample population (Aggarwal & Ranganathan 2019). In this study, descriptive research methodology was also used to determine popular home-prepared complementary foods in KZN.

Quantitative method

Quantitative research methodology was applied to determine objective two (to assess the nutritional composition of the selected home-prepared complementary foods consumed by children living in selected rural and urban population groups in KZN) of this study. A quantitative research method is used to collect and analyse numerical data (Hardeman, Van Weeren, Braganca, Warmerdam & Box 2021). The software Food Finder was used to determine the nutritional composition of home-prepared complementary foods. The quantitative research method allows for quick data collection, and it also enables remote data collection (Hardeman et *al* 2021).

3.3.2 Phase Two – Product Development

Phase two of this study used laboratory experimental research methods.

Laboratory Experiments

The experimental research method was used to determine objective three (to determine how the identified home-prepared complementary foods can be modified through the incorporation of MOLP to improve their nutritional composition); objective four (to determine the effect of MOLP on the physical quality of the identified home-prepared complementary foods) and objective five (to determine the effect of MOLP on the nutritional composition of home-prepared complementary foods). The study design and conceptual framework of the study flow are presented in Figures 3.3 and 3.4.

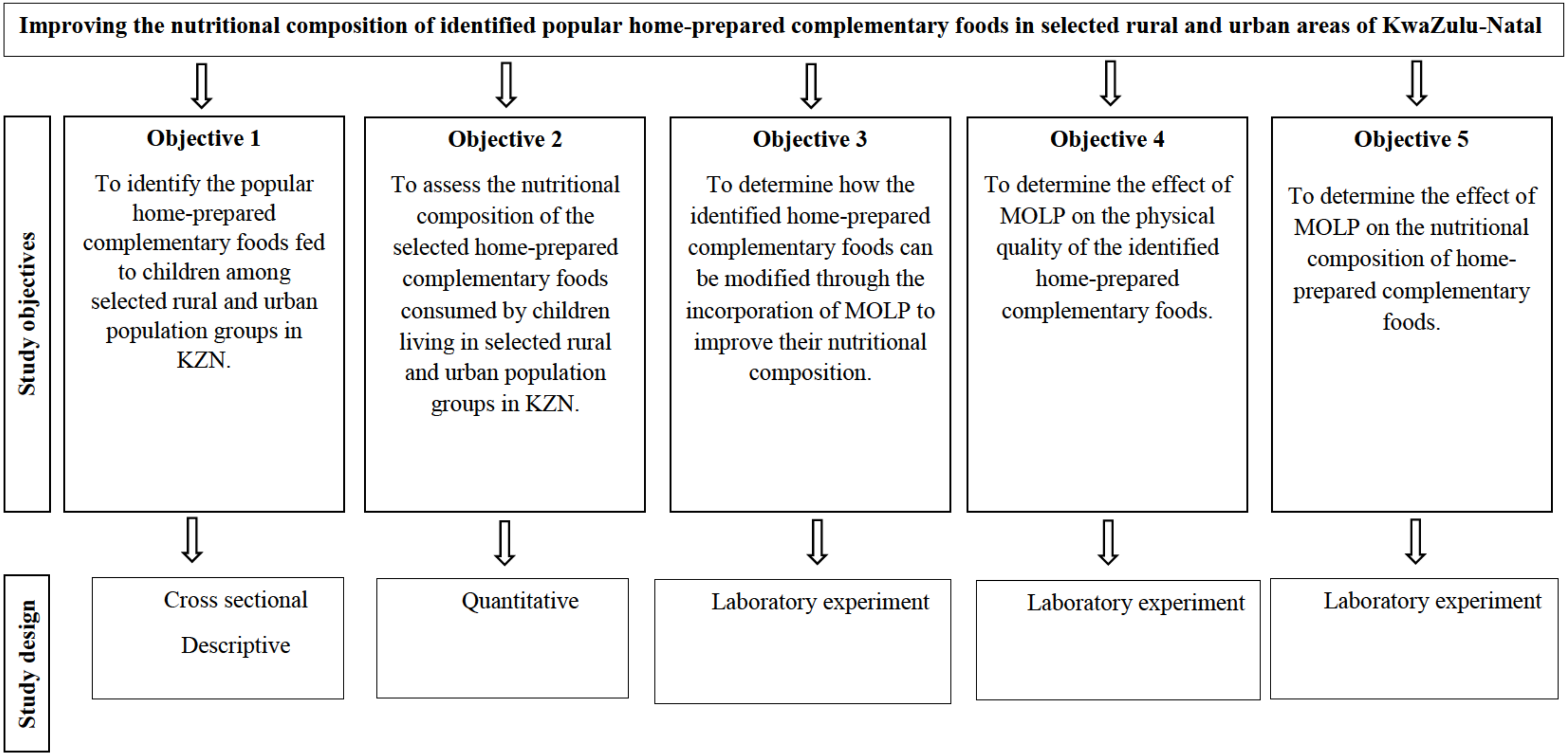

Figure 3.3: Study design

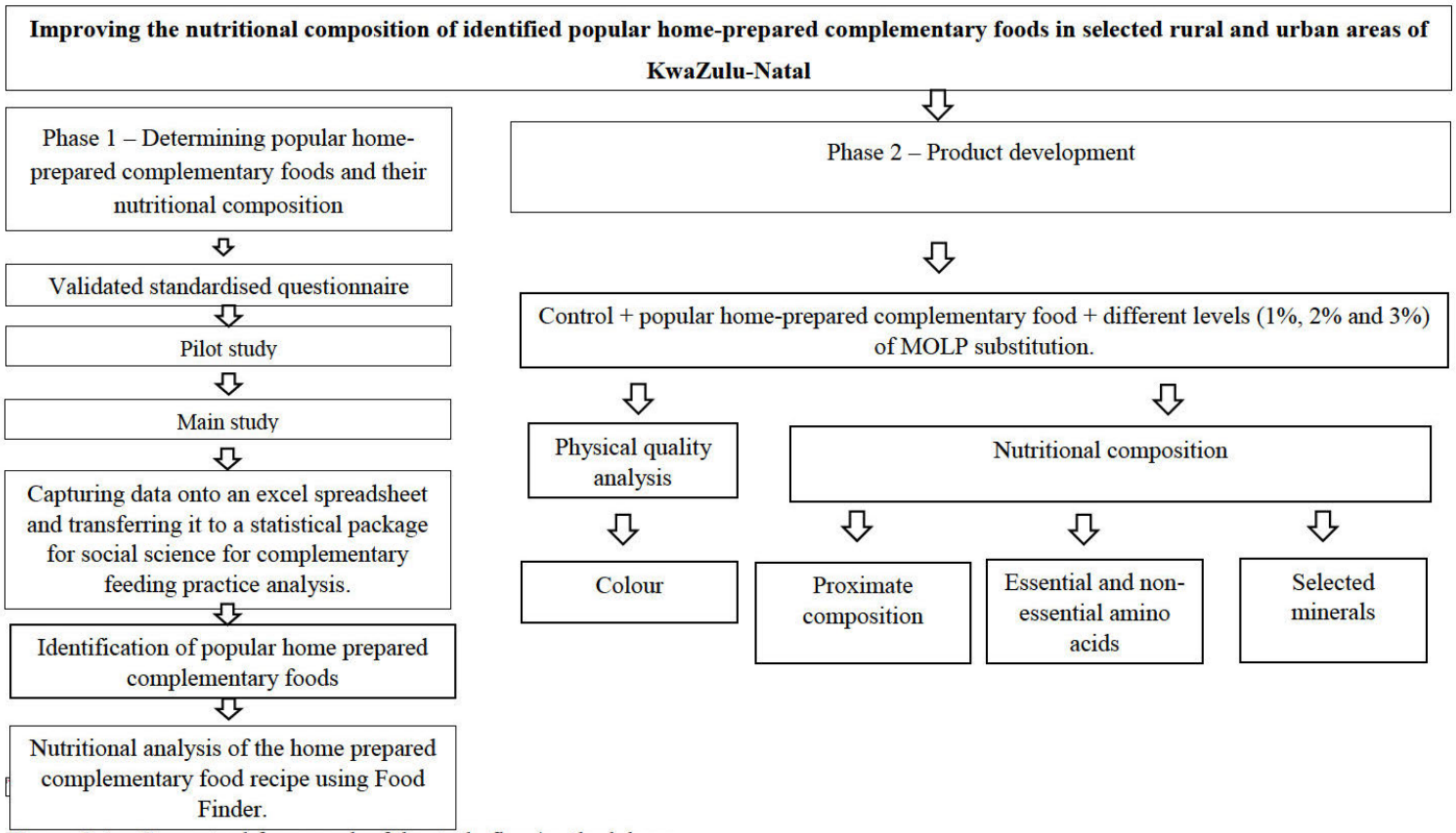

Figure 3.4: Conceptual framework of the study flow/methodology

3.4 Study materials and methods

The study materials and methods used in phases one and two of this study are presented in this section.

3.4.1 Phase one - Determining popular home-prepared complementary foods and their nutritional composition

Phase 1 focused on objective one (to identify the popular home-prepared complementary foods fed to children among selected rural and urban population groups in KZN) and two (to assess the nutritional composition of the selected home-prepared complementary foods consumed by children living in selected rural and urban population groups in KZN) of this study.

Questionnaire

A standardised questionnaire was used for data collection. The researcher developed the questionnaire, and thereafter it was validated by three experts in the science field, namely a dietitian, a food scientist and a statistician. Data collection was conducted during the COVID-19 alert level one lockdown restrictions in SA, where face-to-face contact with participants had to be restricted (Section 3.3). Telephonic interview for data collection offers effective data collection at a low cost, especially during challenging settings (Maffioli 2020). The standardised questionnaires were first written in English (Appendix A) and translated into *isiZulu* (Appendix B) by someone who was proficient in English and *isiZulu*. *IsiZulu* and English are the most dominant languages in KZN (Akpa-Inyang, Ojewole & Chima 2022). The questionnaire had questions on complementary feeding practices and included the home-prepared complementary foods given to infants.

The questionnaire was divided into sections A and B. Section A covered the caregiver and child's personal details separately and the type of food (home-prepared or commercial) the caregiver used to introduce complementary feeding to their children (either home-prepared or commercial). Participants who had used home-prepared complementary food/s to introduce solids proceeded to section B of the questionnaire. Those who had used commercial complementary food/s were excluded from the study. Section B covered questions on complementary feeding practices and home-prepared complementary food/s prepared by the caregivers, from there, the popular home-prepared complementary food was identified, and the nutritional composition of the home-prepared complementary food was analysed using the Food Finder.

Pilot study

A pilot study is conducted in research to test the methodology and improve the study design (Junyong 2017; Leon, Davis & Kraemer 2012). The pilot study was conducted in April 2022 using the first six participants on the list (the list was in alphabetical order of surname). The participants used in the pilot study were not used in the main study.

The pilot study participants were contacted a day before to explain the purpose of the study and obtain consent from them. The consent form was written in English (Appendix C) and in *isiZulu* (Appendix D). The consent form was read to the caregivers and verbal consent was obtained. Those who wanted to participate in the study were given an opportunity to choose the date and time that was suitable for them to participate to ensure a better response rate.

In the pilot study, telephonic calls were long as the researcher had to record the participant's responses on the questionnaire manually. This affected the participants as well; some of the participants had other responsibilities during that time and could not spend a lot of time on the telephonic interview. Along with manually recording the participant's responses to the questionnaire, the interviews were also recorded using the voice recorder as a tactic to save time. This assisted in making calls quicker as the researcher could go back and fill in the answers that were missed or not fully documented during the telephonic interview.

Main study

For the main study, data collection for phase one was conducted between April to June 2022 with 176 participants. All participants that met the inclusion criteria for the current study were given an equal chance to be part of the study. All 176 individuals were contacted. Other challenges not encountered in the pilot study were encountered during the main study; the main challenge was that some of the study participants could not be reached. The participants who could not be reached were contacted again the following day and again the following week before they were excluded from the study. Participants were contacted a maximum of three times on different days before been excluded from the study.

Most of the study participants had more than one contact number. The alternative contact number was used if the main number was not working or answered. Other alternative numbers either belonged to a partner or a relative. In most cases, when the alternative number worked or was answered, the interview could not be conducted because the person who answered the call was either working and/or staying in a different area from that of the caregiver or the partner would state that they were no longer in a relationship. Some calls were answered by someone involved in raising and feeding the child, such as the grandmothers. In those cases, consent was obtained and the interview was conducted with the suitable alternative caregiver.

Data capturing

Data collected during phase one of the study was captured onto an Excel spreadsheet and transferred onto the Statistical Package for Social Sciences (SPSS) version 25. The nutritional composition of the home-prepared complementary foods was analysed with Food Finder (version 1.0), a dietary analysis software. Thereafter, the identified popular home-prepared complementary foods were prepared and substituted with different levels of MOLP to determine the effect of MOLP on the physical quality and nutritional composition of the home-prepared complementary foods. Preparation of MOLP-added home-prepared complementary food was conducted in phase two of this study. The materials and methods are presented in the next section.

3.4.2 Phase Two – Product Development

Phase two focused on objective three (to determine how the identified home-prepared complementary foods can be modified through the incorporation of MOLP to improve their nutritional composition); objective four (to determine the effect of MOLP on the physical quality of the identified home-prepared complementary foods) and objective five (to determine the effect of MOLP on the nutritional composition of home-prepared complementary foods).

Preparation of the identified popular home-prepared complementary food

Figure 3.5 presents the ingredients used to make MOLP-added home-prepared complementary food. White maize porridge (Appendix E), maize and pumpkin porridge (Appendix F) and MOLP-added home-prepared complementary foods (Appendix G) recipes were used.

Figure 3.5: Ingredients used to make MOLP-added home-prepared complementary foods, white maize (A), pumpkin (B) and *Moringa oleifera* leaf powder (C)

White maize meal and pumpkin were purchased from a supermarket in Pietermaritzburg (PMB), SA. MOLP was purchased from a local pharmacy in PMB, SA. White maize porridge was used as the control and was prepared following the recipe for a white maize porridge (Appendix E). The porridges containing white maize and pumpkin were prepared using a South African indigenous food recipe (Appendix F). To prepare the samples, white maize was replaced with MOLP at 1, 2 and 3 % w/w substitution levels. Calculations of MOLP substitution levels (1%, 2% and 3% w/w) are presented in Appendix G.

Analysis of MOLP-added complementary foods

The cooked food samples were cooled before being packaged for freeze-drying. The BTP-9ELEOX freeze dryer was used to dry the food samples. The freeze-dried samples were grounded into powder and stored in an airtight container before colour and nutritional analyses were done. Approved (Standard) methods used for colour and nutritional analysis are described in the next sections.

Colour analysis

The colour analysis of popular home-prepared complementary food samples was conducted using the Hunter lab CFLX-45-2 colour flex. The colour analysis was conducted in triplicate for each food sample. The L value (a measure of lightness), a value (a measure of redness and greenness) and b value (a measure of yellowness) were determined for identified home-prepared complementary food samples prepared during product development of this study. L value represent lightness from black to white on scale of zero to one hundred, while a value and b values represent chromaticity with no specific numeric limit. Negative a value correspond with red and negative b value corresponds with blue and positive b value correspond with yellow.

Nutritional analysis

Nutritional analysis of samples of complementary foods was conducted according to the approved (standard) Association of Official Analytical Chemists methods (AOAC) (2003). Nutritional analysis of each nutrient of each sample was in duplicate. The procedure for the analysis of each nutrient is described below.

Moisture

The official method 934.01 Association of Official Analytical Chemists (AOAC) (2003) was used to measure the moisture content. The samples were dried at 95 ºC for 72 hours in an air-circulated oven. The moisture content was calculated using the weight loss content of the samples. The following equation was used to calculate the moisture content:

$$\% \text{ moisture} = \frac{(\text{mass of the sample+dish})-(\text{mass of sample+dish after drying})}{(\text{mass of the samples+dish})-(\textit{mass of petri dish without the lid})} \text{ x } 100$$

Protein

The protein content was measured with a LECO Truspec Nitrogen Analyser, using the AOAC Official method 990.03 (AOAC 2003). The samples were placed individually in a combustion chamber with an autoloader at 950ºC. The percentage content was calculated using the following equation:

% crude protein = % N x 6.25

Fat

The soxhlet procedure following AOAC official method 920.39 (AOAC 2003) was used to measure the fat content. The Büchi 810 Soxhlet Fat extractor was used for the fat content analysis (Büchi, Flawil, Switzerland). Petroleum ether was used for extraction. The percentage of crude fat was calculated using the equation below:

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

Fibre

Fibre was determined as neutral detergent fibre (NDF). The fat content of the samples was measured after the samples were dried. The samples had to be defatted before the analysis could be conducted if the samples had a fat content of > 10%. Samples were weighed, and Neutral Detergent Reagent and the enzyme amylase were added. The samples were boiled for one hour, and samples were then filtered, using a low vacuum. The contents were dried overnight at 105°C. Their weights were recorded after these samples were allowed to cool. The samples were ashed for three hours at 5500C and weighed after being cooled. The following equation was used to calculate NDF (Van Soest, Robertson & Lewis 1991):

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

Individual Mineral Elements

The calcium, magnesium, manganese, zinc, iron, potassium, copper, sodium and phosphorus were analysed using the Agricultural Laboratory Association of Southern Africa (ALASA) Method 6.5.1. The first step of this process was to freeze-dry the samples in a freeze drier. In a furnace, samples were ashed overnight at 550◦C. The samples were dissolved in HCl, and thereafter HNO3 was added. The samples were analysed using an atomic absorption spectrophotometer. The Analytik Jena Spekol 1300 spectrophotometer was used to determine calcium and phosphorus (Analytik Jena AG, Achtung, Germany). Iron was determined with the Varian SpectrAA atomic absorption spectrophotometer (Varian Australia Pty Ltd, Mulgrave, Victoria) and the zinc with the GBC 905AA spectrophotometer (GBC Scientific Equipment Pty Ltd, Dandenong, Victoria, Australia).

Amino acids

Amino acid separation and detection was by a Waters Acquity Ultra Performance Liquid Chromatograph (UPLC) fitted with a photodiode array (PDA) detector. Accurately, 1 µl of sample/standard solution was injected into the mobile phase, which conveys the derivatized amino acids onto a Waters UltraTag C_{18} column (2.1 x 50mm x 1.7µm) held at 60°C. Analytes eluting off the column were detected by the PDA detector, with each amino acid coming off the column at a unique retention time. Instrument control and data acquisition was performed by MassLynx software, which integrates the peaks at the defined retention times and plots calibration curves for each amino acid based on the peak response (peak area/internal standard peak area) against concentration.

3.5 Data quality control and reduction of bias

During the interview using standardised questionnaire, to ensure data quality control and reduce bias, each participant was required to consent before participating. The consent form was read out to the participants telephonically. Consent to participate in the study was given verbally and this was recorded manually and on the voice recorder by the researcher. The consent form was read to the participants in their preferred language, either English (Appendix C) or *isiZulu* (Appendix D), to ensure that all participants could understand the information on the consent form. The interview was also conducted in a language that the participant preferred between *isiZulu* and English. Each participant had a unique number to keep them anonymous and protect the identity of the participants. They were not referred to by their names in the questionnaire but were referred to by their unique identity number. A standardised, validated questionnaire was used to record the complementary feeding practices and recipes of home prepared complementary foods. The interview was recorded manually and using a digital voice recorder, the researcher cross-checked to ensure that the correct response was documented. The following steps were taken to ensure quality control: scale calibration, using standardised recipes, using the same measuring equipment, pots, and the same brands of raw materials. Samples were transported in an air-tight container to the study site. The food samples were packed in duplicate for nutritional analysis and in triplicate for colour analysis to compare the results. The food samples were labelled alphabetically to prevent bias during the analysis, as they were not labelled according to what was inside the package.

3.6 Statistical analysis

Data from the standardised questionnaires and results of the effect of MOLP on the physical quality and nutritional composition of MOLP-added home-prepared complementary foods were captured onto an excel spreadsheet and cross-checked for accuracy. Thereafter, data were transferred into the SPSS for analysis. Data of nutritional analysis of home prepared complementary food recipes were analysed with Food Finder (version 1.0), a dietary analysis software of the Medical Research Council. Data of physical quality analysis and nutritional analysis were analysed by appropriate descriptive and inferential statistical methods, including one-way analysis of variance (ANOVA). A p-value < 0.05 was considered statistically significant.

3.7 Ethical considerations

Ethical approval for this study was obtained from the University of KwaZulu-Natal Biomedical Research Ethics Committee (UKZN BREC); the protocol reference number is BREC/00003165/2021 (Appendix H). The MACE study obtained ethics approval from the UKZN BREC; the protocol number is BF263/12 (Appendix I). The SONKE study obtained ethics approval from the UKZN BREC; the protocol number is BF250/14 (Appendix J).

3.8 References

Aggarwal R, Ranganathan P (2019). Study designs: Part 2- Descriptive Studies**. Perspectives Clinical Research** 10(1): 34-36.

Akpa-Inyang F, Ojewole E, Chima SC (2021). Patients' Experience on Practice and Applicability of Informed Consent in Traditional Medical Practice in KwaZulu-Natal Province, South Africa. **Evidence-Based Complementary and Alternative Medicine** 2022:11

Ames H, Glenton C, Lewin S (2019). Purposive sampling in a qualitative evidence synthesis: a worked example from a synthesis on parental perceptions of vaccination communication. **BMC Medical Research Methodology** 19:26.

Association of Official Analytical Chemists (AOAC) (2003). **Official methods of analysis of the association of analytical chemist international.** Association of official chemists 17th 3d. AOAC International: Gaithersburg, M, USA.

Department of cooperative governance and traditional affairs of South Africa (COGTA (2020). **Profile and Analysis District Development Model.** https://www.cogta.gov.za/ (Accessed 8 January 2023).

Hardeman AM, PR Van Weeren, FMS Braganca, Warmerdam H, Box HGT (2021). A first exploration of perceived pros and cons of quantitative gait analysis in equine clinical practice. **Equine Veterinary Education** 34(10): 2021.

Junyong (2017). Introduction of pilot study. **Korean Journal of Anesthesiology** 70(6):601-605.

Leon AC, Davis LL, Kraemer HC (2011). The role and interpretation of pilot studies in clinical research. **J Psychiatric Res** 45(5): 626-9.

Maffioli EM (202). Collecting data during an epidemic: novel mobile phone research method. **Journal of International Development** 32:8.

Martinez-Mesa J, Gonzalez-chica DA, Diquia RP, Bonamigo RR, Bastos JL (2016). Sampling: how to select participants in my research study? **Anais Brasileiros de Dermatologia** 3: 326-30.

Statistics South Africa (2022). **60.6 million people in South Africa.** https://www.statssa.gov.za/?p=15601 (Accessed 12 March 2023).

South African Government (2022). **Coronavirus COVID-19 Alert level 1.** https://www.gov.za/covid-19/about/coronavirus-covid-19-alert-level-1 (Accessed 12 January 2023).

Wang X, Cheng Z (2020). Cross-Sectional Studies: Strengths, Weaknesses, and Recommendations. **Elsevier** 158(1S): S65-S71**.**

Van Soest PJ, Robertson JB, Lewis BA (1991). Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. **Journal of Dairy Science 74** (10): 3583 – 97.

CHAPTER 4

RESULTS

Chapter 4 presents and describes in detail the study's results.

4.1 Home-prepared complementary foods given by caregivers to children

4.1.1 Participants characteristics

The participant's characteristics are presented in Table 4.1.

Table 4.1: Participant's characteristics

Criteria	Characteristics	n*(%)
OrCHID study cohort	SONKE	25(52.1)
	MACE	23(47.9)
Caregiver	Mother	45(93.8)
	Grandmother	3(6.3)

*total sample (n=48)

A total of 176 participants with children between the ages of two to five years were identified from the SONKE and MACE cohorts to participate in this study. However, from the identified sample, 110 participants were not available during the time of the study. The following reasons were why they were unavailable; their contact numbers were either going to voicemail, not answered, or answered by the wrong person or a relative/partner who no longer had contact with the caregiver. A total of 66 participants from the SONKE and MACE cohorts were interviewed. However, only 48 of the participants met the inclusion criteria and were eligible to participate in the study.

4.1.2 Age of introduction of solids to children by the caregivers

Although Table 4.2 indicates that there was a significantly higher number of infants (n=23; 47.9%) that were introduced to solids between 6 - < 7 months, there was a significant number of infants (n=16; 33.3%) that were introduced to solids before six months, respectively ($p < 0.001$).

Table 4.2: Age of introduction of solids

Age solids were introduced	n (%)*
Below 6 months	16 (33.3)
Between 6 - < 7 months	23 (47.9)
Between 7 – 12 months	7 (14.6)
Above 12 months	2 (4.2)
p-value	**<0.001**

*total sample (n=48); p value of < 0.05 was considered significant according to the Chi-square goodness-of-fit test.

4.1.3 Types of food items used as complementary foods by the caregivers

As part of the questionnaire, caregivers indicated the food items they gave their children as complementary foods when they initiated complementary feeding. Table 4.3 presents the main food items that were used to introduce complementary feeding. A large number of caregivers (n=29; 60.4%) started complementary foods by giving white maize.

Table 4.3: Main food items that were used to introduce complementary feeding

Food item	n* (%)
White maize	29 (60.4)
Potatoes	6 (12.5)
Pumpkin	5 (10.4)
Other (cooked apple, three-minute cook porridge, cooked instant porridge, *incumbe* and noodles)	8 (16.7)

*total sample (n=48)

The caregivers were also asked to report on the types of home-prepared complementary food that they prepared and fed to their children up to the age one. Table 4.4 presents the home-prepared complementary foods used by the caregivers to feed their children up to the age of one. According to Table 4.4 the three most popular home-prepared complementary foods given were pumpkin (n=26; 54.2%), potato (n=20; 41.7%) and white maize porridge (n=16; 33.3%).

Table 4.4: Home-prepared complementary foods given by caregivers to infants under one year

Complementary food item	n*(%)
Pumpkin	26 (54.2)
Potato	20 (41.7)
White maize porridge	16 (33.3)
Beans	7 (14.6)
Spinach	4 (8.3)
White maize stiff pap	4 (8.3)
Chicken	4 (8.3)
Rice	3 (6.3)
Sweet potato	3 (6.3)
Fish	3 (6.3)
Phuthu	2 (4.2)
Cooked apple	2 (4.2)
Minced beef	2 (4.2)
Jungle oat	1 (2.1)
Incumbe	1 (2.1)
Egg	1 (2.1)
Vienna	1 (2.1)
Carrot	1 (2.1)
Bread	1 (2.1)
Samp	1 (2.1)

n (%) = total number who used a particular complementary food out of total number of caregivers (48)

4.1.4 Sources of vegetables used during complementary feeding

Caregivers were asked questions to determine the source of the food items given to their infants during complementary feeding. Table 4.5 indicates that there were a significantly higher number of caregivers (n=32; 66.7%) that did not have a vegetable garden (p=0.011).

Furthermore, a significantly higher percentage of caregivers, 87.5%, relied on vegetables bought from the shops (p<0.001).

Table 4.5: The availability and use of vegetable gardens at a household level

Questions asked to participants	Frequency (%)			p-value
	Yes n (%)	No n (%)	Did not answer[a]	
Does your family grow vegetables at home?	14 (29.2)	**32 (66.7)**	2 (4.2)	**0.011**
Does your family grow vegetables to sell?	2 (4.2)	**43 (89.6)**	3 (6.3)	**<0.001**
Does your family consume the vegetables they grow?	10 (20.8)	**35 (72.9)**	3 (6.3)	**<0.001**
Does your family buy vegetables from the shop?	**42 (87.5)**	4 (8.3)	2 (4.2)	**<0.001**

[a]: a total number of participants that decided to not answer the question; total sample (n=48); values in bold indicate a p value of < 0.05 and considered significant according to the test-binomial test.

Table 4.6 shows the factors that affected the availability of a vegetable garden at a household level for the caregivers (Table 4.5) who reported that they do not grow vegetables at home (n=32; 66.7 %) where the majority (n=24; 75.0%) of the caregivers disagreed to not needing a vegetable garden at a household level (p=0.001).

Table 4.6: Factors that affected the availability of a vegetable garden at a household level

Factor	Level of agreement n (%)					Mean ± SD	p-value
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree		
My family does not need a vegetable garden	2 (6.3)	24 (75.0)	1 (3.1)	3 (9.4)	2 (6.3)	2.34±0.97	**0.001**
My family does not have space for a vegetable garden	3 (9.4)	12 (37.5)	1 (3.1)	12 (37.5)	4 (12.5)	3.06±1.29	0.786
My family cannot afford to buy seeds/vegetables to plant	9 (28.1)	14 (43.8)	2 (6.3)	1 (3.1)	6 (18.8)	2.41±1.43	**0.026**
There is not enough readily available water to grow vegetables	1 (3.1)	15 (46.9)	-	16 (50.0)	-	2.97±1.06	0.869

Total sample (n=32); p value of < 0.05 was considered significant according to one sample t-test.

Caregivers were asked if they grew or bought any crops for use during complementary feeding. Pumpkin was the most commonly grown and/or bought vegetable by caregivers (n=19; 58.3%) for consumption during complementary feeding (Figure 4.1). These results correlate with the findings presented in Table 4.4, where pumpkin was the most popular home-prepared complementary food.

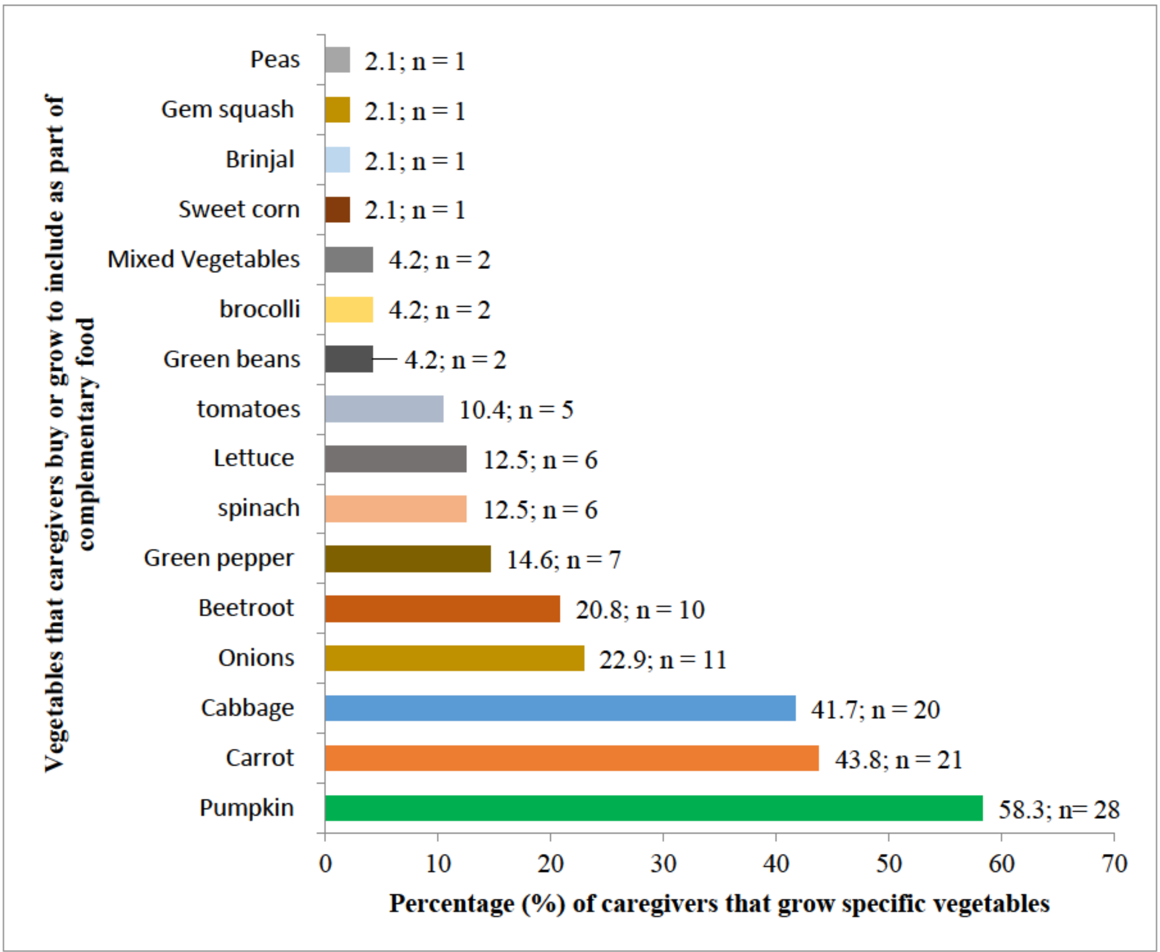

Figure 4.1: Commonly grown and/or bought vegetables by caregivers to use during complementary feeding

To identify the popular home-prepared complementary foods, caregivers were also requested to report on the use of indigenous crops during complementary feeding. Table 4.7 shows results on the indigenous crops used during complementary feeding.

Table 4.7: The use of indigenous crops during complementary feeding

Questions on the use of indigenous crops	Yes	No	Did not answer	p-value
	n (%)			
Does your family grow indigenous crops?	27 (56.3)	17(35.4)	4 (8.3)	0.174
Does your family consume indigenous crops?	26 (54.2)	18 (37.5)	4 (8.3)	0.291
Have you heard of Moringa?	11 (22.9)	32 (66.7)	5 (10.4)	**0.002**
Does your family consume Moringa?	5 (10.4)	39 (81.3)	4 (8.3)	**<0.001**

Total sample (n=48), binomial test.

Although not statistically significant, a total of 56.3% of the caregivers (n=27) consumed indigenous crops. A significant number of caregivers have not heard of moringa (n=32, 66.7%) ($p < 0.002$) or consumed moringa (n=39, 81.3%) ($p < 0.001$).

4.1.5 Portion sizes used during complementary feeding

Table 4.8 presents the portion sizes used during complementary feeding. The majority of the caregivers (n= 17; 35.4%) gave their 6 to <12 months old children 5 to < 10 teaspoons of complementary food (p =0.001). In children between 12 to < 18 months, a significant number of caregivers (n=15; 31.3%) gave their children between 10 teaspoons to ½ cup of complementary food (p= 0.001) and 1 – 2 cups were given to the majority (n=23; 47.9%) of children between 18 to 24 months, p= 0.001 (Table 4.8).

Table 4.8: Portion sizes used during complementary feeding

Age	< 6 months	6-12 months	12-<18 months	18-<24 months	24-<36 months
Portion Size			n (%)		
< 5 tsp	8 (16.7)	4 (8.3)	-	-	-
5-< 10 tsp	6 (12.5)	**17 (35.4)**	2 (4.2)	-	-
10-< ½ cup	-	**10 (20.8)**	**15 (31.3)**	2 (4.2)	-
½ - <1 cup	-	**10 (20.8)**	**14 (29.2)**	**12 (25)**	5 (10.4)
1 – 2 cups	-	-	**11 (22.9)**	**23 (47.9)**	10 (20.8)
>2 cups	-	-	-	5 (10.4)	**29 (60.4)**
Didn't respond	34 (70.8)	6 (12.5)	5 (10.4)	5 (10.4)	3 (6.3)
Can't remember	-	1 (2.1)	1 (2.1)	1 (2.1)	1 (2.1)
P value	0.593	**0.001**	**<0.0001**	**<0.0001**	**<0.0001**

total sample (n=48); values in bold indicate a p value of < 0.05 and considered significant according to chi-square goodness-of-fit.

4.2 Nutritional composition of home-prepared complementary foods

The nutritional compositions of home-prepared complementary foods are presented in Table 4.9 (proximate) and Table 4.10 (minerals). As presented in Table 4.9 and 4.10, 100 g of the cooked white maize porridge provided (popular home-prepared complementary food) 270 KJ/ 100 g, 1.3 g/ 100 g, 0.5 g/ 100 g, 2 mg/ 100 g, 0.5 mg/100 g, 15 mg/ 100 g, 31 mg/ 100 g, 33 mg/100 g, 1 mg/ 100 g and 0.51 mg/ 100 g respectively of energy, protein, fat, calcium, iron, magnesium, phosphorus, potassium, sodium and zinc.

Table 4.9: Proximate composition of analysed home-prepared complementary food recipes collected from caregivers

Home prepared complementary food	**n* (%)**	**Nutrients**			
		Moisture (%)	**Energy (KJ)**	**Protein (g)**	**Fat (g)**
Beans	1 (2.1)	89.6	171	2.0	0.2
Cooked and mashed apple	1 (2.1)	91.6	143	0.2	0.1
Cooked instant porridge	1 (2.1)	40.3	1041	3.4	1.6
Cooked white maize porridge [a]	**23 (47.9)**	**84.6**	**270**	**1.3**	**0.5**
White maize porridge with margarine and peanut butter	2 (4.2)	77.3	448	2.7	5.4
White maize porridge with full fat milk	1 (2.1)	85.4	273	1.6	1.0
Mashed potatoes	7 (14.6)	64.9	256	1.2	0.1
Mashed potatoes with margarine	1 (2.1)	68.4	632	1.3	10
Pumpkin	6 (12.5)	90.7	221	0.7	3.4
Pumpkin with margarine	2 (4.2)	88.3	309	0.7	5.9
Pumpkin with peanut butter	1 (2.1)	75.6	568	5.2	8.5
Samp	1 (2.1)	94.4	86	0.7	0.1
Spinach with peanuts	1 (2.1)	65.3	856	10	15

* This is the number and percentage of participants from the total sample of 48 that gave their infants that food item. [a] : popular home – prepared complementary food , control in this study. Analysis above presents proximate composition for 100g.

Table 4.10: Minerals composition (mg/100 g) of analysed home-prepared complementary food recipes collected from caregivers

Home prepared complementary food	**n (%)**	**Mineral composition (mg/100 g)**						
		Calcium	**Iron**	**Magnesium**	**Phosphorus**	**Potassium**	**Sodium**	**Zinc**
Beans	1 (2.1)	10.0	0.7	19.0	38	135.0	137.0	0.3
Cooked and mashed apple	1 (2.1)	3.0	0.1	3.0	7.0	57.0	0.0	0.03
Cooked instant porridge	1 (2.1)	132.0	1.8	0.0	0.0	0.0	131.0	1.15
Cooked white maize porridge [a]	**23 (47.9)**	**2.0**	**0.5**	**15.0**	**31.0**	**33.0**	**1.0**	**0.51**
White maize porridge with margarine and peanut butter	2 (4.2)	2.0	0.5	14.0	28.0	30	44.0	0.46
White maize porridge with full fat milk	1 (2.1)	20.0	0.4	14.0	38.0	49.0	8.0	0.48
Mashed potatoes	7 (14.6)	9.0	0.5	10.0	31.0	227.0	7503.0	0.23
Mashed potatoes with margarine	1 (2.1)	7.0	0.5	10.0	31.0	232.0	2023.0	0.22
Pumpkin	6 (12.5)	12.0	0.3	8.0	18.0	164.0	36.0	0.13
Pumpkin with margarine	2 (4.2)	12.0	0.3	8.0	17.0	160.0	60.0	0.12
Pumpkin with peanut butter	1 (2.1)	10.0	0.3	7.0	15.0	140.0	67.0	0.11
Samp	1 (2.1)	3.0	0.2	4.0	11.0	30.0	231.0	0.09
Spinach with peanuts	1 (2.1)	130.0	4.1	116.0	155.0	526	58.0	1.56

*This is the number and percentage of participants from the total sample of 48 that gave their infants that food item. [a] : popular home – prepared complementary food, control in this study.

4.3 Effect of MOLP on the physical quality of a modified home-prepared complementary food

The results on the effect of MOLP on the colour of modified home-prepared complementary food will be presented in this section. Figure 4.3 and Table 4.11 present the effect of MOLP on the physical quality (colour) of home-prepared complementary foods. The colour of MOLP-added home-prepared complementary food became darker as the level of MOLP substitution increased (Figure 4.2).

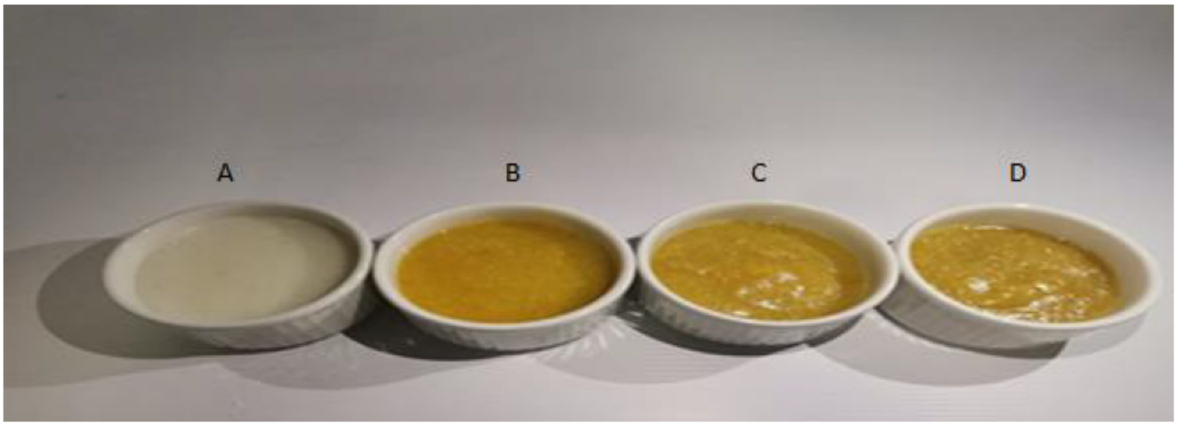

Figure 4.2: Effect of MOLP on the colour of home-prepared complementary food

(a)- control - white maize porridge, (b) - white maize and pumpkin porridge with 1% (w/w) MOLP, (c) - white maize and pumpkin porridge with 2% (w/w) MOLP, (d) - white maize and pumpkin porridge with 3% (w/w) MOLP.

Table 4.11: The CIE color values (Hunter L*, a* and b*) of raw foods, MOLP and modified home-prepared complementary foods

Sample	**Mean ± SD**		
	L	**A**	**B**
Raw white maize	91.90 ± 0.17	- 0.07 ± 0.08	11.57 ± 0.28
Raw pumpkin	72.10 ± 0.46	23.03 ± 0.36	60.15 ± 0.58
MOLP	47.76 ± 0.28	- 5.15 ± 0.05	26.89 ± 0.38
Cooked white maize porridge	92.43 ± 0.02	- 0.94 ± 0.02	9.88 ± 0.03
Cooked *isijingi* with 1% MOLP	79.02 ± 0.18	9.71 ± 0.02	40.14 ± 0.23
Cooked *isijingi* with 2% MOLP	77.69 ± 0.07	8.39 ± 0.10	38.78 ± 0.18
Cooked *isijingi* with 3% MOLP	77.42 ± 0.34	7.08 ± 0.01	39.62 ± 0.29
P value	**<0.01**	**<0.01**	**<0.01**

L: Measure of lightness (0 = black to 100=white); a: Measure of redness and greenness (+a= redness; -a = greenness); b: Measure of yellowness (+b = yellowness; b = blueness); MOLP – *Moringa Oleifera* Leaf Powder; ANOVA/Welch test; Values in bold indicate p<0.05

The post hoc analysis using Games-Howell indicated that the lightness for raw white maize was significantly higher than raw pumpkin, MOLP and all three modified home-prepared complementary foods (p<0.01), whereas cooked white maize porridge was significantly lighter than all samples (p<0.01). Additionally, the raw pumpkin (72.10) was significantly lighter than MOLP (47.76) (p<0.01). According to Table 4.11, MOLP had the darkest measurement of greenness (-5.15).

4.4 Effect of MOLP on the nutritional composition of modified home-prepared complementary food

4.4.1 Proximate composition

The proximate composition of uncooked and cooked food samples is presented in Table 4.12. Raw pumpkin had significantly higher moisture content than cooked white maize porridge (3.98%), cooked white maize and pumpkin with 2% MOLP (3.52%) and cooked white maize and pumpkin with 3% MOLP (4.50%) ($p = 0.001$). Additionally, cooked white maize and pumpkin with 3% MOLP (4.50%) had a significantly higher moisture content compared with cooked white maize and pumpkin with 2% MOLP (3.52%) ($p = 0.001$).

Raw white maize (6.32 g/100 g) had a significantly lower protein content than raw pumpkin (9.13 g/100 g), MOLP (g/100 g) and cooked white maize and pumpkin with 1 % MOLP (7.75 g/100 g) ($p < 0.0001$). *Moringa oleifera* leaf powder (31.7 g/100 g) had a significantly higher protein content than raw white maize (6.32 g/100 g), raw pumpkin (9.13 g/100 g), cooked white maize porridge (6.67 g/100 g), cooked white maize porridge and pumpkin with 1% MOLP (7.75 g/100 g), cooked white maize porridge and pumpkin with 2% MOLP (7.99 g/100 g), cooked white maize porridge and pumpkin with 3% MOLP (7.53 g/100 g) ($p <0.0001$). Additionally, cooked white maize porridge and pumpkin with 1% MOLP (7.75 g/100 g) had significantly higher protein than raw white maize (6.32 g/100 g) ($p < 0.0001$).

Raw pumpkin (1.56 g/100 g) had significantly higher fat content than cooked white maize porridge (0.75 g/100 g) ($p < 0.0001$). Additionally, MOLP (5.33 g/100 g) had significantly higher fat content than raw white maize (1.39 g/100 g), raw pumpkin (1.56 g/100 g), cooked white maize porridge (0.75 g/100 g), cooked white maize porridge and pumpkin with 1% MOLP (1.16 g/100 g) and cooked white maize porridge and pumpkin with 3% MOLP (0.92 g/100 g) ($p <0.0001$). Cooked white maize porridge and pumpkin with 3% MOLP (8.97 g/100 g) had significantly higher NDF content than raw white maize (3.25 g/100 g) ($p < 0.001$). Raw pumpkin (6.93 g/100 g) had significantly higher total mineral content in comparison to raw white maize (0.74 g/100g), cooked white maize porridge (0.70 g/100 g), cooked white maize porridge and pumpkin with 1% MOLP (2.92 g/100 g), cooked white maize porridge and pumpkin with 2% MOLP (2.99 g/100 g), cooked white maize porridge and pumpkin with 3% MOLP (3.13 g/100 g) ($p < 0.0001$). Furthermore, MOLP (9.58 g/100 g) had a significantly higher total mineral content compared to raw white maize (0.74 g/100 g), cooked white maize porridge (0.70 g/100 g), cooked white maize porridge and pumpkin with 1% MOLP (2.92 g/100 g), cooked white maize porridge and pumpkin with 2% MOLP (2.99 g/100 g) and cooked white maize porridge and pumpkin with 3% MOLP (3.13 g/100g) ($p < 0.0001$). On the contrary, cooked white maize porridge and pumpkin with 1% MOLP (2.92 g/100 g) had significantly higher total mineral content than raw white maize (0.74 g/100 g) and cooked white maize porridge (0.70 g/100 g) ($p < 0.0001$). Also, cooked white maize porridge and pumpkin with 2% MOLP (2.99 g/100 g) had significantly higher total mineral content than raw white maize (0.74 g/100 g) and cooked white maize porridge (0.70 g/100g) ($p < 0.0001$). Cooked white maize porridge and pumpkin with 3% MOLP (3.13 g/100 g) had significantly higher total mineral content than raw white maize (0.74 g/100 g) and cooked white maize porridge (0.7 g/100 g) ($p < 0.0001$).

Table 4.12: Proximate composition of raw foods, MOLP and modified home-prepared complementary food samples

Sample	Moisture (%)	Protein (g/100 g, DW[a])	Fat (g/100 g, DW)	NDF[b] (g/100 g, DW)	Total mineral (mg/100 g, DW)
Raw white maize	2.26[c] ± 0.52[d]	6.32 ± 0.06	1.39 ±0.09	3.25 ±0.56	0.74±0.02
Raw pumpkin	7.90 ±0.09	9.13 ±0.07	1.56 ±0.08	14.53 ± 1.22	6.93±0.18
Cooked white maize porridge	3.98 ±0.09	6.67 ±0.16	0.75 ±0.06	16.57 ± 4.04	0.70±0.04
MOLP[e]	3.95 ±0.35	31.70 ± 0.25	5.33 ±0.04	20.50 ± 3.03	9.58±0.04
cooked white maize + pumpkin + 1 % MOLP	4.50 ± 1.36	7.75 ± 0.10	1.16 ± 0.23	9.13 ± 0.50	2.92±0.08
cooked white maize + pumpkin + 2 % MOLP	3.52 ± 0.03	7.99 ± 0.21	1.11 ± 0.25	8.96 ± 0.23	2.99±0.06
cooked white maize + pumpkin + 3 % MOLP	4.50 ± 0.06	7.53 ± 0.45	0.92 ± 0.06	8.97 ± 0.68	3.13±0.06
p-value[f]	**0.001**	**<0.0001**	**< 0.0001**	**0.001**	**< 0.0001**

[a] DW: dry weight basis; [b] NDF: Neutral detergent fibre; [c] Mean of duplicate values; [d] Standard deviation; [e] MOLP: *Moringa oleifera* leaf powder; [f] ANOVA test; Values in bold indicate p<0.05.

4.4.2 Minerals composition

The mineral composition of uncooked and cooked food samples is presented in Table 4.13. *Moringa oleifera* leaf powder (1.57 mg/100 g) has significantly higher calcium content than raw white maize (0.00 mg/100g), raw pumpkin (0.25 mg/100g), cooked white maize porridge (0.00 mg/100g), cooked white maize porridge and pumpkin with 1% MOLP (0.09 mg/100g), cooked white maize porridge and pumpkin with 2% MOLP (0.10 mg/100g) and cooked white maize porridge and pumpkin with 3% MOLP (0.11 mg/100 g) ($p < 0.0001$). Cooked white maize porridge and pumpkin with 1% MOLP (0.09 mg/100 g) had significantly higher calcium content than raw white maize (0.00 mg/100 g) and cooked white maize porridge (0.00 mg/100 g) ($p < 0.0001$). Furthermore, cooked white maize porridge and pumpkin with 2% MOLP (0.10 mg/100 g) had significantly higher calcium content than raw white maize (0.00 mg/100 g), cooked white maize porridge (0.00 mg/100 g) and cooked white maize porridge and pumpkin with 1% MOLP (0.09 mg/100 g) ($p < 0.0001$). Cooked white maize porridge and pumpkin with 3% MOLP (0.11 mg/100 g) had significantly higher calcium content than raw white maize (0.00 mg/100 g), cooked white maize porridge (0.00 g/100 g) and cooked white maize porridge and pumpkin with 1% MOLP (0.09 mg/100g) ($p < 0.0001$). *Moringa oleifera* leaf powder (10.85 mg/100 g) had significantly higher iron content than cooked white maize porridge and pumpkin with 3% MOLP (4.00 mg/100 g) ($p = 0.001$).

Raw pumpkin (2.39 mg/100 g) had significantly higher potassium content than raw white maize (0.10 mg/100 g), cooked white maize porridge (0.12 mg/100 g), cooked white maize porridge and pumpkin with 1% MOLP (0.72 mg/100 g), cooked white maize porridge and pumpkin with 2% MOLP (0.80 mg/100 g), cooked white maize porridge and pumpkin with 3% MOLP (0.83 mg/100 g) ($p < 0.0001$). Cooked white maize porridge (0.12 mg/100 g) had significantly higher potassium content than raw white maize (0.10 g/100 g) ($p < 0.0001$). Additionally, MOLP (1.71 mg/100 g) had significantly higher potassium content than raw white maize (0.10 g/100 g) and cooked white maize porridge (0.12 mg/100 g) ($p < 0.0001$). Cooked white maize porridge and pumpkin with 1% (0.72 mg/100g) (MOLP had significantly higher potassium content than raw white maize (0.10 mg/100 g) and cooked white maize porridge (0.12 mg/100 g) ($p <0.0001$). Cooked white maize porridge and pumpkin with 2% MOLP (0.80 mg/100g) had significantly higher potassium content than raw white maize (0.10 mg/100 g) and cooked white maize porridge (0.12 mg/100 g) ($p < 0.0001$). Cooked white maize porridge and pumpkin with 3% (0.83 mg/100 g) MOLP had significantly higher potassium content than raw white maize (0.10

mg/100 g), cooked white maize porridge (0.12 mg/100 g), Cooked white maize porridge and pumpkin with 1% MOLP (0.72 mg/100 g) and cooked white maize porridge with 2% MOLP (0.80 mg/100 g) ($p < 0.0001$).

Moringa oleifera leaf powder (0.57 mg/100 g) had significantly higher magnesium content than raw white maize (0.03 mg/100g), raw pumpkin (0.16 mg/100g), cooked white maize porridge (0.03 mg/100 g), cooked white maize porridge and pumpkin with 1% MOLP (0.07 mg/100 g), cooked white maize porridge and pumpkin with 2% MOLP (0.08 mg/100 g) and cooked white maize porridge and pumpkin with 3% MOLP (0.07 mg/100g) ($p < 0.0001$). Cooked white maize porridge and pumpkin with 1% (0.07 mg/100g), 2% (0.08 mg/100g) and 3% (0.07 mg/100g) had significantly higher magnesium content than raw white maize (0.03), cooked white maize porridge (0.03 mg/100g) ($p<0.0001$). Additionally, cooked white maize porridge and pumpkin with 2% MOLP had higher magnesium content that cooked white maize porridge and pumpkin with 1% (0.07 mg/100g) and 2% (0.07) MOLP ($p < 0.0001$).

Cooked white maize porridge and pumpkin with 1% (0.02 mg/100g), 2% (0.02 mg/100g), 3% (0.02 mg/100g) MOLP had significantly higher sodium content than raw white maize (0.00 mg/100g) and cooked white maize porridge (0.01 mg/100g) ($p < 0.0001$).

Raw pumpkin (0.26 mg/100g) significantly had higher phosphorus content than cooked white maize porridge (0.09 mg/100g) ($p < 0.0001$). Additionally, MOLP (0.47 mg/100g) significantly had higher phosphorus content than raw white maize (0.08 mg/100g), cooked white maize porridge (0.09 mg/100g), cooked white maize porridge and pumpkin with 1% (0.14 mg/100g), 2% (0.14 mg/100g) and 3% (0.14 mg/100g) MOLP.

Cooked white maize porridge (2.10 mg/100g) had significantly higher zinc content than raw pumpkin (1.50), cooked white maize porridge and pumpkin with 2% (1.90 mg/100g) and 3% (1.90 mg/100g) MOLP. Cooked white maize porridge and pumpkin with 2% (1.90 mg/100g) and 3% (1.90 mg/100g) MOLP had significantly higher zinc content than raw pumpkin (1.50 mg/100g) ($p = 0.001$).

Table 4.13: Minerals composition of raw foods, MOLP and modified home-prepared complementary food samples (mg/100 g, DW[a])

Sample	Calcium	Iron	Potassium	Magnesium	Sodium	Phosphorus	Zinc
Raw white maize	0.00[b] ± 0.00[c]	5.45 ±2.47	0.10 ± 0.00	0.03 ±0.00	0.00 ± 0.00	0.08 ± 0.00	2.35±0.21
Raw pumpkin	0.25 ± 0.02	1.85 ± 1.06	2.39 ±0.01	0.16 ±0.01	0.02 ±0.01	0.26 ±0.01	1.50±0.00
Cooked white maize porridge	0.00 ±0.00	3.85 ±0.49	0.12 ±0.00	0.03 ±0.00	0.01 ±0.00	0.09 ±0.01	2.10±0.00
MOLP [d]	1.57 ±0.04	10.85± 0.07	1.71 ±0.07	0.57 ±0.00	0.05 ±0.01	0.47 ±0.00	2.90±0.28
cooked white maize + pumpkin + 1 % MOLP	0.09 ± 0.00	2.85 ±0.49	0.72 ±0.01	0.07 ±0.00	0.02 ±0.00	0.14 ±0.00	2.00±0.28
cooked white maize + pumpkin + 2 % MOLP	0.10 ±0.00	3.70 ±0.57	0.80 ±0.00	0.08 ± 0.00	0.02 ± 0.00	0.14 ±0.00	1.90±0.00
cooked white maize + pumpkin + 3 % MOLP	0.11 ±0.00	4.00 ±0.00	0.83 ±0.01	0.07 ±0.00	0.02 ±0.00	0.14 ±0.00	1.90±0.00
p-value [e]	**<0.0001**	**0.001**	**< 0.0001**	**< 0.0001**	**<0.0001**	**<0.0001**	**0.001**

[a] DW: dry weight basis; [b] Mean of duplicate values; [c] Standard deviation; [d] MOLP: *Moringa Oleifera* leaf powder; [e]ANOVA test; Values in bold indicate $p<0.05$.

4.4.3 Essential amino acids composition

Essential amino acid composition of uncooked and cooked food samples is presented in Table 4.14. Raw pumpkin (0.34 g/100 g) had significantly higher histidine content than cooked white maize porridge and pumpkin with 1% (0.21 g/100 g), 2% (0.24 g/100 g) and 3% (0.26 g/100 g) MOLP ($p < 0.0001$). Furthermore, MOLP (0.70 g/100 g) had significantly higher histidine content than raw white maize (0.34 g/day), raw pumpkin (0.25 g/100 g), cooked white maize porridge (0.29 g/100 g), cook white maize porridge with pumpkin and 1% (0.21 g/100 g), 2% (0.24 g/100 g) and 3% (0.26 g/100 g) MOLP ($p < 0.0001$).

Additionally, MOLP had significantly higher threonine content than raw white maize (0.32 g/100 g), raw pumpkin (0.30 g/100 g), cooked white maize porridge (0.37 g/100 g), cook white maize porridge with pumpkin and 1% (0.37 g/100 g), 2% (0.37 g/100 g) and 3% (0.35 g/100 g) MOLP ($p < 0.0001$).

Moringa *oleifera* leaf powder (1.70 g/100 g) had significantly higher lysine content than raw white maize (0.09 g/100 g), raw pumpkin (0.27 g/100 g), cooked white maize porridge (0.11 g/100 g), cook white maize porridge with pumpkin and 1% (0.18 g/100 g), 2% (0.12 g/100 g) and 3% (0.17 g/100 g) MOLP ($p < 0.0001$). MOLP (0.41 g/100 g) had significantly higher methionine content than raw pumpkin (0.13 g/100 g) ($p < 0.0001$).

Moringa oleifera leaf powder (1.8 g/100 g) had significantly higher valine content than raw white maize (0.33 g/100 g), raw pumpkin (0.33 g/100 g), cooked white maize porridge (0.36 g/100 g), cook white maize porridge with pumpkin and 1% (0.36 g/100 g), 2% (0.36 g/100 g) and 3% (0.36 g/100 g) MOLP ($p < 0.0001$). *Moringa oleifera* leaf powder (1.47 g/100g) had significantly higher isoleucine content than raw white maize (0.26 g/100 g), raw pumpkin (0.31 mg/100 g), cooked white maize porridge (0.25 g/100 g), cook white maize porridge with pumpkin and 1% (0.29 g/100 g), 2% (0.30 g/100 g) and 3% (0.30 g/100g) MOLP ($p < 0.0001$).

MOLP (2.70 g/100 g) had significantly higher Leucine content than raw white maize (1.08 g/day), raw pumpkin (0.53 g/100 g), cooked white maize porridge (1.15 g/100 g), cook white maize porridge with pumpkin and 1% (0.89 g/100 g), 2% (0.94 g/100 g) and 3% (0.92 g/100 g) MOLP ($p < 0.0001$). Additionally, cooked white maize porridge and pumpkin with 1% (0.89 g/100g) and 2% (0.94 g/100 g) had significantly higher Leucine content than raw pumpkin (0.53 g/ 100 g) ($p < 0.0001$).

Raw white maize (0.84 g/100 g) had significantly higher phenylalanine content than raw pumpkin (0.53 g/100 g), cooked white maize porridge (0.76 g/100 g) and cooked white maize porridge and pumpkin with 2% MOLP (0.66 g/100 g) ($p < 0.0001$).

Table 4.14: Essential amino acid composition of raw foods, MOLP and modified home-prepared complementary food samples (g/100 g. DW[a])

Samples	Histidine	Threonine	Lysine	Methionine	Valine	Isoleucine	Leucine	Phenylalanine
Raw white maize	0.34 [b] ±0.01 [c]	0.32±0.01	0.09±0.04	0.24±0.01	0.33±0.01	0.26±0.04	1.08±0.07	0.84±0.01
Raw pumpkin	0.25±0.02	0.30±0.02	0.27±0.05	0.13±0.02	0.33±0.01	0.31±0.01	0.53±0.01	0.53±0.02
Cooked white maize porridge	0.29±0.00	0.37±0.01	0.11±0.01	0.27±0.04	0.36±0.01	0.25±0.04	1.15±0.03	0.76±0.01
MOLP [d]	0.70±0.01	1.60±0.03	1.70±0.01	0.41±0.03	1.80±0.06	1.47±0.04	2.70±0.11	2.68±0.42
cooked white maize + pumpkin + 1 % MOLP	0.21±0.01	0.37±0.01	0.18±0.04	0.22±0.01	0.36±0.01	0.29±0.02	0.89±0.00	0.67±0.02
cooked white maize + pumpkin + 2 % MOLP	0.24±0.01	0.37±0.01	0.12±0.00	0.22±0.01	0.36±0.01	0.30±0.00	0.94±0.01	0.66±0.00
cooked white maize + pumpkin + 3 % MOLP	0.26±0.01	0.35±0.01	0.17±0.03	0.21±0.02	0.36±0.01	0.30±0.04	0.92±0.05	0.60±0.04
p-value [e]	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**

[a] DW: dry weight basis; [b] Mean of duplicate values; [c] Standard deviation; [d] MOLP: *Moringa Oleifera* leaf powder; [e] ANOVA test; Values in bold indicate p<0.05.

4.4.4 Non-essential amino acids composition

Non-essential amino acid composition of uncooked and cooked food samples is presented in Table 4.15. *Moringa Oleifera* leaf powder (2.35 g/100g) had significantly higher arginine content when compared to raw white maize (0.34 g/100g), raw pumpkin (0.92 g/100g), cooked white maize porridge (0.47 g/100g), cook white maize porridge with pumpkin and 1% (0.57 g/100 g), 2% (0.66 g/100 g) and 3% (0.55 g/100g) MOLP ($p < 0.0001$). Furthermore, cooked white maize porridge and pumpkin with 2% MOLP (0.66 g/100 g) had significantly higher arginine content than raw white maize (0.34 g/100 g) ($p < 0.0001$).

Raw white maize (0.42 g/100 g) had significantly higher serine content than raw pumpkin (0.34 g/100 g) ($p < 0.0001$). Additionally, MOLP had significantly higher serine content when compared to raw white maize (0.42 g/100 g), raw pumpkin (0.34 g/100 g), cooked white maize porridge (0.38 g/100g), cook white maize porridge with pumpkin and 1% (0.37 g/100 g), 2% (0.43 g/100 g) and 3% (0.39 g/100 g) MOLP ($p < 0.0001$).

There was no significant different for glycine composition for both uncooked and cooked food samples. Raw pumpkin (0.85 g/100 g) had significantly higher aspartic acid than raw white maize (0.34), cooked white maize porridge and pumpkin with 1% (0.55 g/100g), 2% (0.63 g/100 g) and 3% (0.66 g/100 g) MOLP ($p < 0.0001$). Furthermore, cooked white maize porridge and pumpkin with 3% MOLP (0.66 g/100 g) had significantly more aspartic acid content than raw white maize (0.34 g/100 g) ($p < 0.0001$).

Raw pumpkin (2.90 g/100 g) had significantly higher glutamic acid content in comparison with raw white maize (1.44 g/100 g), cooked white maize porridge (1.48 g/100 g), cooked white maize porridge and pumpkin with 1% (1.83 g/100 g) and 3% (1.94 g/100 g) MOLP. Additionally, MOLP (3.93 g/100 g) had significantly higher glutamic acid content than raw white maize (1.44 g/100 g), raw pumpkin (2.90 g/100 g), cooked white maize porridge (1.48 g/100 g), cook white maize porridge with pumpkin and 1% (1.83 g/100 g), 2% (2.07 g/100 g) and 3% (1.94 g/100 g) MOLP ($p < 0.0001$).

Moringa Oleifera leaf powder (1.94 g/100 g) had significantly higher alanine content than raw white maize (0.50 mg/100 g), raw pumpkin (0.46 g/100 g), cooked white maize porridge (0.50 g/100 g), cook white maize porridge with pumpkin and 1% (0.51 g/100 g), 2% (0.50 g/100 g) and 3% (0.48 g/100 g) MOLP ($p < 0.0001$).

Cooked white maize porridge (0.71 g/100 g) had significantly more proline content when compared to raw pumpkin (0.24 g/100 g) ($p < 0.0001$). Furthermore, MOLP (1.39 g/100 g) significantly had higher proline content than raw white maize (0.76 g/100 g) and cooked white maize porridge and pumpkin with 3% MOLP (0.56 g/100 g) ($p < 0.0001$). Additionally, both cooked white maize porridge and pumpkin with 1% (0.56 mg/100g) and 2% (0.58 g/100 g) MOLP had significantly higher proline content than raw pumpkin (0.24 g/100 g) ($p < 0.0001$).

Moringa Oleifera leaf powder (1.45 g/100 g) had significantly more tyrosine content than cooked white maize porridge and pumpkin with 1% (0.43 g/100 g) and 3% (0.36 g/100 g) MOLP ($p < 0.0001$).

Table 4.15: Non-essential amino acid composition of raw foods, MOLP and modified home-prepared complementary food samples (g/ 100 g, DW[a])

Samples	Arginine	Serine	Glycine	Aspartic acid	Glutamic acid	Alanine	Proline	Tyrosine
Raw white maize	0.34 [b] ±0.01 [c]	0.42±0.01	0.29±0.02	0.34±0.01	1.44±0.02	0.50±0.01	0.76±0.04	0.42±0.01
Raw pumpkin	0.92±0.08	0.34±0.01	0.30±0.01	0.85±0.01	2.90±0.03	0.46±0.01	0.24±0.01	0.32±0.04
Cooked white maize porridge	0.47±0.07	0.38±0.00	0.30±0.03	0.40±0.06	1.48±0.02	0.50±0.01	0.71±0.02	0.47±0.03
MOLP [d]	2.35±0.05	1.60±0.01	1.67±0.12	2.70±0.03	3.93±0.06	1.94±0.02	1.39±0.06	1.45±0.08
cooked white maize + pumpkin + 1 % MOLP	0.57±0.04	0.37±0.03	0.29±0.02	0.55±0.02	1.83±0.00	0.51±0.01	0.56±0.01	0.43±0.0.01
cooked white maize + pumpkin + 2 % MOLP	0.66±0.00	0.43±0.00	0.30±0.00	0.63±0.01	2.07±0.25	0.50±0.01	0.58±0.00	0.43±0.02
cooked white maize + pumpkin + 3 % MOLP	0.55±0.02	0.39±0.01	0.30±0.03	0.66±0.00	1.94±0.01	0.48±0.01	0.56±0.03	0.36±0.10
p-value [e]	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**

[a] DW: dry weight basis; [b] Mean of duplicate values; [c] Standard deviation; [d] MOLP: *Moringa Oleifera* leaf powder; [e] ANOVA test; Values in bold indicate $p<0.05$.

CHAPTER 5
DISCUSSION

5.1 Home-prepared complementary foods fed to children by caregivers

5.1.1 Age of introduction of solids to children

A good, safe introduction of complementary foods at six months is needed for optimal growth and development in an infant (WHO 2013). In SA, the early introduction of solids before six months is a common practice (Sayed & Schönfeldt 2020). This common practice has several negative effects on an infant, such as childhood malnutrition (Mkhize & Sibanda 2020). Childhood malnutrition can lead to poor child growth and development and irreversible physical and cognitive damage (Nshimyiryo, Hedt-Gauthier, Mutaganzwa, Kirk, Beck, Ndayisaba, Mubiligi, Kateera & El-Khatib 2019). The present investigation revealed that a significant percentage of respondents (n =23; 47.9%) disclosed initiating the introduction of solid foods to their infants at an age ranging from six to under seven months. This was in line with the WHO appropriate complementary feeding recommendation of the safe introduction of solids at six months (WHO 2013). However, the current study also found that a large percentage of infants (n=16; 33.3%) were introduced to solids before six months. These findings are similar to several other studies conducted in KZN, which found that introduction of solids before six months was a common practice in KZN, SA (Kaldenbach & Engerbretsen 2022; Sayed & Schönfeldt 2020; Jama, Wilford, Masango, Haskins, Coutsoudis, Spies & Horwood 2017; Seonandan & McKerrow 2016; Ghuman, Saloojee & Morris 2009; Cape, Faber & Benade 2007). In SA, the early introduction of solids is part of poor feeding practices that contributes to the escalating rates of childhood morbidity and mortality due to undernutrition (Mkhize & Sibanda 2020; Sayed & Schönfeldt 2020; Madiba, Chelule & Mokgatle 2019). A study conducted in KZN found that health system factors (inappropriate advice from health workers e.g. mothers being advised to give water before the six months), mother-baby factors (e.g. mothers perceiving breastmilk insufficient, baby given water because the mother is not expressing milk, positioning and attachment challenges during breastfeeding), social factors (pressure from family members to introduce complementary foods before six months) and returning to work and school before the infant is six months old were the factors responsible for mothers to introduce solids before the infant is six months old (Jama *et al* 2017). Regular trainings for the staff on infant and young child feeding can combat these challenges, as trainings can equip them to be able to educate and support mothers accordingly (Jama et al 2017).

5.1.2 Types of food items used as complementary foods

The age of introduction of solid foods is equally important as the type of complementary foods given to infants (Mkhize & Sibanda 2020; Sayed and Schönfeldt 2020). When complementary foods fed to infants contain insufficient energy and nutrients, it can lead to childhood PEM and micronutrient deficiencies (Mkhize & Sibanda 2020; Sayed and Schönfeldt 2020). Results in this study showed that white maize (n=29; 60.4%), potato (n=6; 12.5%) and pumpkin (n=5; 10.4%) were the main food items that were used to introduce complementary feeding (Table 4.3). Sayed and Schönfeldt (2020) found that the most popular home-prepared complementary food in SA was white maize porridge, which was similar to this study as white maize porridge was also part of the popular home-prepared complementary foods given by the caregivers to infants under one year (Table 4.4). Similar to the findings of this study, previous studies obtained evidence indicating that, in SA, infants are fed a monotonous diet comprising of starchy foods (Mkhize & Sibanda 2020; Panda, Lakra & Panda 2019). A monotonous diet lacks essential nutrients such as protein, vitamins and minerals required for child growth and development, and this can be responsible for widespread childhood malnutrition (Oladiran & Emmambux 2022; Mkhize & Sibanda 2020; Panda, Lakra & Panda 2019). In vulnerable rural communities, availability and affordability determine the type of complementary foods fed to infants (Oladiran & Emmambux 2022).

In SA, most vulnerable households rely on social grants to purchase food (UNICEF 2020). Child support grant (CSG) is a poverty reduction strategy that was implemented by the government in SA. However, even though more than 10 million children in SA receive CSG (R500.00 per child/month) each month (UNICEF 2020), both recipients and non-recipients of CSG are affected by high levels of food insecurity (UNICEF 2020; Zembe-Mkabile, Surender, Sanders, Jackson & Doherty 2015; Patel, Hochfeld, Moodley & Mutwali 2012). The affected households therefore cannot afford nutritious food items and hence rely on starchy food items. The starchy foods are more affordable and accessible and can be purchased in bulk such as white maize, when compared to protein, vegetable and fruit food sources (UNICEF 2020). Over-reliance on starchy complementary foods can contribute to childhood malnutrition if food items from other food groups, such as vegetables, are not included in the complementary foods. Vegetables contain essential nutrients (most which are deficient in starchy foods), such as vitamins and minerals are needed for child growth promotion. The next section discusses sources of vegetables used in complementary feeding in this study.

5.1.3 Sources of vegetables used in complementary feeding

According to a study carried out by Ntila (2017) in Hammanskraal (Gauteng, SA), which surveyed caregivers of children aged between seven to twelve months, it was discovered that 68.9 % (n= 106) of the caregivers did not have vegetable gardens. The present study's results are consistent with these findings, as it was observed that 66.7% (n=32) of the caregivers did not have vegetables gardens (Table 4.5). Home vegetable gardens can be used as part of a food insecurity prevention and income generation strategy (Ntila 2017). However, studies by Ntila (2017), Faber *et al* (2013) and this study show that most vulnerable households do not have vegetable gardens. As a result, most caregivers resort to feeding their children affordable and accessible vegetables such as pumpkin, which was the most commonly used vegetable during complementary feeding (21.7%; n =11) in a study conducted by Ntila (2017). These findings were similar to the findings of this study as pumpkin (n=28; 54.2%) was the most commonly used home-prepared complementary food given to infants under one year (Table 4.4) and the most commonly grown and/or bought vegetable (n=28; 58.3%) during complementary feeding (Figure 4.1). Pumpkin is a good source of vitamins, minerals and dietary fibre; however, it does not contain the nutrients such as protein and/or iron in sufficient amounts to prevent PEM and micronutrient deficiencies (Dhiman, Sharma & Attri 2009). Pumpkin is high in dietary fibre, making it a satiating food, hence when caregivers feed their children pumpkin, as they might stay full longer (FAO 2011). This is not an adequate diet for a growing infant. The WHO recommends small frequent meals with food from different food groups during complementary feeding (WHO 2013). As a result, childhood malnutrition rates might continue to escalate due to infants receiving poor nutrient-quality complementary foods. However, other factors impact the availability of home vegetable gardens, such as affordability and availability of water (Muthwa 2021; Faber *et al* 2013).

In this study, 43.8 % (n=14) of the caregivers disagreed with not being able to afford seeds or vegetables to plant as the reason for not having a vegetable garden (Table 4.6). These findings were different to the findings by Faber *et al* (2013), where ≥ 75% (n= 400) of the caregivers reported cost as the major contributing factor to not having a vegetable garden. Affordability of seeds and/or vegetable to plants plays a major role in whether a household has a vegetable garden, as most vulnerable households depend on social grants to purchase basic food (Mdiya

& Mdoda 2021). Consequently, the government launched the one home, one garden programme. It encourages households to have gardens and use them to fight food insecurity and generate income, where the beneficiaries are given seedlings and gardening tools (South African Government 2020). However, appropriate implementation of home garden programme appropriately to reduce food insecurity is a problem as water scarcity is a serious challenge in some areas (Baiyegunhi 2015). In this study, 50% (n =16) of the caregivers reported that the availability of water was the main factor that affected the availability of a vegetable garden at a household level (Table 4.6). These were similar findings by Mdiya & Mdoda (2021), where water availability was the constraint to home vegetable gardens in Eastern Cape, SA. An increase in rural migrants and informal settlements has affected the service delivery of water supply throughout SA, which has contributed to water scarcity (Bisaga, Parikh & Loggia 2019). *uMgungundlovu* district in KZN is also facing challenges in water provision (it is affected by intermittent, low-pressure, poor water services), and this has not only resulted in public outrage, such as community protests (Muthwa 2021) but has also affected the home vegetable gardens availability as plants and/or seeds need water to grow. Despite the necessity of availability of vegetables in vulnerable households, appropriate complementary food should also contain sufficient quantities of nutrients from other food groups (starch, protein, fruits, fats and oils and dairy products), and the portion size of the complementary foods should be age-appropriate in order to prevent malnutrition (WHO 2013).

5.1.4 Portion sizes used during complementary feeding

As indicated above, portion sizes vary for the different age groups (WHO 2013). At six months, infants must be fed three tablespoons per feed two times per day and between seven to eleven months, they must be fed half (≈115 g) to two-thirds (≈153.3 g) of a cup at each meal three times per day (KZN Department of Health 2015). Continued breastfeeding on demand between meals is recommended during complementary feeding (KZN Department of Health 2015). In this study, the majority of infants between 6 and 12 months (35.4%; n=17) were fed between five (29.6 g) to less than ten (59.2 g) teaspoons per meal (Table 4.8). Therefore, in this study, most children between six to twelve months were fed insufficient portions sizes, which can contribute to escalating incidences of childhood (WHO 2013). This is because insufficient portion sizes might result in unmet energy and nutrient requirements. This is worsened by feeding infants complementary foods with poor nutritional quality. These findings are similar to a study that was conducted in Tanzania, where median portion sizes fed to infants were smaller than the required amounts to prevent malnutrition (Kulwa1, Mamiro, Kimanya, Mziray & Kolsteren 2015). Inadequate quantities and qualities of complementary foods increase the risk of childhood malnutrition (White, Begin, Kumapley, Murray & Krasevec 2017). As presented earlier in this study, most children were also fed insufficient quality with poor nutritional content, as only the starchy foods that lack essential nutrients were popular home-prepared complementary foods (Table 4.3 and 4.4). The home-prepared complementary food recipes were analysed for their nutritional composition.

5.1.5 Nutritional composition of home-prepared complementary foods

Nutrients such as protein, magnesium, phosphorus, potassium, iron and zinc play a vital role in an infant's health and nutritional well-being. These nutrients are important in ensuring optimal functioning of the immune system and fighting infections that can result in child mortality and morbidity due to their deficiencies (Weyh, Kruger, Peeling & Castell 2022). In this study, cooked white maize porridge (n=23; 47.9%) was the popular home-prepared complementary food recipe (Table 4.9). The recipes used by the caregivers were analysed for their nutritional content, and it was found that 100 g of cooked white maize porridge provided 1.3 g of protein, 0.5 mg of iron and 0.51 mg of zinc. The portions consumed by the infants were far below the recommended amounts (see section 5.1.4). Furthermore, even if infants consumed those portions of cooked white maize porridge three times a day, it would not meet the Recommended Dietary Allowance (RDA) for protein, iron and zinc for that age group. It is noteworthy that iron and zinc are common micronutrient deficiencies seen among vulnerable population groups such as infants, and one of the main causes is the consumption of poor-quality foods that lack variety and are consumed in incorrect portions (Bailey, West Jr & Black 2015). The findings from this study concur with the statement as white maize porridge was commonly given to infants. It is a starchy food item and lacks sufficient nutrients required for child growth and development (Faber & Benade 2007). These findings were similar to a study that was conducted by Ntila (2017), where poor quality nutrient food items were the popular home-prepared complementary food where white maize porridge did not meet the RDAs for infants between seven to twelve months. These results emphasise the need to develop a modified complementary food to improve the nutritional composition. To improve the nutritional composition of popular home-prepared complementary foods, this study modified white maize and pumpkin porridge with varying amounts of MOLP to improve its nutritional composition. According to Ntila *et al* (2020) nutrient dense indigenous crops such as moringa can be used to improve the nutritional composition of home-prepared complementary foods.

5.1.6 The use of indigenous crops during complementary feeding

Most people in SA are not aware of the nutritional benefit of *Moringa oleifera* (Moyo *et al* 2011). In this study, twenty-six participants (54.2 %) consumed indigenous crops, but Moringa was not commonly known (Table 4.7). Thirty-two participants (66.7 %) had never heard of or consumed this nutritious crop (n=39; 81.3%). There is currently a lack of data on the popularity and consumption of moringa in SA. However, several studies have investigated the effect of MOLP on the physical quality and nutritional composition of home-prepared complementary foods and found that moringa improved the nutritional composition but affected consumer acceptability due to change in colour and taste as a result of the addition of moringa (Ntila *et al* 2020; Olusanya, Kolanisi, Van Onselen, Ngobese & Siwela 2020; Netshiheni, Mashau & Jideani 2018). Results from the study conducted by Ntila *et al* (2020) found that adding MOLP to white maize porridge affected consumer acceptability as the colour of the porridge changed to a dark green colour. To overcome the colour change challenge, in the current study, pumpkin was added to the white maize porridge before the addition of MOLP to prevent major colour changes and potentially improve the taste of MOLP, as moringa is known for its dark green colour and bitter taste (Govender & Siwela 2020; Karim *et al* 2020).

5.2 Effect of MOLP on the physical quality of a modified home-prepared complementary food

In this study, the food samples became darker with the addition of MOLP (Table 4.11). These findings were similar to studies by Ntila *et al* (2020) and Olusanya *et al* (2020). These results were expected as Moringa has high chlorophyll, which gives it a dark green colour (Karim *et al* 2020). The colour change negatively impacts consumer acceptability (Olusanya *et al* 2020; Ntila, Ndhlala, Kolanisi, Abdelgadir & Siwela 2019). The colour and aroma changes, and consumer acceptability decrease with the addition of MOLP (Olusanya, Kolanisi, Van Onselen, Ngobese & Siwela 2020). Although in the current study, the product got darker, the orange colour of the pumpkin seemed to tone down the undesirable green colour and bitter taste of moringa (Figure 4.2). Therefore, modified complementary food made with white maize, pumpkin and moringa could be more accepted by consumers because the taste and colour of the product are likely to be more acceptable compared to the colour of a product containing white maize and MOLP. Consumer acceptability could not be conducted in this study due to

COVID-19 restrictions. However, the effect of MOLP on the nutritional composition of home-prepared complementary foods was evaluated. The results are discussed below.

5.3 Effect of MOLP on the nutritional composition of complementary foods

In this study, MOLP (31.7 g/100 g) had significantly higher protein content than the control, cooked white maize porridge (6.67 g/100 g). *Moringa oleifera* leaf powder had higher fat and total mineral content when compared to cooked white maize porridge (Table 4.12). These were similar findings by Ntila (2017), where MOLP had superior nutritional content compared to cooked white maize porridge. Increasing MOLP substitution from 0% to 3% (w/w) (6.67 g/100 g to 7.53 g/100 g) resulted in approximately 11% increase in protein content. These findings are similar to findings by Ntila *et al* (2020), where increasing MOLP substitution in cooked white maize porridge from 0% to 10% resulted in an approximately 11% increase in protein concentration (from 8.70 g/100 g to 9.68 g/100 g) in the Lebowakgomo soft white maize porridge. As mentioned earlier, animal protein sources are costly, and the diets of most vulnerable populations lack good quality protein. The improved protein content of the modified complementary food is encouraging as it could contribute to reducing PEM and provide infants with a diet of higher protein content and quality. Generally, essential amino acids (histidine, threonine, lysine and isoleucine) increased with the addition of MOLP (Table 4.14). Humans do not produce essential amino acids but are obtained from their diet (National Research Council Subcommittee 1989). Therefore, an increase with the addition of MOLP might reduce deficiencies if consumed in the correct portions.

If the recommended portions of cooked white maize with pumpkin and 1%, 2% or 3% MOLP are consumed by a six-month-old infant, it would not be enough to meet the protein requirements. However, during the introduction of complementary foods, infants are still breastfed frequently, allowing infants to receive additional protein from breastmilk. The recommended consumption amount for 7-11 months is approximately 345-460 g/day (see section 5.1.4). If the recommended amounts of MOLP-added complementary foods were consumed it would meet more than double the RDA/ Adequate Intake (AI) for protein (11+ g/day) (Institute of Medicine 2006). To meet the protein requirements, an infant needs to consume approximately 150 g of cooked white maize with pumpkin and 1%, 2% or 3% MOLP. These study findings were different from that of Ntila (2017). The difference noted could be due to the addition of pumpkin as well as the processing methods.

Generally, the iron, calcium, potassium, magnesium and phosphorus content increased as the MOLP concentration increased (Table 4.13). The RDA requirements for iron (11 mg/day) and zinc (3 mg/ day) for infants between seven to eleven months (Otten, Hellwig & Meyers 2006, pp 1320 – 1331) would be more than met if the usual portion size was consumed. These findings are encouraging because if experimental complementary foods are consumed in the correct amounts, it could reduce iron and zinc deficiencies.

Although these findings indicate that the incorporation of MOLP increased the nutritional composition of home-prepared complementary foods and suggests that moringa can be used as a fortificant of home-prepared complementary foods. These experimental complementary foods need to be evaluated for consumer acceptability.

5.4 References

Bailey RL, West Jr KP, Black RE (2015). The epidemiology of global micronutrient deficiencies. **Annals of Nutrition and Metabolism** 66(2): doi:10.1159/000371618.

Baiyegunhi LJS (2015). Determinants of rainwater harvesting technology (RWHT) adoption for home gardening in Msinga, KwaZulu-Natal, South Africa. **Water South Africa** 41 (1): 33-39.

Bisaga I, Parikh P, Loggia Claudia (2019). Challenges and Opportunities for Sustainable Urban Farming in South Africa Low-Income Settlements: A Case Study in Durban. **Suitability** 11(20): 5660.

Cape W, Faber M, Benade S (2016). Breastfeeding, complementary feeding and nutritional status of 6 – 12 month-old infants in rural KwaZulu-Natal. **South African Journal of Clinical Nutrition** 20: 16 – 24.

Dhiman AK, Sharma KD, Attri S (2009). Functional constituents and processing of pumpkin: A review. **Journal of Food Science and Technology** 46(5): 411.

Faber M, Benade AJS (2007). Breastfeeding, complementary feeding and nutritional status of 6 - 12 - month-old infants in rural KwaZulu-Natal. **South African Journal of Clinical Nutrition** 20: 1.

Faber M, Laubscher R, Laurie S (2013). Availability of, access to and consumption of fruits and vegetables in a peri-urban area in KwaZulu-Natal, South Africa. **Maternal and Child Nutrition** 9 (3): 409-424.

FAO (2011). **Food composition study guide.** https://www.fao.org (Accessed 12 July 2023).

Ghuman, MR, Saloojee H, Morris G (2009). Infant feeding practices in a high HIV prevalence rural district of KwaZulu-Natal, South Africa. **South African Journal of Clinical Nutrition** 22: 74–79.

Godongwana E (2023). **Budget 2023 Budget Speech; National Treasury Department**. RSA: Pretoria, South Africa.

Govender L, Siwela M (2020). The effect of Moringa oleifera leaf powder on the physical quality, nutritional composition and consumer acceptability of white and brown breads. **Foods** 9: 1910.

Institute of Medicine (2006). Dietary DRI reference intakes. **The essential guide nutrient requirements.** Washington DC: National Academy Press.

Jama NA, Wilford A, Masango Z, Haskins L, Coutsoudis A, Spies L, Horwood C (2017). Enablers and barriers to success among mothers planning to exclusively breastfeed for six months: a qualitative prospective cohort study in KwaZulu-Natal, South Africa. **International Breastfeeding Journal** 12: 43

Kaldenbach S, Engebretsen IM, Haskins L, Conolly C, Horwood C (2022). Infant feeding, growth monitoring and the double burden of malnutrition among children aged 6 months and their mothers in KwaZulu-Natal, South Africa. **Maternal Child Nutrition** 18: e13288.

Karim O, Kayode R, Oyeyinka S, Oyeyinka A (2015). Physicochemical properties of stiff dough ‘amala’prepared from plantain (Musa Paradisca) flour and Moringa (Moringa oleifera) leaf powder. **Hrana Zdr. Boles. Znan. -Strucˇni Cˇ asopis Nutr. Dijetetiku** 4: 48–58.

Kulwa KB, Mamiro PS, Kimanya ME, Mziray R Kolsteren PW (2015). Feeding practices and nutrient content of complementary meals in rural central Tanzania: implications for dietary adequacy and nutritional status. **BMC Nutrition** 15: 171.

KwaZulu-Natal Department of health (2015). **Training and information package on complementary feeding information book.** KZN: Nutrition Directorate

Madiba S, Chelule PK, Mokgatle MM (2019). Attending informal preschools and day care centers is a risk factor for underweight, stunting and wasting in children under the age of five years in underprivileged communities in South Africa. **International Journal of Environmental Research Public Health**16:2589.

Mdiya L, Mdoda L (2021). Socio-economic factors affecting home gardens as a livelihood strategy in rural areas of the Eastern Cape province, South Africa. **South African Journal of Agricultural Extension** 3: 1-15.

Mkhize M, Sibanda M (2020). A review of selected studies on the factors associated with the nutrition status of children under the age of five years in South Africa. **International Journal of Environmental Research Public Health**17:7973.

Moyo B, Masika PJ, Hugo A, Muchenje V (2011). Nutritional characterization of Moringa (Moringa oleifera Lam.) leaves. **African Journal of Biotechnology.** 10(60): 12925-12933

Muthwa EX (2021). **An evaluation of customer satisfaction with water service quality in the uMgungundlovu District Municipality.** https://openscholar.dut.ac.za/bitstream/ (Accessed 23 June 2023).

National Agricultural Marketing Council (NAMC) (2023). **NAMC Food Basket: 28 Selected Food Items Prices.** https://www.namc.co.za/wp-content/uploads/2023/03/Final-Food-Basket-Price-Monthly-Report-March-2023-003.pdf (Accessed on 7 March 2023).

National Research Council Subcommittee (1989). **Recommended Dietary Allowances**. https://www.ncbi.nlm.nih.gov/books (Accessed 15 July 2023)

Netshiheni KR, Mashau ME, Jideani AIO (2018). Nutritional and sensory properties of instant maize porridge fortified with Moringa oleifera leaves and termite (Macrotermes falciger) powders. **Nutrition and Food Science** 49: 654–667.

Nshimyiryo A, Hedt-Gauthier B, Mutaganzwa C, Kirk CM, Beck K, Ndayisaba A, Mubiligi J, Kateera F, El-Khatib Z (2019). Risk factors for stunting among children under five years: A cross-sectional population-based study in Rwanda using the 2015 Demographic and Health Survey. **BioMed Central Public Health** 19: 175.

Ntila SL (2017). **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**. Unpublished dissertation. http://researchspace.ukzn.ac.za (Accessed 12 March 2022).

Ntila S, Ndhlala A, Mashela P, Kolanisi U, Siwela M (2020). Supplementation of a complementary white maize soft porridge with Moringa oleifera powder as a promising strategy to increase nutritional and phytochemical values: A research note. **South African Journal of Botany** 129: 238–242.

Oladiran DA, Emmambux NM (2022). Locally available African complementary foods: Nutritional limitations and processing technologies to improve nutritional quality—A review. **Food Review International** 38: 1033–1063.

Olusanya RN, Kolanisi U, Van Onselen A, Ngobese NZ, Siwela M (2020). Nutritional composition and consumer acceptability of Moringa oleifera leaf powder (MOLP)-supplemented mahewu. **South African Journal of Botany** 129: 175–180.

Otten JJ, Hellwig JP, Meyers LD (2006**). Dietary Reference Intakes – The Essential Guide to Nutrient Requirements**. Washington DC: National Academy of Science.

Panda SK, Lakra K, Panda SC (2019). Dietary diversity among women in the reproductive age group in urban field practice area, Vimszr, Burla. **International Journal of Biological and Medical Research** 3: 9–14.

Patel L, Hochfeld T, Moodley J (2013). Gender and child sensitive social protection in South Africa. **Development Southern Africa** 30: 1.

Sayed N, Schönfeldt HC (2020). A review of complementary feeding practices in South Africa. **South African Journal of Clinical Nutrition** 33: 36–43.

Sayed N, Schönfeldt HC (2022). The use of linear programming to determine whether breastfed infants can achieve a nutritionally adequate complementary feeding diet: a case study of 6-11 month old infants. **South African Journal of Clinical Nutrition** 35(3): 100-107.

Seonandan P, McKerrow N (2016). A review of infant and young child feeding practice in hospital and the home in KwaZulu-Natal Midlands. **South African Journal of Clinical Nutrition** 29: 111–115.

South Africa Government (2020). **MEC Ravi Pillay launches One Home One Garden programme in Umgungundlovu.** https://www.gov.za/speeches/mec-pillay-launch-one-home-one-garden-programme-umgungundlovu-district-22-jun-2020-0000 (Accessed 23 June 2022).

UNICEF (2020). **An update on the exclusion error rate for children who are eligible to receive the child support grant.** https://www.unicef.org (Accessed 12 June 2023).

Weyh C, Kruger K, Peeling P, Castell L (2022). The role of Minerals in the Optimal Functioning of the Immune System. **Nutrients** 14 (3): 644.

White JM, Begin F, Kumapley R, Murray C, Krasevec J (2017). Complementary feeding practices: Current global and regional estimates. **Maternal and child nutrition** 13: e12505.

World Health Organizations (2022). **Infant and Young Child Feeding.** https://www.who.int/data/nutrition/nlis/info/infant-and-youngchild-Feeding (Accessed 8 June 2022).

World Health Organizations (2013). **Guidelines: Updates on the management of severe acute malnutrition In Infants and children**. https://www.who.int/publications-detail-redirect/9789241506328 (Accessed 2 July 2021).

Zembe-Mkabile W, Surender R, Sanders D, Jackson D, Doherty T (2015). The experience of cash transfers in alleviating childhood poverty in alleviating childhood poverty in South Africa: mothers' experiences of the Child Support Grant. **Global Public Health** 10(7): 834 – 51.

CHAPTER 6

CONCLUSIONS, STUDY CRITIQUE AND RECOMMENDATIONS

6.1 Introduction

This chapter presents the conclusions, study critique and recommendations. The study objectives were: (i) to identify the popular home-prepared complementary foods fed to children among selected rural and urban population groups in KZN; (ii) to assess the nutritional composition of the selected home-prepared complementary foods consumed by children living in selected rural and urban population groups in KZN; (iii) to determine how the identified home-prepared complementary foods can be modified through the incorporation of MOLP to improve their nutritional composition; (iv) to determine the effect of MOLP on the physical quality of the identified home-prepared complementary foods; and (v) to determine the effect of MOLP on the nutritional composition of home-prepared complementary foods.

6.2 Conclusions

The study found that early introduction of solids before six months was common, which exposed the infants to the risk of malnutrition, particularly among these communities of low economic status. White maize porridge and pumpkin were the most commonly used home-prepared complementary food with minimal use of fruits, vegetables and/or protein-containing food items. The two food items which were found mainly used in complementary feeding do not contain adequate nutrients and the fact that the complementary foods made with them such as white maize porridge are high in water reduces their nutrient concentration further, as well as reduces the energy density. Therefore, there is a need for home-based sustainable and affordable strategies that can be used to improve the nutritional composition of home-prepared complementary foods at a household level, such as the incorporation of MOLP. The incorporation of MOLP resulted in increased levels of the nutrients of interest, the home-prepared complementary food meets the AIs and RDAs of protein, iron and zinc for the infants between seven to twelve months if the complementary foods are consumed in adequate amounts. Future research needs to be conducted on the use of MOLP as a fortificant in more nutrient dense-accessible and affordable home-prepared complementary foods as well as acceptability of these modified complementary foods.

6.3 Study critique

The following are the study critique for this study:

- Telephonic interviews to collect data affected the sample size and/or number of participants reached, as there were no alternative ways to access the participants if they were not available telephonically. Some participants were not reached for various reasons, such as changing contact numbers. Telephonic interviews were done to reduce contact during the COVID-19 pandemic.
- This study was conducted in KZN, SA using a selected sample population. Therefore, findings from this study cannot be used to draw conclusions on the entire KZN's complementary feeding practices and popular home-prepared complementary foods nutritional composition.
- To reduce contact during the COVID-19 pandemic, only the effect of MOLP on the nutritional composition and physical quality (colour) of home-prepared complementary foods was determined. The consumer sensory acceptability (taste, colour, aroma and texture) was not conducted.

6.4 Recommendations

The following are the study recommendations for this study:

- More research on complementary feeding practices and popular home-prepared complementary foods must be conducted in other parts of KZN, thereafter, conclusions be drawn on KZN's complementary feeding practices and popular home-prepared complementary foods. Similar studies could be conducted in other provinces in SA.
- In the future, a consumer acceptability study on the MOLP-added popular home-prepared complementary foods identified in this study must be conducted to determine its acceptability by caregivers and children.
- Factors that may influence the nutritional composition of moringa, such as environmental factors, agriculture and processing of moringa leaves to MOLP, must be investigated.
- The low-socio economic households are affected by the significant increase in unemployment and the marked decrease in affordability of food, therefore it would be advisable for caregivers to consider alternative use for pumpkins, specifically their

seeds, which are known to contain a comparatively higher concentration of nutrients than the pumpkin itself.

APPENDIX A: QUESTIONNAIRE IN ENGLISH

Research participant code:
MID:

IMPROVING THE NUTRITIONAL COMPOSITION OF IDENTIFIED POPULAR HOME PREPARED COMPLEMENTARY FOODS IN SELECTED RURAL AND URBAN AREAS OF DURBAN, KWAZULU-NATAL

QUESTIONNAIRE

Date:

Time:

Preferred language for interview:

English	isiZulu

Preferred communication:

Video call	Voice call

Study:

MACE	SONKE

SECTION A: PERSONAL DETAILS

Participant name: ____

- **Child's name:** ____________________________
- **Relationship to child:**

Mother	Father	Grandparent	Other: Specify ____________

- **Child's age:**

2 -<3 years	3 - <4 years	4 – <5 years

- **When your child started complementary foods (solids), did you make your child's food yourself or did you buy it from the shop (e.g. purity)?**

Bought from shop	Homemade

If participant answered homemade to question 5 then section B will be asked. If the participant answered store bought they will be excluded from the study.

<u>SECTION B:</u> HOMEMADE COMPLEMENTARY FOODS

- **How old was your child when he/she started solid foods?**

1 - <2 months	**2 - <3 months**	**3 - <5 months**	**5 - <6 months**	**6 - <7 months**	**7 - <8 months**	**8 - <9 months**	**9 - <10 months**	**10 - <11 months**	**11-12 months**

- **What was the main solid ingredient in the first meal you gave your child?**

Maize meal	**Butternut**	**Potato**	**Sweet potato**	**Other**

If you selected OTHER, indicate what the first main solid ingredient was

____

- **List all the homemade food items/meals that were given to your child up to the age of 1 year**

1.	**4.**	**7.**
2.	**5.**	**8.**
3.	**6.**	**9.**

4. Please explain how you prepared the homemade complementary food/s you gave your child at this time by providing the recipes for at least two of the complementary foods.*
Recipe template attached (Annexure A)

5. How much complementary food did you give your child each time you fed her/him this food at the following ages

Age group	Less than 5 teaspoons/25 ml	5 – <10 teaspoons (25-<50ml)	10 teaspoons - <1/2 cup (50 ml - <125ml)	½ - <1 cup (125 - <250ml)	1 - 2 cups (250 - 500ml)	More than 2 cups (>500ml)
<6 months						
6 - <12 months						
12 – <18 months						
18 – <24 months						
24 – 36 months						

6. Vegetables and indigenous crops

6.1 Respond yes or no to the following questions

Statements	Yes	No
6.1.1 Does your family grow vegetables (have a vegetable garden) at home?		
6.1.2 Does your family grow vegetables to sell?		
6.1.3 Does your family consume the vegetables they grow?		
6.1.5 Does your family buy vegetables from the shop?		

6.2 If you answered NO to 6.1.1, please indicate your level of agreement that <u>the following are REASONS why your family does not grow vegetables</u>:

Reasons	Disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Agree
6.2.1 My family does not need a vegetable garden					
6.2.3 My family does not have space for a vegetable garden					
6.2.3 My family cannot afford to buy seeds/vegetable to plant					
6.2.4 There is not enough readily available water to grow vegetables					

6.3 Other reasons for not having a vegetable garden:

____

____

____

6.4 What vegetable/s do you and your family grow AND/OR buy?

1.	**4.**
2.	**5.**
3.	**6.**

6.5 Please respond yes/ no to the following statements

Statements	Yes	No
6.5.1 Does your family grow indigenous/traditional crop/s?		
6.5.2 Does your family consume indigenous crop/s?		
6.5.3 Have you heard of Moringa?		
6.5.4 Does your family consume Moringa?		

6.6 If you answered YES to 6.5.1, which indigenous/traditional crop/s do you/ your family grow?

1.	**4.**
2.	**5.**
3.	**6.**

6.7 If you answered YES to 6.5.2

6.7.1 Which indigenous crop(s) do you / your family consume?

____

____

6.7.2 In what food form do you consume it?

____

____

6.7.3 If you answered NO to 6.5.2, why do you / your family not consume indigenous and/or traditional crops?

____

Thank you for participating ☺

Annexure A: Recipe template

Recipe name:

Preparation time:

Cooking time:

Serving:

Portion sizes:

Ingredients	**Unit**	**Quantity**	**Preparation instruction**

APPENDIX B: QUESTIONNAIRE IN *ISIZULU*

Ikhodi yomhlanganyeli wocwaningo:
MID:

IMPROVING THE NUTRITIONAL COMPOSITION OF IDENTIFIED POPULAR HOME PREPARED COMPLEMENTARY FOODS IN SELECTED RURAL AND URBAN AREAS OF DURBAN, KWAZULU-NATAL

IMIBUZO

Usuku:

Isikhathi:

Ulimi oluncanyelwayo lwenhlolokhono:

iSingisi	isiZulu

Ukuxhumana okuncanyelwayo:

Ucingo lwevidiyo	Ucingo lwezwi

ucwaningo/ isifundo:

MACE	SONKE

ISIQEPHU A: IMINININGWANE YOMUNTU

1. **Igama lombambi qhaza: ____**
2. **Igama lomntwana: __________________________**
3. **Ubudlelwane nomntwana:**

umama	ubaba	Ugogo noma umkhulu	Okunye: ______________

- **Iminyaka yomntwana:**

2 -<3	3 - <4	4 – <5

- **Lapho ingane yakho iqala ukudla okuqinile, ingabe wazenzela ukudla kwengane yakho noma ukuthenge esitolo?**

Wathenga esitolo	Wazenzela/waziphekela ekhaya

Uma umhlanganyeli ephendule ngokuzenzela embuzweni wesi-5 kuzobe sekubuzwa isigaba B. Uma umhlanganyeli ephendule esitolo uzokhishwa ocwaningweni.

ISIQEPHU B: UKUDLA OKWENZA EKHAYA

1. Yayineminyaka (izinyanga) emingaki ingane yakho lapho iqala ukudla okuqinile?

1 - <2	2 - <3	3 - <5	5 - <6	6 - <7	7 - <8	8 - <9	9 - <10	10 - <11	11-12

2. What was the main solid ingredient in the first meal you gave your child?

Impuphu	*Ithanga*	*Izambane*	*ubhatata*	*Okunye*

Uma ukhethe OKUNYE, bonisa ukuthi bekuyini isithako sokuqala esiqinile____

3. Bhala uhlu lwakho konke ukudla/ukudla okwenziwa ekhaya okunike ingane yakho kuze kube unyaka owodwa

1.	**4.**	**7.**
2.	**5.**	**8.**
3.	**6.**	**9.**

4. Sicela uchaze ukuthi ukulungise kanjani ukudla/ukudla okwanelisayo okwenziwe ekhaya okunike ingane yakho ngalesi sikhathi ngokunikeza izindlela zokupheka okungenani ezimbili zokudla okuhambisanayo.

* Isifanekiso seresiphi sinamathiselwe (Isithasiselo A)

5. Kungakanani ukudla okuqinile (solids) oyinikeza ingane yakho isikhathi ngasinye uma uyipha lokhu kudla eminyakeni elandelayo?

Age group	Less than 5 teaspoons/25 ml	5 – <10 teaspoons (25-<50ml)	10 teaspoons - <1/2 cup (50 ml - <125ml)	½ - <1 cup (125 - <250ml)	1 - 2 cups (250 - 500ml)	More than 2 cups (>500ml)
<6 izinyanga						
6 - <12 izinyanga						
12 – <18 izinyanga						
18 – <24 izinyanga						
24 – 36 izinyanga						

6. Imifino kanye nezitshalo zomdabu

6.1 Respond yes or no to the following questions

Izitatimende	Yebo	Cha
6.1.1 Ingabe umndeni wakho utshala imifino (unengadi yemifino) ekhaya?		
6.1.2 Ingabe umndeni wakho utshala imifino ozoyithengisa?		
6.1.3 Ingabe umndeni wakho udla imifino oyitshalayo?		
6.1.5 Ingabe umndeni wakho uthenga imifino esitolo?		

6.2 Uma uphendule ngokuthi CHA ku-6.1.1, sicela ubonise izinga lakho lesivumelwano sokuthi okulandelayo IZIZATHU zokuthi kungani umndeni wakho ungatshali imifino:

Izizathu	Angivumi	Kancane angivumelani	Angivumi noma ngiphikise	Ngiyavuma kancane	Ngiyavuma
6.2.1 Umndeni wami awudingi ingadi yemifino					
6.2.3 Umndeni wami awunayo indawo yengadi yemifino					
6.2.3 Umndeni wami awukwazi ukuthenga imbewu/imifino engingayitshala					
6.2.4 Awekho amanzi anele atholakala kalula okulima imifino					

6.3 Ezinye izizathu zokungabi nayo ingadi yemifino:

____

____

____

6.4 Imiphi imifino eniyitshalayo wena nomndeni wakho KANYE/NOMA niyithenge?

1.	**4.**
2.	**5.**
3.	**6.**

6.5 Sicela uphendule ngoyebo/cha ezitatimendeni ezilandelayo

Izitatimende	Yebo	Cha
6.5.1 Ingabe umndeni wakho utshala izitshalo zendabuko/zendabuko?		

6.5.2 Ingabe umndeni wakho udla izitshalo/izitshalo zomdabu?		
6.5.3 Uke wezwa ngoMoringa?		
6.5.4 Ingabe umndeni wakho uyadla iMoringa?		

6.6 Uma uphendule ngo-YEBO ku-6.5.1, yisiphi isilimo/izitshalo zomdabu ozitshalayo/umndeni wakho?

1.	**4.**
2.	**5.**
3.	**6.**

6.7 Uma uphendule ngo-YEBO ku-6.5.2

6.7.1 Iziphi izitshalo zomdabu ozidla wena/umndeni wakho?

____

____

6.7.2 Ukudla ngaluphi uhlobo lokudla?

____

____

6.7.3 Uma uphendule ngokuthi CHA ku-6.5.2, kungani wena/umndeni wakho ungadli izitshalo zendabuko kanye/noma?

____

____

____

Siyabonga ngokubamba iqhaza ☺

Isithasiselo A: Isifanekiso seresiphi

Igama leresiphi:

Isikhathi sokulungiselela:

Isikhathi sokupheka:

Ukukhonza:

Osayizi bengxenye:

Izithako	**Iyunithi**	**Umthamo**	**Umyalelo**

Eminye imiyalelo/izinqubo:

APPENDIX C: CONSENT FORM IN ENGLISH

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

Environmental Sciences
Dietetics and Human Nutrition
University of KwaZulu-Natal,
Pietermaritzburg Campus,

Dear participant,

INFORMED CONSENT LETTER

My name is Ms Hlengiwe Sokhela and I am a researcher from the University of KwaZulu-Natal, Pietermaritzburg campus. I will be conducting this study under the supervision of Dr Laurencia Govender who is a lecturer and researcher from the University of KwaZulu-Natal, Pietermaritzburg campus. The aim of my research is to improve the nutritional composition of identified popular home-prepared complementary foods in selected rural and urban areas of KwaZulu–Natal.

Participants will be required to indicate what home-based complementary foods they prepared and fed their infants, to provide recipes for the complementary foods prepared and to indicate the types of indigenous crops that are found in the area and if they used any to prepare the complementary foods.

This study has been ethically reviewed and approved by the UKZN Biomedical research Ethics Committee (BREC/0003165/2021).

Please note that:

- Your confidentiality is guaranteed as your inputs will not be attributed to you in person, but reported only as a population member opinion.
- Any information given by you cannot be used against you, and the collected data will be used for purposes of this research only.
- There will be no discomforts or hazards to participants who agree to participate in this study.
- Data will be stored in secure storage and destroyed after 5 years.
- You have a choice to participate, not participate or stop participating in the research. You will not be penalized for taking such an action. Participation is voluntary.
- Your involvement is purely for academic purposes only, and there are no financial benefits involved.
- If you are willing to be interviewed, please indicate (by ticking as applicable) whether or not you are willing to allow the interview to be recorded by the following equipment:

	Willing	**Not willing**
Voice recording		
Video recording		

If I have any questions or concerns about your rights as a study participant, or if you are concerned about an aspect of the study:

I can be contacted at:
Email: hlengiwe0994@gmail.com
Phone number: 065 841 8602

My supervisor can be contacted at:
Email: Govenderl3@ukzn.ac.za
Phone number: 033 260 6154

You may also contact the Project manager Kareshma Ramcharan.
Contact details: email: ramchar4@ukzn.ac.za
Phone number: 031 260 4673

You may also contact the Research Office through:
Research Office, Westville Campus
Govan Mbeki Building
Private Bag X 54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA
Tel: 031 260 4769 - Fax: 031 260 4609
Email: BREC@ukzn.ac.za

Thank you for your contribution to this research.

DECLARATION

I……………………………………………………………………… (full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project.

I understand that I am at liberty to withdraw from the project at any time, should I so desire.

SIGNATURE OF PARTICIPANT	**DATE**
………………………………………	**…………………………………**
SIGNATURE OF WITNESS	**DATE**
(where applicable)	
………………………………………	**…………………………………**
SIGNATURE OF TRANSLATOR	**DATE**
(where applicable)	
………………………………………	**…………………………………**

APPENDIX D: CONSENT FORM IN *ISIZULU*

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

School of Agricultural, Earth and Environmental Sciences
Dietetics and Human Nutrition
University of KwaZulu-Natal,
Pietermaritzburg Campus,

Mbambiqhaza othandekayo,

INCWADI YEMVUME ENOLWAZI

Igama lami ngingu- Ms Hlengiwe Sokhela, ngingumcwaningi wase- University of KwaZulu-Natal, esikhungweni sase-Pietermaritzburg. Ngizobe ngenza ucwaningo ngaphansi komphathi u-Dr Laurencia Govender ongumfundisi nomcwaningi wase-University of KwaZulu-Natal, esikhungwe sase- Pietermaritzburg. Inhloso yalolucwaningo ukwenza ngcono noma ukukhuphula izinga lomsoco wokudla okunikwa izingane okwenzelwe ekhaya endaweni yasedolobheni nasemaphandleni eThekwini KwaZulu–Natal.

Ababambe iqhaza kulolucwaningo kuzodingeka ukuthi bakhombise noma babike ngezinhlobo zokudla okulungiswe ekhaya (home-based complementary foods) abakuphe izinsana. Kuzophinda kudingeke ukuthi babike ngamaresiphi abawasebenzisile kaye nezinhlobo zezitshalo ezitholakala kulendawo abahlala kuyo. Kuzodingeka ukuthi baphinde babike ngazo uma bezisebenzisile ukwezela abantwana ukudla.

Lolucwaningo lubuyekeziwe lwathola nemvumo ngokusemthethweni e-UKZN kwikomidi le Biomedical research Ethics
(Inombolo yemvumo BREC/0003165/2021).

Sicela uqaphele lokhu:

- Imfihlo yakho iqinisekiwe, okufaka kulolucanwingo angeke kukhonjiswe omunye umuntu kodwa kuzobikwa njengenani labantu abayingxenye yalolucwaningo.
- Imininingwane oyinikezayo angeke isetshenziswe ngokumelene nawe, futhi idatha eqoqiwe izosetshenziselwa ucwanino kuphela.
- Angeke kube khona ukungakhululeki noma ubungozi kulaba abavume ukubamba iqhaza kulolucwaningo.
- Idatha izogcinwa endaweni noma kwisitoreji esivikelekile futhi izobhujiswa emva kweminyaka emihlanu.
- Unelungelo lokukhetha ukuba ingxenye yalolucwaningo, noma ukungabi ingxenye noma ukukhetha ukuyeka ukuba yingxenye yalolucwaningo. Angeke uze ujeziswe uma ukhetha ukuyeka.
- Inhloso yokuba ingxenye yalolucwanimgo eyezemfundo kuphela futhi ayikno inzuzo yemali.

- Uma unesifiso sokuba yingxenye yalolucwaningo oluhlanganisa ukubuzwa imibuzo, sicela ukhombise ngokukhetha okufisayo lapha ngezansi:

	Uzimisele	**Awuzimisele**
Irekhoda yezwi		
Irekhoda yevidiyo		

Uma unemibuzo noma ukukhathazeka mayelana namalungelo akho njengombambiqhaza walolucwaningo noma ukhathazekile ngezici zalolucwaningo:

Ngingathintwa kulemininingwane:
Imeyili: hlengiwe0994@gmail.com
Inombolo yocingo: 065 841 8602

Umphathi wami angathintwa kulemininingwane:
Imeyili: Govenderl3@ukzn.ac.za
Inombolo yocingo: 033 260 6154

Ungaphinde uxhumane ne-Project manager u-Kareshma Ramcharan.
Imeyili: ramchar4@ukzn.ac.za
Inombolo yocingo: 031 260 4673

Ungaphine uxhumane nehhovisi le-Research kulemininingwane:
Research Office, Westville Campus
Govan Mbeki Building
Private Bag X 54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA
Inombolo yocingo: 031 260 4769 – Ifekisi: 031 260 4609
imeyili: BREC@ukzn.ac.za

Siyabonga ngokubamba iqhaza kulolucwaningo.

ISIMEMEZELO

I……………………………………………………………………… (amagama akho aphelele) ngiyaqinisekisa ukuthi ngiyaqonda konke okuqukethwe iledokhumenti kanye nemvelo yocwaningo. Ngiyavuma ukubayingxenye yephrojektho yalolucwaningo. Ngiyaqonda ukuthi nginelungelo lokuhoxa kulephrojekthi yalolucwaningo noma inini, uma nginesifiso sokwenza lo

I-SIGNATURE YOMBAMBIQHAZA	**USUKU**
………………………………………	**…………………………………**
I-SIGNATURE YAFAKAZI (uma kunesidingo)	**USUKU**
………………………………………	**…………………………………**
I-SIGNATURE YOMHUMUSHI (uma kunesidingo)	**USUKU**
………………………………………	**…………………………………**

APPENDIX E: SOFT WHITE MAIZE PORRIDGE RECIPE

Ingredients

- 500 ml water
- 90 g (175 ml) white maize

Methods

1. Measure 375 ml of water and bring to boil.
2. Moisten the white maize with the remaining 125 ml of water, then add gradually to the boiling water, stirring until it boils again.
3. Cover the saucepan and allow to boil gently for 30 minutes or longer.
4. Serve.

APPENDIX F: WHITE MAIZE AND PUMPKIN PORRIDGE RECIPE

Ingredients

- 560 g pumpkin (pilled and cubed)
- 165 g white maize meal

Method

1. Cook pumpkin for 20 minutes.

2. Add white maize and mix well.

3. Simmer for 15 minutes, stirring occasionally until cooked.

4. Serve.

APPENDIX G: QUANTITIES OF INGREDIENTS USED TO PREPARE THE COMPLEMENTARY FOODS CONTAINING MOLP

	Ingredients	Percentage of MOLP (w/w)		
		1% MOLP	**2% MOLP**	**3% MOLP**
Quantity	**MOLP**	0.01 x 20.5 = 0.2 g	0.2 x 2 = 0.4 g	0.2 x 3 = 0.6 g
	maize meal	20.5 – 0.2 = 20.3 g	20.5 – 0.4= 20.1 g	20.5 – 0.4 = 19.9 g
	Pumpkin	69.5 g	69.5 g	69.5 g
	Water	500 ml	500 ml	500 ml

APPENDIX H: ETHICS APPROVAL LETTER FOR THIS STUDY

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

18 November 2021

Miss Hlengiwe Sinenhlanhla Charmaine Sokhela (212508801)
School of Agri Earth & Env Sc
Pietermaritzburg

Dear Miss Sokhela,

Protocol reference number: BREC/00003165/2021
Project title: Improving the nutritional composition of identified popular home prepared complementary foods in selected rural and urban areas of Durban, KwaZulu-Natal
Degree: MSc

EXPEDITED APPLICATION: APPROVAL LETTER

A sub-committee of the Biomedical Research Ethics Committee has considered and noted your application.

The conditions have been met and the study is given full ethics approval and may begin as from 18 November 2021. Please ensure that any outstanding site permissions are obtained and forwarded to BREC for approval before commencing research at a site.

This approval is subject to national and UKZN lockdown regulations, see (http://research.ukzn.ac.za/Libraries/BREC/BREC_Amended_Lockdown_Level_1_Guidelines.sflb.ashx). Based on feedback from some sites, we urge PIs to show sensitivity and exercise appropriate consideration at sites where personnel and service users appear stressed or overloaded.

This approval is valid for one year from 18 November 2021. To ensure uninterrupted approval of this study beyond the approval expiry date, an application for recertification must be submitted to BREC on the appropriate BREC form 2-3 months before the expiry date.

Any amendments to this study, unless urgently required to ensure safety of participants, must be approved by BREC prior to implementation.

Your acceptance of this approval denotes your compliance with South African National Research Ethics Guidelines (2015), South African National Good Clinical Practice Guidelines (2020) (if applicable) and with UKZN BREC ethics requirements as contained in the UKZN BREC Terms of Reference and Standard Operating Procedures, all available at http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx.

BREC is registered with the South African National Health Research Ethics Council (REC-290408-009). BREC has US Office for Human Research Protections (OHRP) Federal-wide Assurance (FWA 678).

The sub-committee's decision will be noted by a full Committee at its next meeting taking place on 14 December 2021.

Yours sincerely,

[redacted]

Prof D Wassenaar
Chair: Biomedical Research Ethics Committee

Biomedical Research Ethics Committee
Chair: Professor D R Wassenaar
UKZN Research Ethics Office Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Email: BREC@ukzn.ac.za
Website: http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx

APPENDIX I: ETHICS APPROVAL LETTER FOR MACE STUDY

UNIVERSITY OF
KWAZULU-NATAL
INYUVESI
YAKWAZULU-NATALI
RESEARCH OFFICE
BIOMEDICAL RESEARCH ETHICS ADMINISTRATION
Westville Campus
Govan Mbeki Building
Private Bag X 54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604769 - Fax: 27 31 260-4609
Email: BREC@ukzn.ac.za
Website: http://research.ukzn.ac.za/ResearchEthics/BiomedicalResearchEthics.aspx

18 December 2012

Dr. Rajen Naidoo
Discipline of Occupational and Environmental Health
University of KwaZulu-Natal
Howard College
Durban
4041

PROTOCOL: The Mother and Child in the Environment (THE MACE STUDY). REF:BF263/12.

PROVISIONAL APPROVAL

A sub-committee of the Biomedical Research Ethics Committee has considered your response dated 08 November 2012 to BREC letter dated 26 October 2012.

The study is given **PROVISIONAL APPROVAL** pending receipt of:

1. Hospital Permission letters (Wentworth, Prince Mshiyeni, King Edward VIII, Mahatma Gandhi, Kind George V and Addington Hospital)
2. EThekwini municipal antenatal clinics- permission letters

Please refer to attached document "Permission to Conduct a Research Study/Trial". This must be completed and submitted to the Hospital Manager for signature. For King Edward VIII Hospital (KEH) and Inkosi Albert Luthuli Central Hospital (IALCH) studies please submit the document **together with items 1 to 5 as outlined on the form.**

Once the document has been signed it should be returned to this office.

Only when full ethical approval is given, may the study begin. **Full ethics approval has not been given at this stage.**

PLEASE NOTE: Provisional approval is valid for 6 months only - should we not hear from you during this time - the study will be closed and reapplication will need to be made.

Your acceptance of this provisional approval denotes your compliance with South African National Research Ethics Guidelines (2004), South African National Good Clinical Practice Guidelines (2006) (if applicable) and with UKZN BREC ethics requirements as contained in the UKZN BREC Terms of Reference and Standard Operating Procedures, all available at http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx.

BREC is registered with the South African National Health Research Ethics Council (REC-290408-009). BREC has US Office for Human Research Protections (OHRP) Federal-wide Assurance (FWA 678).

Yours sincerely

[redacted]

Senior Administrator: Biomedical Research Ethics

APPENDIX J: ETHICS APPROVAL LETTER FOR SONKE STUDY

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI
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Biomedical Research Ethics Administration
Westville Campus, Govan Mbeki Building
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Tel: 27 31 2604769 - Fax: 27 31 2604609
Email: BREC@ukzn.ac.za
Website http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx

12 April 2017

Dr Saloshni Naidoo
Room 314, 3rd Floor
North Tower
George Campbell Building
Howard Campus
naidoos71@ukzn.ac.za

Dear Dr Naidoo

PROTOCOL: A prospective cohort study: Examining the impact of pesticide exposure on the reproductive outcomes in pregnant women and the neurobehavioural outcomes of their offspring in South Africa. REF: BF250/14

RECERTIFICATION APPLICATION APPROVAL NOTICE

Approved:	09 December 2017
Expiration of Ethical Approval:	08 December 2018

I wish to advise you that your application for Recertification received on 10 January 2017 for the above protocol has been noted and approved by the Biomedical Research Ethics Committee (BREC) at a meeting held on 11 April 2017 for another approval period. The start and end dates of this period are indicated above.

If any modifications or adverse events occur in the project before your next scheduled review, you must submit them to BREC for review. Except in emergency situations, no change to the protocol may be implemented until you have received written BREC approval for the change.

Yours sincerely

[redacted]

Ms A Marimuthu
Senior Administrator: Biomedical Research Ethics