THE POTENTIAL OF PROVITAMIN A-BIOFORTIFIED MAIZE AND SWEET POTATO, AND BAMBARA GROUNDNUT FOR IMPROVING THE NUTRITIONAL STATUS OF RURAL COMMUNITIES IN KWAZULU-NATAL, SOUTH AFRICA

BY

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PREFACE

The work described in this thesis was carried out from July 2015 to November 2019, under the supervision of Dr Kirthee Pillay and Prof Muthulisi Siwela.

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

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Dr Kirthee Pillay (Supervisor)

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DECLARATION

I, Laurencia Govender, declare that:

1. The entity of the work contained in this thesis is my original work, except where otherwise stated.
2. This thesis, or any part of it, has not been submitted for any degree or examination at any other university.
3. Where other sources have been used, they have not been copied and have been properly acknowledged.
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ABSTRACT

The double burden of malnutrition, under- and over-nutrition, is a serious health problem and a leading contributor to the global disease burden. Undernutrition presents as wasting, stunting, underweight and micronutrient deficiencies, such as vitamin A, iron and zinc, while over-nutrition presents as overweight, obesity and several non-communicable diseases. Children under the age of five years and pregnant women are the most affected by malnutrition, especially in rural areas. In developing countries, such as South Africa (SA), the major contributing factors to all forms of malnutrition are poverty, food and nutrition insecurity as well as the shift from traditional diets to more westernised diets. There have been several strategies employed in SA to alleviate malnutrition, especially vitamin A deficiency (VAD), yet it still remains a problem. Provitamin A (PVA)-biofortified crops could be used as a complementary strategy to address VAD; however, there are challenges of poor consumer acceptability. The poor acceptability of PVA-biofortified foods could be improved by combining them with other commonly consumed plant food items and animal food sources such as chicken to produce provitamin A-rich traditional dishes. However, animal food products can be unaffordable to many economically disadvantaged households, thus legumes could be used as an alternative and cheaper protein source. Bambara groundnut is an underutilised indigenous legume that is found in sub-Saharan Africa (SSA). It is a good source of protein and when consumed together with cooked starch-based products, it forms a complementary protein. Therefore, combining PVA-biofortified maize with bambara groundnut could contribute to improving the nutritional status of vulnerable population groups in SSA, including SA.

Cream-fleshed sweet potato (CFSP) (*Ipomoea batata* L.) is a commonly consumed crop in SA and would be ideal for PVA-biofortification to produce orange-fleshed sweet potato (OFSP). Unlike PVA-biofortified maize that showed poor consumer acceptability, OFSP has been found acceptable to consumers. The OFSP has a high PVA carotenoid concentration, therefore it could be used as a food-based approach to address VAD among the economically disadvantaged population groups who are usually at risk of VAD, particularly rural communities.

Research conducted on the nutritional composition and consumer acceptability of composite dishes made with PVA-biofortified maize and OFSP is limited, especially in SA. Furthermore, there is paucity of literature on the nutritional composition and consumer acceptance of bambara groundnut combined with cooked PVA-biofortified maize. Thus, this study

investigated the potential of PVA-biofortified maize and sweet potato, and bambara groundnut for improving the nutritional status of rural communities in KwaZulu-Natal (KZN), SA.

In order to formulate an effective food-based approach to address malnutrition, the nutritional status and dietary patterns of the target population group/s (communities) needed to be determined. Thus, the first study objective was to assess the nutritional status, using selected anthropometric indices and dietary intake methods, of four rural communities in KZN, who had been selected for investigating the proposed food-based nutrition approach. Purposive sampling generated a sample of 50 households each in four rural areas of KZN: Swayimane, Tugela Ferry and Umbumbulu and 21 households at Fountain Hill Estate. Anthropometric [height, weight, mid-upper arm circumference (MUAC), and waist circumference] and dietary intake data (repeated 24-hour recall and food frequency) were collected. The Food Finder 3 software of the Medical Research Council (MRC), SA, was used to analyse dietary intake data, and the Statistical Package for Social Sciences (SPSS, version 25) was used to analyse the other data sets. The Estimated Average Requirement (EAR) cut-point method was used to assess the prevalence of inadequate nutrient intake. The results of the study indicated that 17.9 % (n=7), 30.8% (n=12) and 15.5% (n=6) of the children under five years were underweight, stunted and overweight, respectively. According to the MUAC measurements, 20.5% (n=8) and 5.1% (n=2) of the children under five years had severe acute malnutrition (SAM) and moderate acute malnutrition (MAM), respectively. The Fisher's Exact test showed that a significant proportion (37.5%; n=3) of those with a MUAC below 11.5 cm had a weight-for-height (WFH) Z-score below -3 standard deviation (SD) of the WHO child growth standards median, indicating severe malnutrition (p=0.046). The majority of the adult participants were either overweight (23.6%; n=76) or obese (29.5%; n=95), with a higher prevalence of overweight and obesity among females than males. According to the Binomial test, a significant number (67.0%; n=213) of adult participants had waist circumference measurements below 88 cm and 102 cm for females and males, respectively ($p<0.05$). The Chi-square test indicated that there was a significant relationship between gender and waist circumference ($p<0.05$). A significant proportion of adult males (92.9%; n=105) had a normal waist circumference and were not at risk of obesity-related diseases, whilst a significant proportion ($p<0.05$) of adult females (47.3%; n=97) were at risk of obesity-related diseases, such as diabetes, high cholesterol and hypertension. Adult participants that were underweight or had a normal body mass index (BMI) were not at risk of co-morbidities and obesity, whilst participants who were classified as obese class I, II and III had a high risk of co-morbidities ($p<0.05$).

Although not statistically significantly different, there was a higher prevalence of over-nutrition than undernutrition at all four research sites for females aged 16-35 years old. There was a significant relationship between BMI and the risk of having a clinically undesirable waist circumference ($p<0.05$). There was frequent consumption of food items high in carbohydrates (mainly the cereal grain foods), and low intake of micronutrients and fibre by most age groups. The food frequency results indicated that onion, *phutu*, brown bread, tomato, rice, apple, eggs and chicken were the most commonly consumed food items. Results of analysis by the EAR-cut point method indicated that, among most of the age groups, there was a high prevalence of inadequate intake of several nutrients, including dietary fibre, vitamins, including vitamin A and minerals, including zinc and iron.

The second study objective was to determine the effect of replacing white maize and CFSP with PVA-biofortified maize and OFSP, respectively, on the nutritional composition of traditional and indigenous dishes of KZN, SA. The *phutu* combinations were selected based on a survey conducted in four selected rural study sites in KZN to determine popular dishes in which maize was combined with other food items. Popular indigenous knowledge systems (IKS)-based recipes were collected to determine methods of preparing and processing white maize and CFSP into food products. *Phutu* (traditional crumbly porridge) was selected as the cooked maize meal dish, curried cabbage as a vegetarian dish and curried chicken as a meat dish. Curried bambara groundnut was selected as an alternative animal protein source. Grains of one PVA-biofortified maize variety and one white variety (control) was cooked into *phutu*. Both varieties of *phutu* were served with either curried cabbage, chicken or bambara groundnut. Two types of boiled sweet potato were used in the study; OFSP and CFSP (control). Composite dishes were prepared by combining either PVA-biofortified *phutu* or white *phutu* with other food items, separately, i.e. curried cabbage, curried chicken and curried bambara groundnut and the nutritional composition of the dishes were analysed. Generally, the proximate composition of the PVA-biofortified *phutu* composite dishes were not significantly different from those of white *phutu* composite dishes (controls) ($p>0.05$). However, the PVA concentration of PVA-biofortified *phutu* composite dishes was higher than that of the white *phutu* composite dishes (controls). The OFSP had a significantly lower protein concentration, but was significantly higher in other nutrients, including PVA relative to the CFSP ($p<0.05$).

The third investigation determined the effect of replacing white maize and CFSP with PVA-biofortified maize and OFSP, respectively, on the sensory properties and consumer acceptance of traditional and indigenous dishes of KZN, SA. The sensory acceptability of the composite dishes and sweet potatoes was evaluated by 60 participants each from the two rural areas (Swayimane and Umbumbulu), using a five-point facial hedonic scale and a paired preference test. Focus group discussions (FGDs) were conducted with 56 participants recruited from the consumer panel to assess consumer perceptions about the composite dishes made with PVA-biofortified *phutu* and OFSP. The majority of the participants rated the composite dishes containing PVA-biofortified *phutu* as "good" and the acceptability of the composite dishes varied significantly ($p<0.05$). Compared to other age groups, the 50-59 year age group showed a higher preference for the white *phutu* and curried chicken composite dish, whereas the 30-39 year age group showed a higher preference for the PVA-biofortified *phutu* and curried chicken composite dish. The acceptability of OFSP and CFSP was similar. The FGDs indicated that participants had positive perceptions of the PVA-biofortified *phutu* when served with curried chicken or cabbage. However, they had mixed perceptions when served with curried bambara groundnut. The older FGD participants perceived that some of the composite dishes, such as *phutu* and curried bambara groundnut, would not be acceptable to younger consumers as they were not accustomed to bambara groundnut, especially its sensory attributes such as taste, texture and aroma. There were positive responses to the proposal to replace the CFSP with OFSP. Most of the FGD participants perceived the OFSP to be butternut due to its orange colour, sweet taste and visual appeal. The FGD participants expressed a willingness to grow and purchase the PVA-biofortified maize and PVA-biofortified OFSP, if planting materials were made available or if the two types of biofortified crops were available in the local markets for utilisation as staple foods.

The study findings show that under- and over-nutrition, and poor dietary diversity are prevalent in rural KZN. There was a low intake of several nutrients, including dietary fibre and several micronutrients. The study findings indicate that there is a need to increase the availability, accessibility, and utilisation of diverse foods through appropriate agricultural and nutritional interventions. Biofortification could be used as a complementary strategy to assist with the alleviation of VAD in SSA. Although, in several studies, PVA-biofortified foods have been found less acceptable compared to counterpart white maize foods, the PVA-biofortified foods investigated in this study were perceived positively by most of the participants. Overall, the study findings suggest that PVA-biofortified maize and OFSP can replace white maize and CFSP, respectively, in selected traditional dishes of the rural communities studied, to alleviate VAD. Further research should be conducted using a larger sample size, larger area and with different PVA-biofortified maize food types and varieties of OFSP, to obtain results for large rural populations in all provinces of SA.

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DEDICATION

This thesis is dedicated to my late grandmother Mrs Kanimah Sivagami Aiyer (1941 - 2002)

You taught me never to give up and put my all in whatever I do. I promised you that one day I would become a Dr and finally the day is here. I know that you would have been proud of this accomplishment.

and

My late grandfather Mr Arthmoolam (Adhi) Govender (1943-2019)

You have always been proud of me ever since I was a little girl. I wish you could have celebrated this milestone with me.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABBREVIATIONS

AI	Adequate Intake
AOAC	Association of Official Analytical Chemists
BMI	Body Mass Index
CFSP	Cream-fleshed sweet potato
CIP	International Potato Centre
DAFF	Department of Agriculture, Forestry and Fisheries
DoH	Department of Health
EAR	Estimated Average Requirement
ECD	Early Childhood Development
EER	Estimated Energy Requirements
FAO	Food and Agriculture Organization of the United Nations
FFQ	Food Frequency Questionnaire
FGDs	Focus group discussions
FHE	Fountain Hill Estate
HFA	Height-for-age
HIV	Human Immunodeficiency Virus
HST	Health Systems Trust
IKS	Indigenous Knowledge System
IMAM	Integrated Management of Acute Malnutrition
KZN	KwaZulu-Natal
MAM	Moderate Acute Malnutrition
MRC	Medical Research Council
MUAC	Mid-upper arm circumference

nDoH	National Department of Health
NFCS	National Food Consumption Survey
NFCS-FB	National Food Consumption Survey: Fortification Baseline
NAM	Not at risk of Malnutrition
NAMC	National Agricultural Marketing Council
OFSP	Orange-fleshed sweet potato
PEM	Protein-energy malnutrition
PVA	Provitamin A
RDA	Recommended Dietary Allowance
SA	South Africa
SADHS	South African Demographic and Health Survey
SAM	Severe Acute Malnutrition
SAMRC	South African Medical Research Council
SAVACG	South African Vitamin A Consultative Group
SD	Standard deviation
SPSS	Statistical Package for Social Sciences
SSA	sub-Saharan Africa
Stats SA	Statistics South Africa
UKZN	University of KwaZulu-Natal
UL	Tolerable Upper Intake Level
UNICEF	United Nations Children’s Fund
VAD	Vitamin A deficiency
WFA	Weight-for-age
WFH	Weight-for-height

WFP	World Food Programme
WHO	World Health Organization
WRC	Water Research Commission

CHAPTER 1
INTRODUCTION, THE PROBLEM, AND ITS SETTING

1.1 Motivation and justification for conducting the study

Malnutrition manifests as either undernutrition (stunting, wasting and underweight), over-nutrition (overweight, obesity and diet-related non-communicable diseases) or micronutrient deficiencies, and is a leading contributor to the global disease burden [United Nations Children's Fund (UNICEF), World Health Organization (WHO) & World Bank Group 2017; UNICEF 2016; Faber & Wenhold 2007]. Globally, in 2016, approximately 1.9 billion adults were overweight and 650 million were obese (WHO 2020). Additionally, in 2017, 22.2%, 5.6% and 7.5% of children under five years were stunted, overweight and wasted, respectively (Development Initiatives 2018). Stunting in children is not only a serious health concern globally, but is also a concern in developing countries including South Africa (SA). It is a serious health problem as it increases the risk of non-communicable diseases in adulthood and can lead to reduced mental development and poor academic performance in children (WHO 2019). The 2016 South African Demographic and Health Survey (SADHS) indicated that 27% of children under five years were stunted and one in five women was severely obese, with a body mass index (BMI) greater than 35 kg/m^2 [National Department of Health (nDoH), Statistics South Africa (Stats SA), South African Medical Research Council (SAMRC) & ICF 2017]. All forms of undernutrition could be attributed to very limited access to good quality nutrient-dense foods (Faber & Wenhold 2007).

Micronutrient deficiencies are highly prevalent in developing countries with the most common micronutrient deficiencies being: vitamin A, iodine, iron, zinc and folic acid (Bailey, West Jr & Black 2015). Vitamin A deficiency (VAD) is a serious health problem in developing regions, especially sub-Saharan Africa (SSA) (UNICEF 2019). Vitamin A plays a crucial role in human health, as it is required in cellular pathways involving vision, immune function and ocular health (Mahan & Raymond 2017, p1063). Vitamin A deficiency can lead to several health-related problems such as xerophthalmia, keratomalacia, poor immune function and increased susceptibility to infection, muscle weakness, irreversible damage to the cornea, night blindness, vomiting, anorexia, pneumonia and pigmentary retinopathy (Mahan & Raymond 2017, p1063; Temple & Steyn 2016, p161; Chapman 2012). The South African government has put various strategies in place to assist in the alleviation of VAD namely; food fortification, vitamin A supplementation and dietary diversification. Despite the interventions employed in SA to combat VAD, there has been a slow improvement in the vitamin A status of South Africans (DoH 2018; DoH 2013; Swart, Sanders & McLachlan 2008, pp139, 140; DoH & UNICEF 2007). As alluded to earlier, all forms of malnutrition are of public health concern. A number of national studies have documented that both under- and over-nutrition co-exist in SA. However, these national studies do not reflect the nutritional status of individuals in all areas within each of the provinces. In KwaZulu-Natal (KZN), the national studies were conducted in specific districts and sub-districts within KZN, and therefore do not necessarily reflect the nutritional status of the KZN population as a whole. Furthermore, there is a paucity of data on the nutritional status of specific rural communities in SA and thus, it would be beneficial to investigate the nutritional status of people living in the districts and sub-districts of KZN, which have not been previously investigated as it would provide a baseline nutritional status for possible nutrition interventions.

Despite interventions employed in SA to combat malnutrition, it remains a problem. This emphasises the importance of investigating complementary strategies to address malnutrition. Biofortification of staple crops could succeed as a new and alternative way of addressing the challenge of micronutrient malnutrition, including VAD (Singh, Praharaj, Singh & Singh 2016, pp3, 4). Biofortification involves breeding staple crops for increased micronutrient content using the best traditional breeding practices (Singh *et al* 2016, p3). Although the fortification of maize meal and wheat flour was legislated in SA in October 2003, the accessibility and affordability of these commercially fortified foods to economically disadvantaged communities remain questionable, as malnutrition is still prevalent in these communities (DoH & UNICEF 2007).

Over a millennium ago, indigenous and traditional crops were the main source of foods for rural South African communities. However, with urbanisation, there has been a shift from consuming indigenous and traditional foods to consuming more western foods, with less consumption of indigenous and traditional foods (Van der Hoeven, Osei, Greeff, Kruger, Faber & Smuts 2013). Reduced consumption of these foods in rural areas could contribute to micronutrient deficiencies (Van Rensburg, Van Averbeke, Slabbert, Faber, Van Jaarsveld, Van Heerden, Wenhold & Oelofse 2007; Modi, Modi & Hendriks 2006). There are various indigenous and traditional crops grown in KZN (Modi *et al* 2006). These crops are prepared using different cooking methods and vary in their nutritional composition depending on how they are prepared (Fabbri & Crosby 2016). Indigenous and traditional foods are usually consumed together with white maize-based foods such as *phutu* (a crumbly porridge made from maize meal) or *pap* (a stiff porridge made from maize meal) (Lewu & Mavengahama 2011). White maize is usually consumed in combination with other foods such as potatoes, dark green leafy vegetables (*imifino*) and cabbage (Modi *et al* 2006).

Although it is well accepted that rural communities in SA are heavily dependent on agriculture for their livelihoods, agricultural production and food utilisation levels of the different crops are not well documented, compared to commercial agricultural production. Thus, food production and utilisation patterns of maize and sweet potato by rural communities of KZN are not well documented. Indigenous knowledge system (IKS)[1]-based methods are usually specific to a rural area. As a result, information on how plant foods from a particular area are processed and prepared can be used to improve traditional recipes that are currently nutritionally inadequate (Lewu & Mavengahama 2011).

White maize (*Zea mays*) is a popular traditional staple in many developing countries, such as SA (Tumuhimbise, Namutebi, Turyashemererwa & Muyonga 2013; Nuss & Tanumihardjo 2010; Johnson 2000, p31). White maize is usually milled into maize meal and consumed in rural areas of KZN (Faber, Van Jaarsveld, Kunneke, Kruger, Schoeman & Van Stuijvenberg 2015; Faber, Laubscher & Laurie 2013; Steyn, Nel & Casey 2003; Labadarios, Steyn, Maunder, Macintyre, Swart, Gericke, Huskisson, Dannhauser, Vorster & Nesamvuni 2000). Unlike white maize, yellow maize[2] is not commonly used as food. It is regarded as a food item for poor individuals and used as animal feed (Nuss, Arscott, Bresnahan, Pixley, Rocheford, Hotz, Siamusantu, Chileshe & Tanumihardjo 2012; Khumalo, Schönfeldt & Vermeulen 2012). Another popular staple crop consumed by developing countries is cream-fleshed sweet potato (CFSP) (*Ipomoea batata* L.). Although CFSP is commonly consumed in SA, it is not a staple crop in SA. Major production of this crop has been documented in KZN [Mitra 2012; Department of Agriculture Forestry and Fisheries (DAFF) 2011, p1]. Cream-fleshed sweet potato is commonly consumed, but replacing it with orange-fleshed sweet potato (OFSP) could improve the nutritional status of economically

[1] Indigenous knowledge system (IKS): This type of knowledge system is not based on scientific knowledge but developed by a community and passed down from previous generations (Ajibade 2003).
[2] For the purpose of this thesis, provitamin A-biofortified maize may also be referred to as yellow maize, orange maize or biofortified maize.

disadvantaged people, whose diets are generally deficient in micronutrients, particularly vitamin A. However, it is important to note that OFSP is a new crop and many individuals may be unaccustomed to it, thus, there is a need to investigate the nutritional composition and consumer acceptability of this crop in KZN.

Provitamin A (PVA)-biofortified maize and OFSP have been shown to have higher concentrations of PVA, compared to white maize and CFSP [International Potato Centre (CIP) (2019); Sheftel, Gannon, Davis & Tanumihardjo 2017]. Replacing white maize and CFSP with PVA-biofortified maize and OFSP, respectively, could significantly improve the vitamin A intake of economically disadvantaged rural communities. Unfortunately, several studies have indicated that PVA-biofortified maize is poorly accepted due to the unfamiliar yellow/orange colour, aroma and flavour that are mainly due to the carotenoid pigments in the biofortified maize (Talsma, Melse-Boonstra & Brouwer 2017; Nuss *et al* 2012; De Groote, Kimenju & Morawetz 2011; De Groote, Tomlins, Haleegoah, Awool, Frimpong, Banerji, Chowdury & Meenakshi 2010; De Groote & Kimenju 2008). A study conducted in KZN, SA, on the consumer acceptability of PVA-biofortified maize on its own found poor acceptance of the biofortified maize among adults and older school children (Pillay, Derera, Siwela & Veldman 2011). To date, most studies have investigated the nutritional composition and consumer acceptability of PVA-biofortified maize cooked in different forms and served on its own but have not investigated combining PVA-biofortified maize with other commonly consumed food items. Combining PVA-biofortified maize and OFSP with other common plant-based food items and animal foods, such as chicken to make composite dishes, may increase its consumer acceptance (Amod, Pillay, Siwela & Kolanisi 2016). The presence of other cooked plant food items and animal food sources in the composite foods may reduce the intensities of the atypical sensory attributes of PVA-biofortified maize, thereby increasing its acceptability. For example, the colour and aroma of the PVA-biofortified maize may be attenuated to acceptable intensities by including vegetables that have an acceptable colour (e.g. green) and aroma. These vegetables could also improve the palatability of PVA-biofortified maize.

Several studies on OFSP have indicated that although OFSP has an intense orange colour in comparison to the other sweet potato varieties, it was better accepted (Omodamiro, Afuape, Njoku, Nwankwo, Echendu & Edward 2013; Tomlins, Ndunguru, Stambul, Joshua, Ngendello, Rwiza, Amour, Ramadhani, Kapande & Westby 2007; Ssebuliba, Muyonga & Ekere 2006; Van Jaarsveld, Faber, Tanumihardjo, Nestel, Lombard & Benadé 2005). Combining PVA-biofortified maize and OFSP with other ingredients, may improve the nutritional composition of the composite dish when compared with the same composite dish made with white maize or CFSP. This is because of reported differences in the nutritional composition of white maize and PVA-biofortified maize (Pillay, Siwela, Derera & Veldman 2013) and CFSP and OFSP (Sanoussi, Adjatin, Dansi, Adebowale, Sanni & Sanni 2016).

Maize is high in starch but limited in protein content (Ai & Jane 2016). Animal food products are a good source of protein but are unaffordable to vulnerable households [National Agricultural Marketing Council (NAMC) 2019]. Especially since there was a 3% increase in the cost of a basic food basket in SA from 2018. This 3% increase also affected the price of plant-based proteins however plant-based proteins are still cheaper than animal-based proteins (NAMC 2019). Legumes are a good alternative to animal-based proteins as they not only contain protein but also carbohydrates, vitamins and minerals (Maphosa & Jideani 2017, p104). Legumes can be consumed together with maize to achieve a complementary protein effect (Insel, Ross, McMahon & Bernstein 2017, p238). This results in a diet that has high-quality protein (Insel *et al* 2017, p238). Bambara groundnut (*Vigna subterranean*) is one of the neglected and underutilised indigenous crops found in SSA (Chivenge, Mabhaudhi, Modi & Mafongoya 2015). This legume contains between 16-25% protein, indicating that it is a good complementary protein for other starch-based foods such as maize (Lichtfouse 2016, p376; Mwale, Azam-Ali & Massawe 2007; Linnemann & Azam-Ali 1993, pp13-58). Furthermore, bambara groundnut contains the essential amino acid methionine, which is not found in other legumes, making this crop more nutritionally complete (Stone, Massey, Theobald, Styslinger, Kane, Kandy, Tung, Adekoya, Madan & Davert 2011, p3). Legumes, such as bambara groundnut are grossly underutilised despite their high agronomic and nutritional potential. Combining bambara groundnut with PVA-biofortified maize could contribute to improving the nutritional status of economically disadvantaged individuals whose diets lack variety and are nutritionally incomplete. Unfortunately, even though bambara groundnut is nutrient-dense, it is generally underutilised as a food due to its hard-to-cook, hard-to-mill and anti-nutritional properties (Ndidi, Ndidi, Aimola, Bassa, Mankilik & Adamu 2014; Boye, Zare & Pletch 2010; Uvere, Uwaegbute & Adedeji 1999). Individuals in SA are not accustomed to bambara groundnut (Oyeyinka, Pillay & Siwela 2017), more specifically rural communities of KZN. Cooked PVA-biofortified maize combined with bambara groundnut has the potential to improve the nutritional status of economically disadvantaged individuals living in rural areas of KZN. However, the nutritional composition and consumer acceptability of this combination has not been investigated, thus there was a need to investigate this.

It was imperative to determine the nutritional status of selected rural populations in KZN to have a baseline for nutritional interventions and to determine IKS-based methods commonly used to process and prepare white maize and CFSP and replace it with PVA-biofortified maize and OFSP. The use of PVA-biofortified maize and OFSP together with existing strategies employed by the DoH-SA, may have the potential to improve the vitamin A status of vulnerable population groups in KZN. Thus, the potential of PVA-biofortified maize and sweet potato, and bambara groundnut for improving the nutritional status of rural communities in KZN, SA, was investigated.

1.2 Problem statement

Provitamin A-biofortified maize, OFSP and bambara groundnut have the potential to serve as nutritional interventions to address VAD, but are currently not well utilised. Therefore, research is needed to generate knowledge that would promote the utilisation of these plant-based foods, including the nutritional composition and consumer acceptability.

1.3 Aim of the study

The aim of this study was to assess the potential of bambara groundnut and PVA-biofortified maize and sweet potato for improving the nutritional status of rural communities in KZN, SA.

1.4 Study objectives

The objectives of this study were:

1.4.1 To assess the nutritional status[3] using selected anthropometric indices and dietary intake methods of four rural communities in KZN, SA. Because this study involved a food-based approach to address nutrition problems, baseline nutritional data of the targeted community was required.

[3] The vitamin A status of the population was not determined due to financial constraints.

1.4.2 To determine the effect of replacing white maize and CFSP with PVA-biofortified maize and OFSP, respectively, on the nutritional composition of traditional and indigenous dishes of KZN, SA.

1.4.3 To determine the effect of replacing white maize and CFSP with PVA-biofortified maize and OFSP, respectively, on the sensory properties and consumer acceptance of traditional and indigenous dishes of KZN, SA. Although PVA-biofortified maize composite dishes and OFSP are being proposed for addressing VAD, it is not known if they would be acceptable to the target community, therefore, there was a need to investigate this.

1.5 Hypotheses

The following hypotheses were tested in the study:

1.5.1 There would be high rates of malnutrition among both children and adults in the rural communities of KZN selected for the study. A food-based approach could significantly contribute to the alleviation of malnutrition, but the potential of the foods proposed needed to be assessed, including their nutritional composition and consumer acceptance.

1.5.2 Composite dishes made with PVA-biofortified maize and OFSP would have a superior nutritional composition compared to the same composite foods made from white maize and CFSP.

1.5.3 The consumer acceptance of composite foods made with PVA-biofortified maize and OFSP would be low due to the unacceptable and unfamiliar sensory properties exhibited by PVA-biofortified foods.

1.6 Study parameters

The parameters for the study were as follows:

1.6.1 Phase 1 of the study was restricted to rural African communities residing in Swayimane, Tugela Ferry, Umbumbulu and Fountain Hill Estate (FHE), KZN, SA.

1.6.2 Phase 2 of the study was restricted to rural African communities residing in Swayimane, and Umbumbulu, KZN, SA.

1.6.3 For the dietary assessment, only children who were not at a day-care, crèche or did not attend a school feeding program the day before data collection were included in the study. This was done so that accurate dietary information could be collected. Mothers or caregivers are usually unaware of the quantities and types of foods that are consumed by their children at day-care, crèche or a school feeding program.

1.6.4 The study was limited to one variety of yellow/orange maize, CFSP, OFSP and bambara groundnut.

1.6.5 The determination of usual portion sizes by caregivers[4] was limited to those who had children between the ages of 1-5 years in their care at the time of the study.

Study parameters relevant to specific sub problems are discussed in the relevant sections of the thesis.

1.7 General assumptions

It was assumed that:

1.7.1 All trained research assistants followed the correct procedures when taking anthropometric measurements and when collecting dietary intake data.

1.7.2 All participants answered questions honestly and without bias.

Assumptions relevant to specific sub problems are discussed in the relevant sections of the thesis.

1.8 Definition of terms

Adequate intake (AI): "The recommended average daily intake level based on observed or experimentally determined approximations or estimates of nutrient intake by a group (or groups) of apparently healthy people that assumed to be adequate; used when the RDA cannot be determined" (Institute of Medicine 2006, p8).

Bambara groundnut: Bambara groundnut (*Vigna subterranean*) is a grain legume. It is an indigenous crop in Africa and is well adapted to and thrives in the agronomical marginal regions (Chibarabada, Modi & Mabhaudhi 2017).

[4] For the purpose of this study, a caregiver is any person that looks after a child under the age of 18 years.

Biofortification: Biofortification is a complementary strategy that involves the breeding of staple crops that are micronutrient-rich by conventional plant breeding or genetic modification (Singh *et al* 2016, p3; Saltzman, Birol, Bouis, Boy, De Moura, Islam & Pfeiffer 2013; Stevens & Winter-Nelson 2008).

Composite dish: For this study, a composite dish was any dish that contained either PVA-biofortified *phutu* or white *phutu*, served with either curried cabbage, chicken or bambara groundnut.

Curried: It is the method whereby meat or vegetable is cooked using a blend of spices and prepared in a sauce (Varman 2017).

Estimated average requirement (EAR): The EAR value is an estimated daily value for a specific nutrient that meets the requirements of 50% of a specific age group and gender (Institute of Medicine 2006, p8).

Food and nutrition insecurity: Is the inability to access adequate quantities of nutritious foods required for optimal growth and development (Napoli, De Muro & Mazziotta 2011).

Food fortification: Food fortification is a cost-effective process that involves the addition of micronutrients to foods that are commonly consumed by vulnerable populations (Pretorius & Schönfeldt 2012; Gillespie & Mason 1994).

Food frequency: A questionnaire that is used to assess the frequency with which foods are consumed (Rodrigo, Aranceta, Salvador & Varela-Moreiras 2015).

Indigenous: Originating or innate to a specific area (Ajibade 2003).

Indigenous knowledge systems (IKS): A knowledge system developed based on community practices and passed down from generation to generation (Ajibade 2003).

Malnutrition: Malnutrition is a result of a deficiency, excess or imbalance of one or more macro- or micro-nutrients (UNICEF 2016). Malnutrition presents as either undernutrition (underweight, wasting, stunting and micronutrient deficiencies) or over-nutrition (overweight, obesity and chronic diseases of lifestyle) [Food and Agriculture Organization of the United Nations (FAO)], International Fund for Agricultural Development (IFAD), UNICEF, World Food Programme (WFP) & World Health Organization (WHO) 2017].

Orange-fleshed sweet potato (OFSP): Sweet potato that is rich in β-carotene (Tanumihardjo, Ball, Kaliwile & Pixley 2017).

Pap: A stiff porridge made from maize meal (Lewu & Mavengahama 2011).

***Phutu*:** A crumbly porridge made from maize meal (Lewu & Mavengahama 2011).

Provitamin A (PVA)-biofortified maize: Maize that is provitamin A- biofortified by conventional breeding and contains higher levels of provitamin A carotenoids (HarvestPlus 2018; WHO 2018).

Provitamin A carotenoids: These include carotenoids, β-cryptoxanthin, β-cryptoxanthin, β-carotene and α-carotene and are converted by the human body to vitamin A as required (Toti, Chen, Palmery, Valencia & Peluso 2018; Mezzomo & Ferreira 2016).

Sweet potato: A tuber and staple crop in Africa, also known as cream-fleshed sweet potato or *ipomoea batatas* (Sanginga 2015).

Traditional: Beliefs and customs that have been passed down from previous generations (Ajibade 2003).

1.9 Outline of the thesis

The structure of the thesis is as follows:

Chapter 1: Introduction, the problem, and its setting.

Chapter 2: Literature review.

Chapter 3: Study design, background to the study site and ethical approvals.

Chapter 4: Assessment of the nutritional status of four selected rural communities in KwaZulu-Natal, South Africa.

Chapter 5: Effect of replacing non-biofortified white maize and sweet potato with provitamin A-biofortified maize and orange-fleshed sweet potato on the nutritional composition of popular traditional foods of KwaZulu-Natal province, South Africa.

Chapter 6: Consumer perceptions and acceptability of traditional composite dishes made with provitamin A-biofortified maize and orange-fleshed sweet potato in KwaZulu-Natal, South Africa.

Chapter 7: Overall discussion

Chapter 8: Overall conclusions and recommendations

1.10 Referencing style

The referencing style used in this thesis is according to the guidelines used at Dietetics and Human Nutrition, University of KwaZulu-Natal (UKZN), Pietermaritzburg.

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CHAPTER 2

LITERATURE REVIEW[5]

2.1 Introduction

Worldwide, many forms of malnutrition co-exist. Malnutrition presents as either undernutrition (underweight, wasting, stunting and micronutrient deficiencies) or over-nutrition (overweight, obesity and chronic diseases of lifestyle) [Food and Agriculture Organization of the United Nations (FAO)], International Fund for Agricultural Development (IFAD), United Nations Children's Fund (UNICEF), World Food Programme (WFP) & World Health Organization (WHO) 2017]. Globally in 2016, 815 million people had chronic undernutrition. Stunting affected 155 million children under five years and wasting affected 52 million children between the ages of one and 12 years. Over-nutrition is as much of a problem as undernutrition. The 2016 statistics indicated that 41 million children under the age of five years were overweight (FAO *et al* 2017). Both under- and over-nutrition are not only on the rise globally, but is also a major concern in sub-Saharan African countries, including South Africa (SA) (Faber & Wenhold 2007).

In SA, all forms of malnutrition could be attributed to, in part, the shift from traditional diets, which were high in carbohydrates and fibre, to western diets which are high in fat. The shift in dietary habits seems to be contributing significantly to the increased risk of chronic diseases of lifestyle such as obesity, hypertension, coronary heart disease and hyperlipidaemia (Van Zyl, Van der Merwe, Walsh, Groenewald & Van Rooyen 2012; Lutter, Daelmans, De Onis, Kothari, Ruel, Arimond, Deitchler, Dewey, Blössner & Borghi 2011; Schönfeldt, Gibson & Vermeulen 2010; Faber & Wenhold 2007; Bourne, Lambert & Steyn 2002). The dietary shift has had varying impacts on the nutritional and health status of different demographic groups in SA. A high prevalence of over-nutrition has been reported among South African women, whereas children and infants are mostly affected by undernutrition (Shisana, Labadarios, Rehle, Simbayi, Zuma, Dhansay, Reddy, Parker, Hoosain, Naidoo, Hongoro, Mchiza, Steyn, Dwane, Makoae, Maluleke, Ramlagan, Zungu, Evans, Jacobs, Faber & Sanhanes-1 Team 2013). Similar to other countries in sub-Saharan Africa (SSA), there are several underlying causes of malnutrition in SA, including poverty, food

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insecurity, inadequate infrastructure and access to health care facilities, lack of education and inadequate food intake (Bain, Awah, Geraldine, Kindong, Sigal, Bernard & Tanjeko 2013; Kimani-Murage, Kahn, Pettifor, Tollman, Dunger, Gómez-Olivé & Norris 2010; Chopra, Daviaud, Pattinson, Fonn & Lawn 2009; Manary & Sandige 2008; Smuts, Faber, Schoeman, Laubscher, Oelofse, Benadé & Dhansay 2008). These causes are largely inter-linked (UNICEF 1998), with poverty being the leading cause, including in SA (Bain *et al* 2013).

Poverty can be defined as the lack of or limited access to necessities, such as safe clean water, health care, shelter, sanitation, nutritious food and basic education due to economic constraints (WHO 2016; Woolard 2012). The 2015 statistics indicated that one in every two South Africans is poor, which equates to approximately 30.4 million South Africans [Statistics South Africa (Stats SA) 2017]. In SA, Africans are particularly affected by poverty. The highest unemployment rates were found among the African population in 2016 (30.2%) and 2017 (31.0%) (Stats SA 2019a). The KwaZulu-Natal (KZN) province has the largest proportion of poor households in SA and has been one of the poorest provinces in SA since 2011 (Stats SA 2017; Argent *et al* 2009). Poor households are at a high risk of malnutrition, as they cannot afford a diverse diet (Mabhaudhi, Chibarabada & Modi 2016a; Wenhold, Annandale, Faber & Hart 2012). Within KZN, 37.2% of poor households receive a child support grant (Stats SA 2017), which is currently R445/month per child [Republic of South Africa (RSA) 2020]. In some instances, households depend solely on grants for purchasing food in SA. A basic food basket costs approximately R883.16/month in SA, which may be unaffordable to many economically disadvantaged people [National Agricultural Marketing Council (NAMC) 2019]. Several strategies have been proposed to address dietary diversity in economically disadvantaged rural households. These include biofortification and the promotion of underutilised crops that are nutrient-dense (Mabhaudhi *et al* 2016a).

Food and nutrition insecurity can be defined as the inability to access adequate quantities of nutritious foods required for optimal growth and development (Napoli, De Muro & Mazziotta 2011). There is a direct relationship between food and nutrition insecurity and poverty (Kimani-Murage *et al* 2010). In SA, at the national level, food insecurity affects one in five households (Labadarios, Moodie & Van Rensburg 2007). Most rural communities consume diets that have very limited variety and are typically inadequate in fruits and vegetables (WHO 2013).

Micronutrient deficiencies are common in developing countries such as SA. These micronutrient deficiencies include iron, iodine, zinc and vitamin A (Bailey, West Jr & Black 2015).

Various national studies have been conducted to assess the nutritional status of South Africans. The South African Vitamin A Consultative Group (SAVACG) conducted a survey in 1994 on children aged 0-71 months (Labadarios & Van Middelkoop 1995), while the National Food Consumption Survey (NFCS 1999) surveyed children aged 1-9 years of age (Labadarios, Steyn, Maunder, Macintyre, Swart, Gericke, Huskisson, Dannhauser, Vorster & Nesamvuni 2000). The 2005 National Food Consumption Survey-Fortification Baseline (NFCS-FB) was conducted on children aged 1-9 years and women of childbearing age (Labadarios *et al* 2007). The most recent national study, the South African National Health and Nutrition Examination Survey (SANHANES-1) was conducted in 2012 (Shisana *et al* 2013). These studies have given an overall view of the nutritional status of the South African population and have drawn conclusions on the nutritional status of South Africans living in different provinces. The sampling method used when conducting the national studies was disproportionate stratification by province. This means that only a certain fraction of the province was sampled. Therefore, the data obtained from these studies are arguably not a true reflection of the nutritional status of different population groups found in specific localities within the province, including district and sub-district levels (Shisana *et al* 2013; Labadarios & Van Middelkoop 1995).

This literature review aims to establish what is currently known (i.e. before this study) regarding the nutritional status of people living in KZN, especially those living in economically disadvantaged rural areas, by evaluating available data and information on the nutritional status of population groups residing in KZN. This study focussed on poor rural communities because most of the national studies indicated that economically disadvantaged rural populations are the worst affected and are most vulnerable to both under- and over-nutrition (Shisana *et al* 2013; Labadarios *et al* 2007; Labadarios *et al* 2000).

2.2 Nutritional status of South African children and adults with a focus on KwaZulu-Natal

2.2.1 Undernutrition

Undernutrition is a serious nutritional problem as it leads to poor quality of life due to the loss of body cell mass. It is associated with various health issues such as anaemia, hepatic mass losses, infection, emphysema, gastrointestinal tract (GIT) atrophy and intestinal bacterial overgrowth (Escott-Stump 2015, p618). Undernutrition, more specifically stunting, is common in South African children, affecting approximately 27% of children under the age of five years [National Department of Health (nDoH), Stats SA, South African Medical Research Council (SAMRC) & ICF 2017]. There are a number of measurements used to classify undernutrition in children using the WHO classification. These include a weight-for-age (WFA), height-for-age (HFA) and weight-for-height (WFH). This classification indicates if a child is underweight, stunted or wasted. The WFH can further classify a child as having severe acute malnutrition (SAM), moderate acute malnutrition (MAM), not acutely malnourished (NAM) or being overweight (WHO 2017). For persons under 18 years of age, the mid-upper arm circumference (MUAC) is another common anthropometric measurement used in addition to weight and height, to identify malnutrition. Tables 2.1, 2.2 and 2.3 provide a detailed classification of malnutrition using anthropometric indicators (WHO 2014). These indicators were formulated using the WHO guidelines (WHO 2017; WHO 2014).

Table 2.1: Weight-for-age and weight-for-height classification for children 1-5 years of age (WHO 2017)

WFA	WFH[6]	Z score
Severely underweight	Severely wasted	Below -3 SD[7]
Moderately underweight	Moderately wasted	Between -2 and -3 SD
Normal weight	Not wasted	Above -2 and below +2 SD
Overweight	Overweight	Above +2 SD

[6] The WFH can be used to classify severe acute malnutrition (SAM), moderate acute malnutrition (MAM), not acutely malnourished (NAM) and over-nutrition (WHO & UNICEF 2009).
[7] SD=Standard deviation.

Table 2.2: Height-for-age classification for children 1-5 years of age (WHO 2008)

HFA	Z score
Severely stunted	Below -3 SD
Moderately stunted	Between -2 and -3 SD
Normal height	Above -2 SD and below +3SD
Tall	Above + 3SD

Table 2.3: Mid-upper arm circumference classification in children 1-5 years of age (WHO 2014)

MUAC	Classification
Below 11.5 cm	SAM
11.5 – 12.5 cm	MAM
Above 12.5 cm	NAM

2.2.1.1 Stunting

Although the global rates of stunting decreased by 6.6% from 2015 to 2016, 155 million children under five years are still affected by stunting (FAO *et al* 2017). According to the 2005 NFCS-FB study, one in five children in SA were stunted, with those living in rural areas most affected by stunting (Labadarios, Swart, Maunder, Kruger, Gericke, Kuzwayo, Ntsie, Steyn, Schloss, Dhansay, Jooste, Dannhauser, Nel, Molefe & Kotze 2008). Moreover, the prevalence of stunting was high in KZN, with 24% and 26% in the UMkhanyakude and Zululand districts, respectively (Schoeman, Faber, Adams, Smuts, Ford-Ngomane, Laubscher & Dhansay 2010). These results are similar to the results reported in a more recent study, the 2012 SANHANES-1 study (Shisana *et al* 2013). Between 2005 and 2012, stunting in South African children aged 1-3 years worsened as the rates increased from 23.4 to 26.5% (Shisana *et al* 2013; Labadarios *et al* 2007). According to the 2016 South African Demographic and Health Survey (SADHS), stunting affected 27% of children under the age of five years, indicating an increase in stunting in comparison to other studies (nDoH *et al* 2017). There are many implications of stunting, especially in children under five years of age [Health Systems Trust (HST) 2016; UNICEF 2016; Escott-Stump 2015, pp28, 645].

Stunting is a chronic form of malnutrition (UNICEF 2016) and is diagnosed when HFA is below minus two standard deviations (SD) of the WHO child growth standards median. (UNICEF 2012). Stunting is caused either by inadequate food intake or by the consumption of foods that lack adequate nutrients for an extended period of time (WHO 2019). It is a serious health problem as it can lead to reduced mental development, poor performance in school, poor social-emotional development and increased risk for chronic diseases of lifestyle, later on in life (HST 2016; UNICEF 2016; Escott-Stump 2015, pp28, 645). It is important to determine the WFA in children under five years of age, as they are most vulnerable to all forms of malnutrition, including stunting (HST 2016; UNICEF 2016; Escott-Stump 2015, pp28, 645). From the point of in-utero fetal development up to two years of age, children are at risk of poor development due to inadequate nutrition. After two years, some of these effects become irreversible (HST 2016). These children perform poorly in school, suffer from food and nutrition insecurity and lack financial stability later on in life (HST 2016; Escott-Stump 2015, pp28, 645). This contributes to an economic loss as these children grow up to become unemployed adults reliant on social grants, thus perpetuating a vicious cycle of poverty and food insecurity (HST 2016; Escott-Stump 2015, pp28, 645).

2.2.1.2 Underweight

Underweight is diagnosed when WFA is less than the minus two SD of the WHO child growth standards median. It is a serious nutritional problem that may be caused by either weight loss or poor nutritional intake (WHO 2017). Globally, 16% of children under five years are underweight. This figure is higher in SSA, with 21% of children under five years underweight (UNICEF 2012). Although these percentages are high, the prevalence of underweight and wasting has reduced in SA. National studies conducted for the period 2005-2012 indicated that the prevalence of underweight and wasting in children aged 1-3 years in SA declined from 11% to 6.1% and 5.1% to 2.2%, respectively (Shisana *et al* 2013; Labadarios *et al* 2007). In KZN, the highest prevalence (6%) of underweight in children between the ages of 12-23 months was found in the UMkhanyakude district (Schoeman *et al* 2010).

As alluded to earlier, poor dietary intake may contribute to malnutrition. The improvement in undernutrition in KZN could be attributed to the Integrated Management of Acute Malnutrition (IMAM) programme that was implemented by the national Department of Health in 2014 (DoH 2014) and the new 2018 standard operating procedures on the prevention and management of malnutrition in KZN (DoH 2018). Although the prevalence of underweight and wasting in children has improved, it remains important to determine the nutritional status of vulnerable children and adults in rural KZN. This is especially because many of those living in economically disadvantaged rural areas with malnutrition may remain undiagnosed, as they live far away from health care facilities (Strasser 2003).

2.2.1.3 Wasting

Wasting is diagnosed when WFL/WFH is less than minus two SD of the WHO child growth standards median. Wasting is a serious nutritional problem that may be caused by either weight loss or poor nutritional intake (WHO 2017). It can present as protein-energy malnutrition (PEM), which is the most common form of malnutrition observed in developing countries. It is caused by a lack of one or more macronutrients that are required by body tissue to sustain the optimal functioning of the human body (Manary & Sandige 2008). This form of malnutrition is caused by a protein and glycaemic carbohydrate deficiency (Mahan & Raymond 2017, p374). Malnutrition can manifest in different ways depending on the symptoms presented, with PEM often manifesting itself as SAM with or without oedema or MAM. Severe acute malnutrition is characterised by the presence of severe wasting or pitting oedema and MAM presents clinically as moderate wasting with no oedema (DoH 2018). Malnutrition can be classified using anthropometric measurements (Tables 2.1. 2.2 and 2.3).

When an individual is malnourished, the body goes into a state of starvation (Mahan & Raymond 2017, p374). Glucose is the main energy source for the body, obtained from the consumption of carbohydrate-containing foods. Although free fatty acids are utilised to provide energy when glucose is unavailable in the body, certain organs, such as the kidneys, brain, eyes and red blood cells, are unable to use free fatty acids as a source of fuel and require glucose as an energy source. When the body is in a state of starvation, the brain still requires a constant supply of energy. The liver produces ketone bodies, which are partly used as an energy source by the brain during starvation (Mahan, Escott-Stump & Raymond 2012, pp55-56). Starvation affects the GIT, cardiac muscle, liver, kidneys and the immune system (Manary & Sandige 2008). During starvation, appropriate nutrition is required to correct electrolyte imbalance, prevent further organ damage and provide the correct amounts of macronutrients for sustainability. The human body is significantly affected during episodes of starvation (Mahan *et al* 2012, pp55-56).

2.2.1.4 Micronutrient deficiencies, particularly vitamin A deficiency

Although micronutrient deficiencies are also a problem in developing countries, they are not routinely treated. Globally, about two billion people have micronutrient deficiency due to the consumption of poor-quality foods that lack diversity. The most common micronutrient deficiencies observed in developing countries are vitamin A, iron, iodine and zinc (Bailey *et al*

2015). Micronutrient deficiencies result in several health conditions, including growth retardation and delayed development (Bain *et al* 2013). The 1999 NFCS showed that South African children had a low intake of the following micronutrients: vitamin A, calcium, iron, zinc, folate, vitamin B_6, niacin, riboflavin, vitamin C and vitamin E. The study further indicated that, in SA, the highest prevalence of micronutrient deficiencies was noted in rural communities (Labadarios *et al* 2000). Similarly, the 2005 NFCS-FB study also found that many micronutrients were consumed at less than 67% of the recommended dietary allowances (RDA). These included calcium, iron, zinc, selenium, vitamin D, vitamin C, vitamin E, riboflavin, niacin, folic acid and vitamin D (Labadarios *et al* 2008). On a national level, poor iron status was noted in one in five and one in 10 women and children, respectively. Iron deficiency anaemia affected 5.9% of children aged 1-9 years in KZN (Labadarios *et al* 2008). The prevalence of iron deficiency in South African children reduced from 5% in 1994 to 1.9% in 2012 (Shisana *et al* 2013; Labadarios *et al* 2000; Labadarios & Van Middelkoop 1995). Nationally, 43.3% of children in SA have a poor zinc status (Labadarios *et al* 2008).

Vitamin A deficiency is a common micronutrient deficiency observed globally and throughout SSA (Shisana *et al* 2013; Bain *et al* 2013; Labadarios *et al* 2008; Smuts, Dhansay, Faber, Van Stuijvenberg, Swanevelder, Gross & Benadé 2005; Labadarios *et al* 2000; Labadarios & Van Middelkoop 1995). A few national studies have documented VAD in SA. In 1994, the SAVACG study (Labadarios & Van Middelkoop 1995) reported that 33.3% of South African children had VAD, while the 2005 NFCS-FB study (Labadarios *et al* 2008) reported that 63.6% had VAD. This showed that the VAD situation had worsened between 1994 and 2005. Furthermore, the 2005 NFCS-FB study reported that two in three women had VAD. In KZN alone, six out of ten women had VAD, which was the highest prevalence in SA. Forty-four percent of children between the ages of 1-9 years living in KZN had VAD. Overall, KZN had the second highest prevalence of VAD (Labadarios *et al* 2008; Labadarios *et al* 2000; Labadarios & Van Middelkoop 1995). A more recent study, the 2012 SANHANES-1 study, reported an improvement in the VAD situation in SA (Shisana *et al* 2013). Although still significantly high, the SANHANES-1 study reported a decline in the number of children with VAD (43.6%). The SANHANES-1 study also reported that there was an improvement in the vitamin A status of females residing in KZN. Those with the lowest education levels were the most affected by VAD (Shisana *et al* 2013).

Although the prevalence of VAD in SA has decreased, it still remains a challenge, especially in KZN (Shisana *et al* 2013; Labadarios *et al* 2008). It is vital to find ways to reduce VAD as vitamin A is an important micronutrient required by the human body. Vitamin A deficiency affects protein synthesis, vision, growth and development and could result in a child not being able to reach their full potential, both physically and mentally (Mahan & Raymond 2017, p1063). The main reasons for VAD, especially in SA, are poor economic status and limited access to nutritious foods. A possible solution to this problem could be diversifying household food baskets with biofortified crops and underutilised indigenous crops. However, the acceptability of such crops by economically disadvantaged rural communities remains a challenge. It is therefore important to identify the foods consumed by people at risk of VAD in KZN, and analyse the nutritional composition of the foods.

A recent longitudinal study conducted on children aged 4-6 years and 6-8 years in rural KZN, found that out of the 103 children in the study, 37.9% of the children were mildly anaemic, 60.2% were moderately anaemic and 1.9% were severely anaemic (Gwetu, Chhagan, Craib, Taylor & Kauchali 2015). These study results were in contrast to the results obtained from the 2012 SANHANES-1 study. A possible reason for the difference in results could be due to the classification used to analyse data. The study conducted by Gwetu *et al* (2015), classified anaemia using two target groups, i.e. 0-59 months (mild: 10-10.9 g/dl; moderate: 7-9.9 g/dl; and severe: <7 g/dl) and 5-11 years (mild: 11-11.4 g/dl; moderate: 8-10.9 g/dl; and severe: <8 g/dl) (Gwetu *et al* 2015). On the other hand, the 2012 SANHANES-1 study classified anaemia in children under five years as follows: mild (10-10.9 g/dl); moderate (7-9.9 g/dl) and severe (<7 g/dl) (Shisana *et al* 2013). The results from Gwetu *et al* (2015) are similar to previous national studies (Labadarios *et al* 2008; Labadarios & Van Middelkoop 1994), and local studies (Faber, Jogessar & Benadé 2001; Oelofse, Faber, Benadé & Kenoyer 1999). These studies all indicated that the prevalence of anaemia ranged from 16.5 to 33% between 1994 and 2005 (Labadarios *et al* 2008; Faber *et al* 2001; Oelofse *et al* 1999; Labadarios & Van Middelkoop 1995). As previously highlighted, the 2012 SANHANES-1 study used disproportionate stratification that did not cover every area of a specific province (Shisana *et al* 2013). This may explain, in part, the differences noted.

A separate study conducted on the urban population of Durban, KZN also found high rates of anaemia. The cross-sectional prospective study conducted in a regional hospital found that out of

2000 pregnant patients enrolled in the study, 854 patients (42.7%) were anaemic. From the pregnant women that were anaemic, 81.4% were mildly anaemic, 18% were moderately anaemic and 0.6% were severely anaemic (Tunkyi & Moodley 2016). Anaemia in pregnancy is a significant problem as it affects the health of both the mother and fetus. Iron is required during pregnancy to assist with fetal growth and improves the Apgar[8] score, which indicates how well the infant is doing outside the womb. A mother suffering from anaemia is at risk of maternal and perinatal mortality due to poor nutritional status (Pasricha, Drakesmith, Black, David & Biggs 2013; Allen 2000). Anaemia during pregnancy can result in a low birth weight or premature delivery (Allen 2000). This is a serious problem, as the vicious cycle of malnutrition continues. These infants may suffer from developmental delays that may affect their academic performance in school, with possible unemployment later in life, hence exposing them to poverty and food insecurity (HST 2016; Escott-Stump 2015, pp28, 645; Kimani-Murage *et al* 2010).

Although there has been an improvement in the iron status of South Africans, it is important to highlight that national studies only sampled a portion of the province and were not district specific. It also indicates that iron deficiency anaemia affects two vulnerable groups in KZN, women of childbearing age and children. It is important to prioritise the nutritional status of these two vulnerable groups as they are at high risk of micronutrient malnutrition (Shisana *et al* 2013; Labadarios *et al* 2000; Labadarios & Van Middelkoop 1995). A possible long-term strategy that could be explored to help address micronutrient malnutrition is dietary diversification, through the promotion of household and community food gardens, utilisation of indigenous crops and consumption of biofortified foods.

Improvements in the prevalence of micronutrient deficiencies could be attributed to the success of the nutritional interventions implemented to help alleviate micronutrient deficiencies (DoH 2018; Swart, Sanders & McLachlan 2008; DoH & UNICEF 2007). Although these interventions have shown an improvement in the prevalence of micronutrient deficiencies, progress has been slow. Despite the improvement in the iron status of women and children observed from national studies, it is evident that it remains a problem in some areas of KZN (Shisana *et al* 2013). With the high poverty rates and the worsening economy, many economically disadvantaged rural communities remain unable to access basic food items (NAMC 2019; RSA 2019). This leads to poor nutritional

[8] Apgar (A: appearance, P: pulse, G: grimace, A: activity, R: respiration)

status as the foods consumed lack variety and many essential nutrients. Assessing the dietary intake of the rural population in KZN could assist in improving dietary intake by modifying current eating patterns or advising on cheaper, more nutritious food options. Current recipes could be documented and assessed for nutritional composition. Items from these recipes could be substituted with more nutritious options. For example, substituting unfortified white maize with yellow maize or sweet potato with OFSP could improve vitamin A intake and address VAD. Adding fruits and vegetables to diets that lack variety by promoting vegetable gardens, utilising wild vegetables and fruit or biofortified foods, could assist in diversifying household food baskets.

2.2.2 Over-nutrition

For many years, undernutrition has been under the spotlight, while over-nutrition has received less attention. However, this has now changed (DoH 2018; Haslam & James 2005). Over-nutrition was previously mostly associated with affluence. However, due to the nutritional transition, it is now also prevalent in middle and low-income groups. Over-nutrition is a major risk factor for chronic diseases of lifestyle, especially in women (Devanathan, Esterhuizen & Govender 2013).

2.2.2.1 Overweight and obesity in children

There are several possible causes of childhood obesity. These include increased consumption of poor quality, high-energy foods, children born to mothers who were overweight or obese during pregnancy, overweight or obese parents, low physical activity and metabolic disorders (Escott-Stump 2015, p626). Overweight and obesity are serious health concerns, especially in children, as it increases the risk of other chronic diseases of lifestyle later, such as cardiovascular disease, hypertension and diabetes mellitus (Escott-Stump 2015, p626). Stunting in children increases the risk of obesity in adulthood (FAO *et al* 2017).

Globally, in 2016, 41 million children under the age of five were overweight. Southern Africa accounts for 12% of the overweight children (FAO *et al* 2017). The 2005 NFCS-FB found that 1 in 10 South African children was overweight (Labadarios *et al* 2008). A separate study conducted by Armstrong, Lambert, Sharwood & Lambert (2006), using random sampling in South African children aged 6-13 years in five selected provinces during the National Health Survey (2001-2004), found that the prevalence of overweight and obesity increased with age among African girls. However, the opposite trend was observed with white girls. The combined percentage of overweight and obesity increased from 11.9% in African girls aged six years to 21.8% in African girls aged 13 years (Armstrong *et al* 2006). Similarly, a national study conducted in 2012 in SA, reported that the prevalence of overweight and obesity was lower in boys (11.5% and 4.7%, respectively) than girls (16.5% and 7.1%, respectively). These results were consistent for all age groups. KwaZulu-Natal was one of the provinces with high rates of obesity among children. The prevalence of obesity in KZN was 6.1% and 8.5% among boys and girls, respectively. Furthermore, this national study reported that African girls were the most affected by obesity (Shisana *et al* 2013).

2.2.2.2 Overweight and obesity in adults

African women were reported to be at greatest risk for obesity in SA (nDoH, Stats SA, SAMRC & ICF 2019). Another study that reviewed demographic and health surveys to assess the nutritional status in seven African countries found that in Africa, overweight and obesity were on the rise. Furthermore, this review noted that economically disadvantaged women and those that had less than primary school education were the most affected by overweight and obesity (Ziraba, Fotso & Ochako 2009). A similar trend was observed in SA. The 2012 SANHANES-1 study reported that, on a national level, the prevalence of obesity in women from the rural formal and rural informal populations was 31.8% and 37.6%, respectively. Furthermore, KZN was shown to have the second highest prevalence of obesity. The prevalence of overweight and obesity was higher in women (24.8% and 39.2%, respectively) than men (20.1% and 10.6 %, respectively) (Shisana *et al* 2013).

A few studies have assessed the nutritional status in the KZN population (Table 2.4) and limited data has been collected from the urban KZN population. Many authors reported that stunting affected young children, whereas overweight and obesity were a major problem among females from both urban and rural areas of KZN (Table 2.4) (Napier & Oldewage-Theron 2015; Duncan, Howe, Manukusa & Purdy 2014; Devanathan *et al* 2013; Grobbelaar, Napier & Oldewage-Theron 2013; Zhou, Lurie, Bärnighausen, McGarvey, Newell & Tanser 2012; Smuts *et al* 2008; Jinabhai, Taylor & Sullivan 2003). It was noted that the prevalence of overweight and obesity increased with age in African females (Napier & Oldewage-Theron 2015; Duncan *et al* 2014; Devanathan *et al* 2013; Grobbelaar *et al* 2013; Zhou *et al* 2012; Smuts *et al* 2008; Jinabhai *et al* 2003).

Table 2.4: Studies conducted to assess the nutritional status of the KwaZulu-Natal population

Authors	Study design and methods	Area	Participants	Findings
Napier & Oldewage-Theron (2015)	Cross-sectional study. Three informal settlements, randomly selected. Anthropometric data was collected (weight and height) and a structured 24-hour recall was conducted.	EThekwini Municipal District (Urban area).	Girls in secondary school and women aged 19-28 years of age (n=523).	- Stunting was evident in young girls (7.7%). - Forty-three percent of the girls were at risk of being overweight and 12.8% were overweight. - BMI for age indicated that 5.2% of the women were underweight and that 30.5% and 15% were overweight and obese, respectively. - Half the women had a normal BMI. - The intake of micronutrients was adequate among both the girls and women, however, the energy intakes were inadequate.
Duncan *et al* (2014)	Nested cross-sectional study. Anthropometric measurements and blood pressure were measured for all participants. A questionnaire was formulated and participants interviewed.	Manguzi, KwaZulu-Natal (Mahlungulu, Maputa, Mshundu, Thengane and Zama Zama).	Males (n=109) and females (n=391). Patients from 11 primary health care clinics.	- The results of the study indicated that 28% of the participants were overweight, 34% were obese and 4% were underweight. - This study concluded that most of the participants were overweight and obese; however, not many participants perceived that they were overweight.
Devanathan *et al* (2013)	A cross-sectional exploratory study. Systematic sampling was used. Anthropometric measurements were taken and interviews were conducted.	Wentworth Hospital, Durban, KZN.	Urban African women (n=328) aged 19-70 years.	- The prevalence of overweight and obesity was 16% and 76%, respectively. - All participants had one or more chronic diseases of lifestyle. - The overweight and obese women who had one or more chronic diseases of lifestyle perceived themselves as thinner than they were.
Grobbelaar *et al* (2013)	Cross-sectional study. Anthropometric measurements were taken. A seven-day cycle menu was obtained and analysed.	Three residential care facilities in Durban.	Girls (n=33) and boys (n=110) aged 5-18 years	- Severe stunting was noted in 4.7% and 3.3% of the boys aged 4-8 years and 14-18 years, respectively. - Stunting affected 13.3% and 20% of girls aged 9-13 years and 14-18 years, respectively. - Wasting was noted in 6.7% of girls aged 9-13 years and 3.3% of boys aged 14-18 years. - Approximately 27% of girls aged 14-18 years were overweight and 33.5% of girls aged 9-13 years were at risk of becoming overweight.

Table 2.4: Studies conducted to assess the nutritional status of the KwaZulu-Natal population continued.

Authors	Study design and methods	Area	Participants	Findings
Grobbelaar *et al* (2013)				- This study found that younger boys were more overweight than younger girls, while the opposite was noted for older boys compared to girls. - These authors found that the majority of children consumed all the food on their plate. - The energy, protein and carbohydrate intakes met 100% or more of the dietary reference intake (DRI). The children did not meet their calcium and iodine requirements. Further, a low intake of vitamin C was noted in both the older girls and boys. Recommended fibre intakes were not met by any of the groups. - Results from this study showed that fruit and vegetable intake was limited. On average, a single serving of 40 grams of vegetable was given to the children, whereas fruit was only given three times a week. - This study concluded that although large portions were given to the children, the foods were nutritionally inadequate and there was a poor intake of fruits, vegetables, milk and milk products.
Kolahdooz, Spearing, & Sangita (2013)	A cross-sectional study assessing dietary adequacy from a 24-hour recall. Participants were randomly selected.	Empangeni, KZN.	Rural adults (n=136) (52 males and 84 females).	- The energy content of both male and female diets exceeded the acceptable macronutrient distribution ranges (2200 and 1800 kCal, respectively). - Mean daily energy intake from carbohydrate for both males and females was higher than the estimated average requirements (EAR) (69% and 66%, respectively). - Although the protein intake was adequate, plant sources of protein were consumed by the majority of the subjects. - The male participants consumed inadequate amounts of vitamin A, B_{12}, calcium and zinc. - The sodium intakes in all groups were higher than the EAR. - This study concluded that despite food fortification in South Africa, the majority of the study population consumed diets that contained inadequate amounts of vitamin A, B_{12}, C, D and E, calcium, zinc and pantothenic acid.

Table 2.4: Studies conducted to assess the nutritional status of the KwaZulu-Natal population continued.

Authors	Study design and Methods	Area conducted	Participants	Findings
Tathiah, Moodley, Mubaiwa, Denny & Taylor (2013)	Retrospective study. Secondary analysis of anthropometric data (weight and height) collected during the Human papillomavirus (HPV) vaccination demonstration project VDP in Zululand, SA during 2011.	Nongoma and Ceza, Zululand.	Girls aged 9-14 years.	- There was a high prevalence of stunting in the 11-12 year age group. - More than 50% of children aged 13-14 years were stunted. - Overall, 9% were overweight, 3.8% obese, 4% underweight and 9.2% stunted. - Both under and over nutrition was noted in girls between 9-14 years residing in two rural areas of KZN.
Spearing, Kolahdooz, Lukasewich, Mathe, Khamis & Sharma (2012)	Cross-sectional study. Random selection of persons living in rondavels of the same socioeconomic status. Data obtained for the recipes were analysed by Nutribase clinical Nutrition Manager, version 9.	A rural village surrounding Empangeni, KZN.	Males (n=34) and females (n=45) that prepared or purchased foods.	- Commonly consumed composite dishes were; fried beef, beef stew, beef soup, fried chicken, chicken soup, chicken stew, fish stew, dumplings, *ujeqe, phutu*, potatoes, stiff pap, beans, samp and beans, fried spinach and fried cabbage. - The study found that participants' diets contained good sources of protein, vitamins and minerals; however, it was high in fat.
Zhou *et al* (2012)	Cross-sectional study. A large population-based survey measuring BMI and blood pressure.	Hlabisa sub-district in rural Umkhanyakude.	BMI (n=2298) and blood pressure (n=2307). Females aged 15-49 years and males aged 15-54 years.	- More than half of the participants were overweight (58.4%). - Females were more likely to be overweight in comparison to their male counterparts.
Schoeman *et al* (2010)	A cross-sectional study was conducted. Structured interview questionnaires were used and anthropometric measurements were taken (height and weight).	Umkhanyakude (n=398) (sub-district Jozini), Zululand (n=303) (sub-district Pongola) and OR Tambo (n=364) (sub-district Nyandeni)	Children between 0-59 months from UMkhanyakude, Zululand and OR Tambo.	- Thirty percent of participants in the two KZN districts had food gardens. - Half of the participants from the two KZN districts had experienced a food shortage in the previous 12 months. - Zululand had the lowest coverage of vitamin A supplementation. - Wasting was not a concern in this study. - The highest rates of stunting were seen in UMkhanyakude (6%), in the 12-23-month old group. - Stunting was higher in the second year of life. - The rates of overweight in the 0-23-month group were higher than underweight. - There was a high rate of obesity noted among the caregivers living in Zululand (60%).

Table 2.4: Studies conducted to assess the nutritional status of the KwaZulu-Natal population continued.

Authors	Study design and methods	Area conducted	Participants	Findings
Smuts *et al* (2008)	A cross-sectional study was conducted. A questionnaire was used and anthropometric measurements were taken.	OR Tambo and Alfred Nzo district (Eastern Cape, n=1794) and UMkhanyakude and Zululand (n=1988).	Children 0-71 months old and caregivers.	- Between 16-18% of the children in both provinces were overweight. - Childhood malnutrition doubled from the first year of life to the second. Further, the prevalence of stunting was significantly high in the Nongoma district of KZN. - The mean BMI for the caregivers was above 25 kg/m^2 for all areas, except the UMkhanyakude district. - Obesity was higher among females; 45% of female caregivers in KZN were obese. - Only 9% of the caregivers in the UMkhanyakude district were underweight. - This study indicates that maternal over-nutrition and childhood malnutrition co-exist in both the Eastern Cape and KZN.
Jinabhai *et al* (2003)	A cross-sectional survey conducted in 1995 on primary school children in KZN. Anthropometric data was collected. WHO and International obesity task force (IOTF) sets were used to measure nutritional status.	Eleven schools from the Vulamehlo district (rural) (n=802).	Grade 3 pupils, aged 8-11 years.	- Females had a higher prevalence of overweight and obesity in comparison to their male counterparts. - Levels of stunting ranged between 31.4-75% in this study. There was no clear link between stunting and obesity in this particular study.

The studies reviewed indicated that overweight and obesity affected females more than males. There are many possible reasons for the increasing prevalence of obesity in older girls of African ethnicity. Some studies have noted that overweight is perceived as being associated with wealth and a negative Human Immunodeficiency Virus (HIV) status (Duncan *et al* 2014; Devanathan *et al* 2013). Thinness is usually associated with illness and being HIV positive (Devanathan *et al* 2013). From the studies reviewed, it was noted that some overweight and obese participants did not perceive themselves as overweight or obese. Furthermore, the participants did not recognise that they had a weight problem (Duncan *et al* 2014; Devanathan *et al* 2013). These social misconceptions further emphasise the need for education and awareness programs, especially in economically disadvantaged rural communities (Duncan *et al* 2014; Devanathan *et al* 2013).

Over-nutrition increases the risk for chronic diseases of lifestyle (Devanathan *et al* 2013). Various studies conducted in KZN have noted that although participants consumed large portions of foods, these foods were nutritionally inadequate. These foods were often high in energy, carbohydrates and sodium, but low in micronutrients such as vitamin A, vitamin B_{12}, vitamin C, vitamin D, vitamin E, zinc, pantothenic acid, calcium and iodine. A poor intake of fruits, vegetables, dairy products and fibre was noted (Kolahdooz *et al* 2013; Grobbelaar *et al* 2013; Spearing *et al* 2012). These results indicate that there is a need to improve dietary diversity.

Based on the literature reviewed, it is evident that there is limited data on the nutritional intake of people living in KZN. It is also important to highlight that these studies were conducted in specific districts and sub-districts within KZN, and therefore do not necessarily reflect the nutritional status of the KZN population as a whole. Furthermore, the nutritional status of most of the localised areas within KZN has not been investigated. Each area has a population with a different income, socio-economic status and education level. These factors could possibly affect the nutritional status of the populations living within these districts. Therefore, it would be beneficial to investigate the nutritional status of people living in the districts and sub-districts of KZN, which have not been previously investigated.

2.3 Interventions to combat nutritional problems in KwaZulu-Natal

In response to the nutritional problems discussed thus far in this chapter, there have been several interventions employed by the South African DoH in order to combat these problems. These include food fortification, vitamin A supplementation, the prevention and management of malnutrition and dietary diversity (DoH 2018; DoH 2013; Swart *et al* 2008; DoH & UNICEF 2007). These are discussed further in this section.

2.3.1 Food fortification

The results of the 1999 NFCS study led to the fortification of foods to improve the nutritional status of South Africans (Labadarios *et al* 2000). Food fortification is a cost-effective process that involves the addition of micronutrients to foods that are commonly consumed by vulnerable populations (Pretorius & Schönfeldt 2012; Gillespie & Mason 1994). As of October 2003, the South African Department of Health made it mandatory for all maize meal and wheat flour to be fortified with vitamin A, iron, zinc, folic acid, thiamine, niacin, vitamin B_6 and riboflavin (DoH & UNICEF 2007). The decision to use maize meal and wheat flour were taken because the commonly consumed foods in SA were bread and maize (Labadarios *et al* 2000). However, access to fortified foods remains problematic for economically disadvantaged people who rely on social grants to purchase food (NAMC 2019; Stats SA 2019b; Labadarios *et al* 2008). This implies that alternative solutions are needed to reach this vulnerable group.

2.3.2 Vitamin A supplementation

Vitamin A supplementation was another strategy employed by the South African DoH to assist in the alleviation of VAD. The KZN DoH guidelines state that all children over six months of age and under five months should receive a routine dose of vitamin A supplementation (DoH 2013). A therapeutic dose is issued to all children that present to the hospital or clinic with severe malnutrition or signs of VAD (DoH 2018; DoH 2013). Although this programme is currently in place in KZN, not all children benefit from it. Health care facilities are usually far from where people reside and many people do not have money to transport children to health care facilities for supplements. Many children only receive a therapeutic dose of vitamin A on admission to hospital with malnutrition (DoH 2018; DoH 2013). Results of a study conducted in KZN indicated that there was poor utilisation of health care facilities. A high percentage of mothers (25%) living in KZN had no access to basic healthcare and many home deliveries were noted (Smuts *et al* 2008). Another study conducted in UMkhanyakude and Zululand indicated that not all the children residing in these areas received vitamin A supplementation (Schoeman *et al* 2010).

As alluded to earlier, other than financial constraints, poor maternal education is also a contributing factor to poor nutritional intake. Poor utilisation of health care facilities to obtain vitamin A supplementation may be attributed to low levels of education. Caregivers from these communities may be unaware of the importance of vitamin A supplementation (Faber & Benadé 2007), thus resulting in a poor vitamin A status in children from these areas. Maternal education could play a significant role in reducing malnutrition, as mothers could be educated on the effective utilisation of basic resources as well as family planning. This could result in smaller families and improved nutritional status in children (Bain *et al* 2013).

2.3.3 Prevention and management of malnutrition in KwaZulu-Natal

As mentioned earlier, both under- and over-nutrition co-exist (nDoH *et al* 2017; Shisana *et al* 2013). A possible reason why malnutrition is not detected early is that there is poor utilisation of health care facilities due to location as well as financial constraints (Bain *et al* 2013; Chopra *et al* 2009; Smuts *et al* 2008). Many caregivers only bring their children to health care facilities when they are ill and, in most cases, the children are severely malnourished. This is because there are several family members involved in the decision making on when to bring the child to the hospital (Haskins, Grant, Phakathi, Wilford, Jama & Horwood 2017).

The old policy for treating malnutrition could be a contributing factor in improving the prevalence of wasting and underweight observed in KZN (nDoH *et al* 2017; DoH 2014; Shisana *et al* 2013). The problem with the old policy was that the primary focus was on undernutrition in children. In KZN, since March 2018, the DoH has implemented standard operating procedures on the prevention and management of malnutrition in KZN. The new policy now incorporates children and adults, both under- and over-nutrition, as well as food security. Nutritional treatment is based on the diagnosis and either nutritional advice only or nutritional advice and nutritional supplements are issued (DoH 2018). Table 2.5 indicates the nutritional supplements that are issued to children under five years and pregnant and lactating women. Different supplements are issued depending on the severity of the undernutrition and the age of the individual (DoH 2018).

Table 2.5: Nutritional supplements issued to children 1-5 years of age and pregnant and lactating women in KwaZulu-Natal (DoH 2018)

Age group	**Classification**	**Supplements**	**Malnutrition statistics from national studies**	
6-69 months	SAM	Outpatient treatment: RUTF (Tubs calculated on individuals weight)	**1-3-year-old children** **NFCS (2005):** 0.9% of children were severely wasted. **SANHANES (2012):** 1.1% of children were severely wasted.	**4-6-year-old children** **NFCS (2005):** 1.5% of children were severely wasted. **SANHANES (2012):** 0.8% of children were severely wasted.
6-11 months	MAM/NAM at Risk	Infant cereal and RUTF	**1-3-year-old children** **NFCS (2005):** 5.1% of children were wasted. **SANHANES (2012):** 2.2% of children were wasted.	**4-6-year-old children** **NFCS (2005):** 5.0% of children were wasted. **SANHANES (2012):** 2.0% of children were wasted.
12-59 months	MAM/NAM at Risk	EMM, RUTF and LFED		
Pregnant	SAM/MAM/NAM	EMM and LFED		
Lactating	SAM/ MAM/NAM	EMM, RUTF and LFED		

RUTF: Ready to use therapeutic food; EMM: Enriched maize meal; LFED: Lactose-free energy drink.

The national integrated early childhood development (ECD) policy, which was approved by the cabinet in 2015, could also be another contributing factor to the improvement in malnutrition. This policy is child-centred and focuses on conception until a year before a child enters formal school. The policy emphasises that the first 1000 days of a child's life are vital for optimal growth and development and that pregnant mothers should receive good nutrition for the fetus to grow well. Food and nutritional support are one of the components of this policy. It involves nutritional support for pregnant women and infants and young children. As part of the community work program, it helps families with young children to start food gardens. One of the ECD programmes includes health care and nutrition. The programmes are centred around improving maternal, infant and young child nutrition by promotion and support of breastfeeding, appropriate counselling on correct complementary feeding, growth monitoring for children from birth to 2 years at home, community or health care facilities, micronutrient supplementation, food and nutritional supplementation for pregnant women and young children in the community by community health care workers or community outreach programmes (RSA 2015). Guidelines on nutrition for early ECD centres were developed for ECD practitioners and caregivers that provide partial care for children from birth to 6 years to assist in improving nutritional status. These guidelines were developed in conjunction with other government policies including the ECD policy. The guideline includes healthy eating for babies and children up to 6 years, menus and recipes, while child health is under maintaining safety and a healthy environment (DoH 2016).

2.3.4 Dietary diversity

Dietary diversity is a long-term strategy used to assist in combating micronutrient deficiencies in SA (Latham, Ash, Ndossi, Mehansho & Tatala 2001). It involves adding a variety of foods to the diet such as fruit and vegetables, legumes, starch and animal products (Faber, Phungula, Venter, Dhansay & Benadé 2002). In SA, KZN has the highest energy, protein, fat carbohydrate and fibre intake among children, however, micronutrient intake is poor (Labadarios *et al* 2000). The 1999 NFCS study found that two-thirds of South African children, including those residing in KZN, consumed only half of the RDA for calcium, iron, zinc, selenium, vitamin A, vitamin D, vitamin C, vitamin E, riboflavin, niacin, vitamin B_6 and folic acid (Labadarios *et al* 2000). Unfortunately, the diets of the majority of people living in tribal and informal urban areas in South Africa, specifically KZN, lack dietary diversity (Bain *et al* 2013; Smuts *et al* 2005).

The commonly consumed foods in SA are mealie meal, white sugar, tea, brown bread, non-dairy creamer, brick margarine, chicken meat, full cream milk and dark green leafy vegetables (Steyn, Nel & Casey 2003; Labadarios *et al* 2000). A study conducted in a peri-urban site in Marianhill, Pinetown, KZN by Faber, Laubscher & Laurie (2013), showed that commonly consumed foods were sugar, maize meal porridge, bread, rice, cordial squash, hard margarine, tea and legumes, similar to other studies. On the other hand, the foods that were consumed by more than half the participants in rural KZN were maize meal and bread (Faber, Van Jaarsveld, Kunneke, Kruger, Schoeman & Van Stuijvenberg 2015). From this it is evident that many of these diets are low in eggs, legumes, animal products and vitamin A-rich fruit and vegetables, due to the high costs of these foods (Labadarios, Steyn & Nel 2011; Labadarios *et al* 2008; Faber *et al* 2002).

2.4 Biofortification

The South African government has put various strategies in place to assist in the alleviation of malnutrition, including VAD (DoH 2018; DoH 2012; Swart *et al* 2008; DoH & UNICEF 2007). However, there is still a need for a complementary or alternate strategy to assist in the reduction of VAD. An effective and sustainable approach to address VAD could be through biofortification (Singh, Praharaj, Singh & Singh 2016, pp3,4). Biofortification is a complementary strategy that involves the production of micronutrient-rich crops (Singh *et al* 2016, p3). The two methods used for biofortification are genetic modification and conventional breeding (Saltzman, Birol, Bouis, Boy, De Moura, Islam & Pfeiffer 2013; Stevens & Winter-Nelson 2008).

HarvestPlus has a biofortification programme that uses conventional breeding and has identified seven crops suitable for biofortification namely; beans (*Phaseolus vulgaris*), maize (*Zea mays*), pearl millet (*Pennisetum glaucum*), wheat (*Triticum aestivum*), cassava (*Manihot esculenta*), sweet potato (*Ipomoea batatas*), and rice (*Oryza sativa*). Of the seven crops, three crops (cassava, maize and sweet potato) have been identified for PVA-biofortification (HarvestPlus 2018; WHO 2018). White maize and cream-fleshed sweet potato (CFSP) are two commonly grown and consumed crops in SA [Department of Agriculture, Forestry and Fisheries (DAFF) 2017; Low, Mwanga, Andrade, Carey & Ball 2017] and are therefore ideal for PVA-biofortification (DAFF 2017; Low *et al* 2017; Mitra 2012).

Some studies have indicated that there is low acceptance of biofortified crops (Pillay, Derera, Siwela & Veldman 2011; Muzhingi, Langyintuo, Malaba & Banziger 2008; Stevens & Nelson-Winter 2008). However, there have also been reports of acceptance. Govender, Pillay, Derera & Siwela (2014), found that caregivers were willing to give their infants porridge made with PVA-biofortified maize if it had a health benefit and was affordable and readily available. Additionally, Amod, Pillay, Siwela & Kolanisi (2016) reported that biofortified maize was acceptable to caregivers if it was consumed with another food item such as chicken stew. Thus, this strategy could be introduced to assist in improving the nutritional intake of economically disadvantaged rural people. However, before this is implemented, there is a need to determine the acceptability of biofortified foods in KZN.

2.5 Linking agriculture to address malnutrition

The traditional crops grown in KZN are maize, beans, potatoes, pumpkin, amadumbe and groundnuts (Modi, Modi & Hendriks 2006). This traditional food basket highlights a lack of dietary diversity due to the lack of nutrient-dense foods. Due to the high cost of food, household and community food gardens are now being promoted as an alternative means of improving availability and access to nutritious foods, in economically disadvantaged rural households. A study conducted by Modi *et al* (2006) found that wild vegetables contributed to the nutritional intake of the study participants from Ezigeni, a rural location in KZN. Wild vegetables are found in abundance when other vegetables are scarce (Modi *et al* 2006). KwaZulu-Natal province has the second highest consumption of wild vegetables in SA with as many as 24 species of wild vegetables identified in KZN. The authors noted that although these vegetables were available, there has been a decline in their consumption. This could be attributed to the nutrition transition from traditional diets to more westernised diets. Increased consumption of wild vegetables could improve food insecurity by providing variety to a diet that is already nutrient deficient (Bvenura & Afolayan 2015; Modi *et al* 2006).

Although wild vegetables are not routinely consumed and communal gardens are not popular, many people grow foods for their own consumption. A study conducted by Faber *et al* (2013), found that cabbage and pumpkin were popular items consumed in KZN. Fifty percent of the participants consumed cabbage and 63% grew their own pumpkin (Faber *et al* 2013). Yellow vegetables, which are high in vitamin A were only consumed by a small percentage of children in KZN, which could be the reason for the poor vitamin A status (Faber *et al* 2015). A possible intervention to assist in improving the nutritional status of vulnerable groups is to improve the consumption of wild vegetables. There has been a decline in the consumption of these often-free crops due to a lack of education. These crops are most often nutrient-dense and readily available. There are, however, challenges with the acceptability of some of these indigenous leafy vegetables. The acceptability of indigenous crops could be improved if people residing in rural communities in SA were made aware of the health benefits associated with the consumption of these crops, and incorporating them into already existing traditional dishes that may currently lack indigenous crops.

2.6 Traditional, indigenous and innovative crops with a potential to alleviate malnutrition in rural areas of South Africa, with a focus on KwaZulu-Natal

2.6.1 Underutilised crops

Modi *et al* (2006) reported that several indigenous crops in KZN could be utilised as food sources to diversify diets. The utilisation of these crops could provide nutrients that are currently lacking in the diets of economically disadvantaged rural people. For example, amaranth, blackjack and gallant soldier are popular indigenous crops in the Ezigeni area of KZN (Modi *et al* 2006). Of these, amaranth contains vitamin C and iron while blackjack contains vitamin A and vitamin E (Modi *et al* 2006). A study conducted by Olumakaiye (2011) found that the vitamin C content of amaranth ranged from 0.79-1.7 mg/100 g and iron content ranged from 35.42-53.58 mg/100g (Olumakaiye 2011). Amaranth contains non-haem iron, which is less well absorbed. However, amaranth also contains vitamin C, which when consumed together with a non-haem iron-containing food, enhances the absorption of iron (Mahan & Raymond 2017, p1079). It is important to note that the amount of nutrients obtained from these nutrient-rich foods depends on the amount eaten as well as preparation methods used. If prepared correctly and eaten in appropriate amounts, they could be used to diversify diets, especially where other vegetables are lacking (Modi *et al* 2006). Mabhaudhi *et al* (2016a) further emphasised that improved utilisation of underutilised crops could contribute to improving dietary diversity and providing nutrient-dense foods to economically disadvantaged rural communities.

2.6.1.1 Sweet potato

There are four main root and tuber crops grown in Africa, namely cassava, yam, potato and sweet potato (Sanginga 2015). From these crops, sweet potato is a starchy food crop with a short cycle of between 3-5 months, thus suitable for double cropping (two or more crops grown on the same land) (Jenkins, Carmen & Houghtaling 2015; Sanoussi, Adjatin, Dansi, Adebowale, Sanni & Sanni 2016; Sanginga 2015). This is advantageous especially in months where other crops are not harvested (Sanoussi, Adjatin, Dansi, Adebowale, Sanni & Sanni 2016; Sanginga 2015).

Cream-fleshed sweet potato is the most commonly consumed sweet potato in Africa and contains several vitamins and minerals such as potassium, phosphorus, vitamins C, K, E, several B vitamins and dietary fibre. However, it lacks beta-carotene (Low *et al* 2017; Mitra 2012). It is high in carbohydrates, but low in protein and fat (Sanoussi *et al* 2016). Orange-fleshed sweet potato is a new crop that could improve nutritional status; it not only contains the vitamins and minerals found in CFSP but also contains beta-carotene, a good source of vitamin A (Mitra 2012; Burri 2011).

Unlike PVA-biofortified maize, several studies have shown positive responses from participants toward OFSP, despite the orange colour (Pillay, Khanyile & Siwela 2018; Laurie, Faber, Calitz, Moelich, Muller & Labuschagne 2013; Tomlins, Owori, Bechoff, Menya & Westby 2012; Chowdhury, Meenakshi, Tomlins, Owori 2011; Tomlins, Ndunguru, Stambul, Joshua, Ngendello, Rwiza, Amour, Ramadhani, Kapande & Westby 2007). A study conducted by Pillay *et al* (2018) on infant caregivers, found that a complementary food made with OFSP was well accepted by the caregivers (Pillay *et al* 2018). Additionally, another study that investigated the acceptance of OFSP by caregivers, reported that the OFSP was preferred to the pale-fleshed sweet potato for all sensory attributes investigated (Low & Van Jaarsveld 2008).

Moreover, a study conducted in Uganda found that the deep orange coloured sweet potato was preferred over yellow or white sweet potato (Chowdhury *et al* 2011). The OFSP is grown during summer seasons in temperate regions but can be grown throughout the year in subtropical regions (DAFF 2016). Thus, it would be a suitable crop for a food-based approach to reduce VAD. It can be bought from a limited number of stores in SA. The Kara and Beauregard varieties of OFSP costs R26.99/kg and R23.99/kg, respectively (Woolworths 2020). Biofortified crops could be accepted if their non-biofortified counterparts are commonly consumed and known to individuals of a particular area. Orange-fleshed sweet potato is a good example of a biofortified crop that has the potential to reduce VAD, thus, further research should be conducted on its nutritional composition and consumer acceptability, especially in KZN.

2.6.1.2 Bambara groundnut

As mentioned earlier, a basic food basket in SA costs R883.16/month, which is a 3% increase from 2018 (NAMC 2019). This price rise makes animal food products unaffordable to vulnerable households (NAMC 2019). Plant-based proteins have also risen in price; however, they are still cheaper than animal sources (NAMC 2019). Legumes, a widely consumed plant food is considered cheaper than animal sources and is a source of protein as well as carbohydrates, minerals and vitamins (Maphosa & Jideani 2017, p104).

Bambara groundnut (*Vigna subterranean*) is an indigenous crop in Africa and is well adapted to and thrives in the agronomical marginal regions (Chibarabada, Modi & Mabhaudhi 2017), where a significant proportion of vulnerable individuals live in SSA countries, including SA. Although bambara groundnut is grown in various parts of SA, it is an underutilised legume (Chivenge, Mabhaudhi, Modi & Mafongoya 2015). It is a traditional crop grown by subsistence farmers in Mpumalanga, Limpopo, North-West province, Gauteng and KZN. Within KZN, this crop is grown in Greytown, Msinga, Nkamdla, Nguthuthu, Makhati & Kosibaai (Agriculture, Forestry & Fisheries 2016). Bambara groundnut is a summer crop (Makanda, Tongoona, Madamba, Icishahayo & Derera 2008) and grows optimally in temperatures between 30-35 °C (Agriculture, Forestry & Fisheries 2016).

Unlike other legumes, bambara groundnut contains the essential amino acid methionine (Lichtfouse 2016, p376; Stone, Massey, Theobald, Styslinger, Kane, Kandy, Tung, Adekoya, Madan & Davert 2011; Mwale, Azam-Ali & Massawe 2007). Moreover, bambara groundnut has been found to have high levels of essential fatty acids, minerals and vitamins (Adeleke, Adiamo & Fawale 2018). The combination of a starch-based food such as maize and a legume such as bambara groundnut would result in a good quality complementary protein (Lichtfouse 2016, p376; Mwale *et al* 2007; Linnemann & Azam-Ali 1993, pp13-58).

Unfortunately, even though bambara groundnut has the potential to form a complementary protein when consumed with a starch-based food item and is nutrient-dense, it is underutilised as a food source in SSA for several reasons (Bogart, Tickle-Degnen & Joffe 2012). Bambara groundnut exhibits anti-nutritional properties and hard-to-mill and hard-to-cook properties (Ndidi, Ndidi, Aimola, Bassa, Mankilik & Adamu 2014; Boye, Zare & Pletch 2010; Uvere, Uwaegbute & Adedeji 1999). Additionally, the acceptability of bambara groundnut is a challenge, as many South Africans are unaccustomed to this crop (Oyeyinka, Pillay & Siwela 2017). Although bambara groundnut is underutilised, a few studies conducted in SA have found that when bambara groundnut was prepared in some food types, it was positively accepted by consumers (Oyeyinka, Tijani, Oyeyinka, Arise, Balogun, Kolawole, Obalowu & Joseph 2018; Oyeyinka *et al* 2017; Okafor, Okafor, Leelavathi, Bhagya & Elemo 2015). Furthermore, roasting, a heat processing method, has been found to improve the protein quality and taste of bambara groundnut (Okafor *et al* 2015). Bambara groundnut can be purchased for approximately R150.90/kg (Faithful to Nature 2020). Production of bambara groundnut by subsistence farming using single or double cropping could be more cost-effective. Bambara groundnut is grown in various areas of KZN, thus it could possibly be accepted by rural communities. The consumption of bambara groundnut together with PVA-biofortified cooked maize could improve dietary diversity and nutritional content of diets in economically disadvantaged communities. However, the nutritional composition and consumer acceptability of this combination should be further investigated in rural communities of KZN.

2.7 The way forward

Despite the implemented nutrition interventions, more work is required to improve the nutritional status of economically disadvantaged rural communities in KZN. The sustainable development goals (SDGs) one, two and three speak explicitly to the need to (i) end poverty, (ii) achieve zero hunger, and (iii) ensure good health and well-being (Sachs 2012). Achieving these goals is important and discussions on how to do that currently dominate the post-2015 debate (Mabhaudhi *et al* 2016a; Mabhaudhi, O'Reilly, Walker & Mwale 2016b). It is evident that food and nutrition security remains a major problem in developing countries, including SSA (Temple & Steyn 2016, p29-30). A multi-disciplinary approach needs to be adopted to help address poor nutrition. Agriculture on its own is insufficient to provide nutritious produce. Poor utilisation of nutritious foods will not change the nutritional status of vulnerable people (Temple & Steyn 2016, p34)

Malnutrition is a serious public health concern, especially in children. A major contributor to poor nutritional status is poverty. Financial insecurity directly affects the utilisation of foods, which affects the nutritional status of vulnerable groups (Mabhaudhi *et al* 2016a). According to Mabhaudhi *et al* (2016a), agriculture should be recognised as a provider of nutrition and not as a provider of food. This emphasises the crucial role that agriculture and optimal utilisation of nutritious food play in improving the nutritional status of vulnerable populations. Before one can determine what optimal utilisation is for a specific population, one needs to determine which foods are consumed within that population group. Thus, it is important to assess food intake and identify sources of food among economically disadvantaged rural communities in KZN, to strengthen and diversify their food systems.

2.8 Conclusion

The trends in the nutritional status of population groups in the province of KZN are similar to national trends. There is a burden of both under- and over-nutrition. Undernutrition, specifically stunting, remains a problem in children. Over-nutrition, including both overweight and obesity, are a problem among African females. Data on the micronutrient status of both the rural and urban population as well as the nutritional status of the different population groups in KZN are limited. There is a gap in knowledge with regards to the nutritional status of rural population groups in the local municipalities of uMshwathi, Msinga and eThekwini, in uMgungundlovu and uMzinyathi Districts and the eThekwini metropolitan of KZN, which were the focus of the current study. This is attributed to the fact that national studies aimed to determine the nutritional status of the South African population and not specific sub-groups, within the population. Consequently, while such studies are plausible, they have limitations of over-generalising the nutritional status of specific sub-groups. Availability and access to nutritious foods is a major obstacle to improving the diets of economically disadvantaged rural people. The majority of them rely on social grants, which restricts them to a narrow food basket that lacks diversity. Under these circumstances, agriculture offers an opportunity to address the availability and accessibility of diverse nutrient-dense foods in economically disadvantaged rural communities. The promotion of household and community food gardens and subsistence farming should be encouraged. From national studies conducted (Shisana *et al* 2013; Labadarios *et al* 2007; Labadarios *et al* 2000), it is evident that dietary intake, habits and patterns and the nutritional status vary across the provinces in SA, as well as across defined population groups within a province. To implement targeted food-based approaches to address malnutrition, the nutritional status of specific provinces and defined local areas within a province should be determined to provide baseline data. In that regard, one of the study objectives was to assess the nutritional status (using selected anthropometric indices and dietary intake methods), of population groups in four, defined rural areas in the local municipalities of uMshwathi, Msinga and eThekwini, in uMgungundlovu and uMzinyathi Districts and the eThekwini metropolitan of the KZN province as the nutritional status of these target population groups were unknown. Vitamin A deficiency is a public health concern and provitamin A-biofortified maize composite dishes and OFSP are being proposed to improve the vitamin A status of these population groups. However, the nutritional composition and consumer acceptance of traditional dishes incorporating PVA-biofortified maize and sweet potato need to be investigated.

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CHAPTER 3

STUDY DESIGN, BACKGROUND TO THE STUDY SITE AND ETHICAL APPROVALS

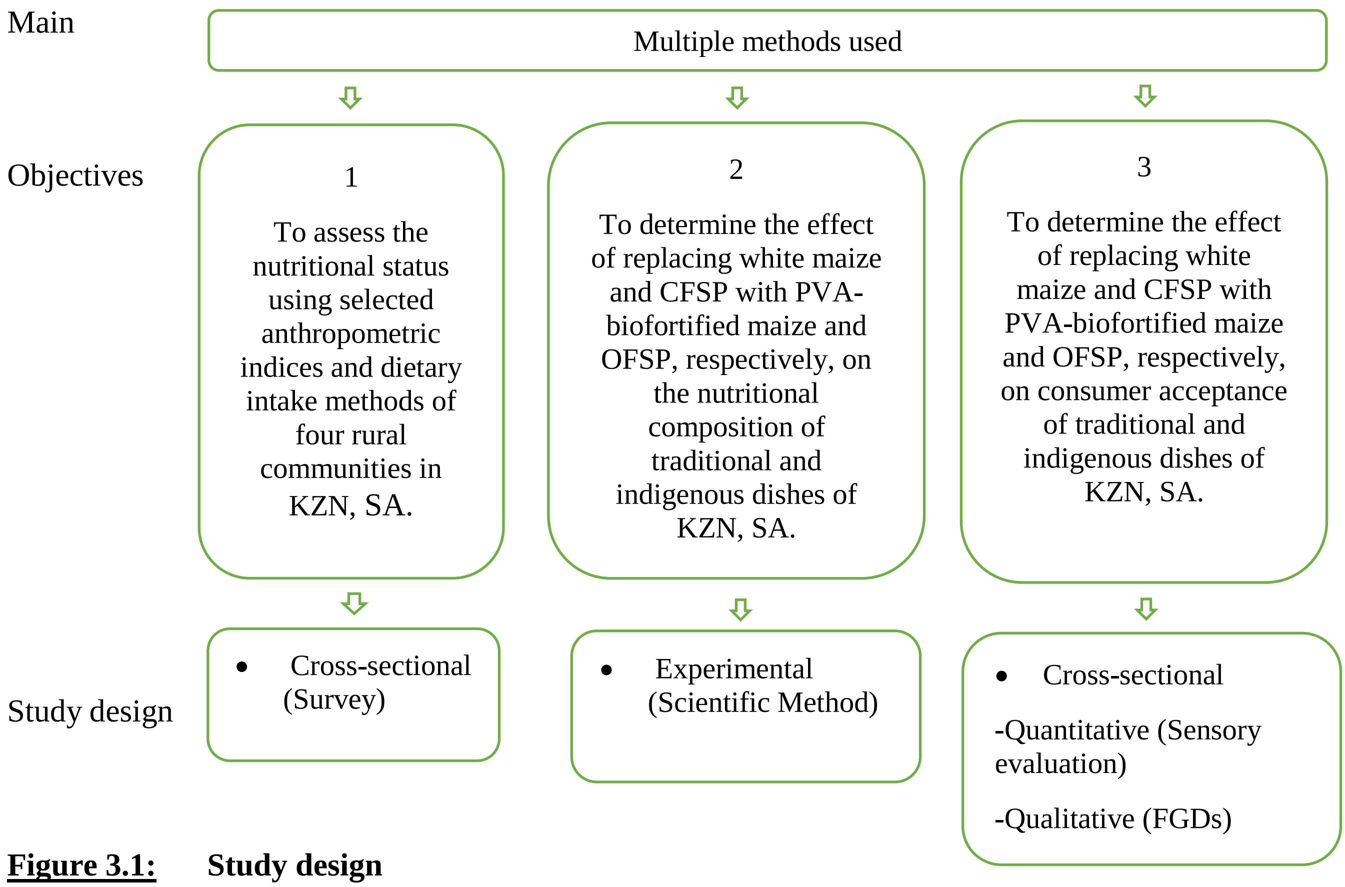
This chapter presents the study design, background to the study site and ethical approvals.

3.1 Study design

This study was a cross-sectional study. It was a cross-sectional study as data was collected at one point in time for each phase of the study. Cross-sectional studies are ideal for investigating the prevalence of many variables in a selected population at one point in time or over a limited period of time (Sedgwick 2014; Levin 2006). This type of study design is most often used in public health research and is cost-effective. Numerous outcomes and variables can be investigated and it is generally quick to conduct. There is no risk of losing participants during the study as it is only conducted at one point in time (Sedgwick 2014; Levin 2006). However, a limitation to this study design is that it gives the researcher data on the population at one point in time only. Therefore, results could vary if investigated at another point in time and there is no follow-up conducted (Sedgwick 2014; Levin 2006).

Quantitative descriptive data for phase 1 and 2 of the study were collected using a survey. A survey is used to collect specific data from a selected population. This survey was conducted using a face-to-face interview. This type of study design allows for standardised information to be collected as each of the participants would be asked the same questions. The advantage of this method is that multi-method data collection can be used, it allows the researcher to have more complex interviews, lower refusal rates, high response quality and the researcher is present during answering of the survey to address any problems that may arise (Owens 2002). The limitations to this are that it can be costly and take a longer time to collect information depending on the length of the survey (Owens 2002).

Phase 2 of the study used an experimental study design and a quantitative approach. Food samples were analysed for their nutritional content. Provitamin A-biofortified *phutu* composite dishes and OFSP were the experimental food samples and white *phutu* composite dishes and CFSP were the control food samples. For the sensory evaluation component of the study, a quantitative analysis of liking and preference of food samples was conducted using a five-point facial hedonic scale (1= very bad; 5= very good) and paired preference test. Qualitative data was obtained for the focus group discussion and thereafter subjected to thematic analysis. Using both quantitative and qualitative methods provides greater insight into the target population and helps to obtain more information on that specific target population so that appropriate interventions can be provided (Almalki 2016). The study design and conceptual framework of the study flow/methodology are illustrated in Figures 3.1 and 3.2, respectively.



<u>Figure 3.1:</u> **Study design**

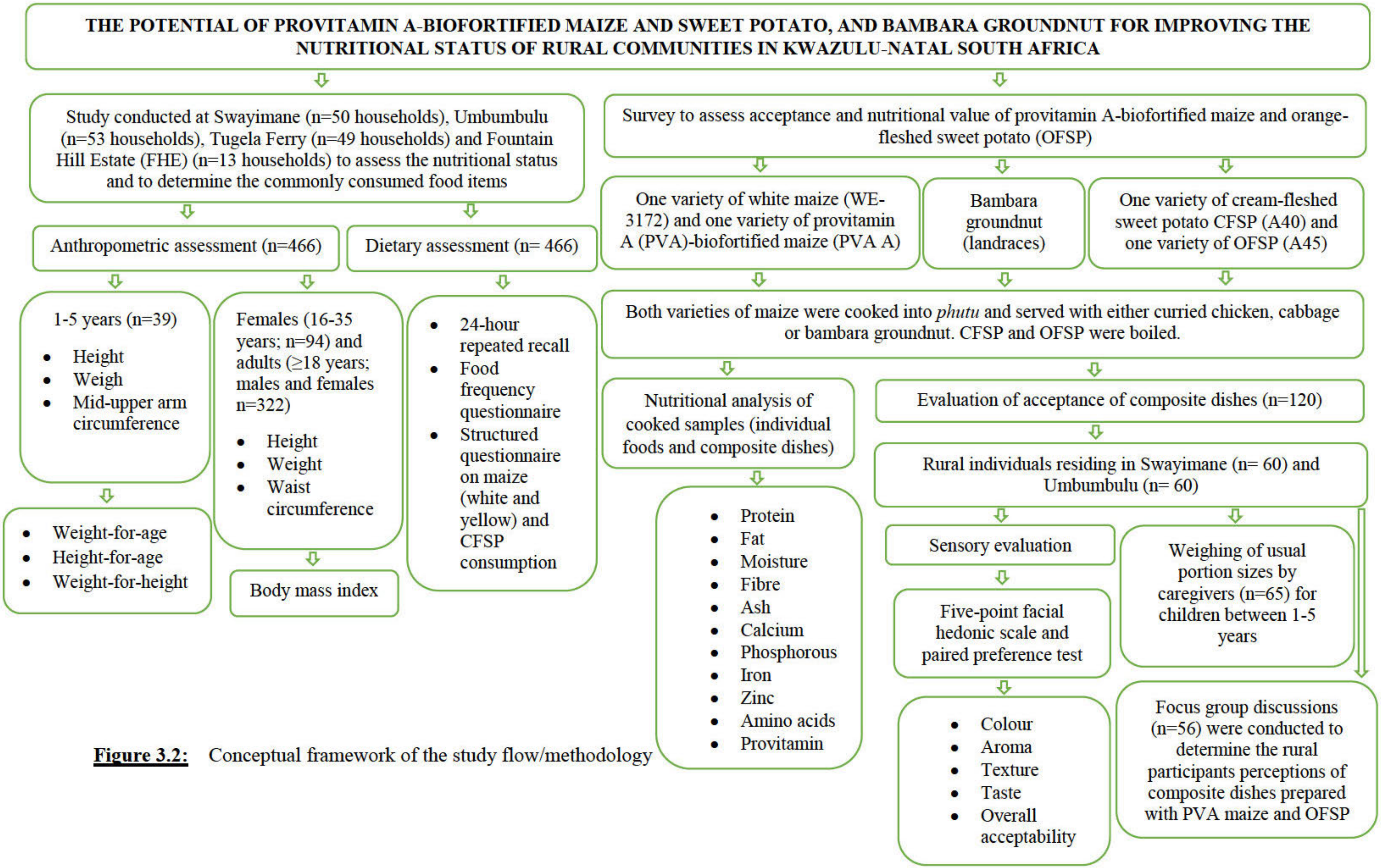


Figure 3.2: Conceptual framework of the study flow/methodology

3.2 Background information on KwaZulu-Natal and research sites

KwaZulu-Natal (KZN) is one of the nine provinces in South Africa (SA) [Department of Health (DoH) 2014]. It covers an area of 92 100 km^2 [Statistics South Africa (Stats SA) 2006]. It forms a border with three other provinces, namely: Eastern Cape, Mpumalanga and the Free State (The Local Government Handbook 2016). Pietermaritzburg is the provincial capital city in KZN, while Durban is the largest city (The Local Government Handbook 2016). Within KZN, there is one metropolitan (eThekwini Metropolitan), 10 districts and 50 municipalities. The districts and their local municipalities within the KZN province are shown in Figure 3.3 and Table 3.1.

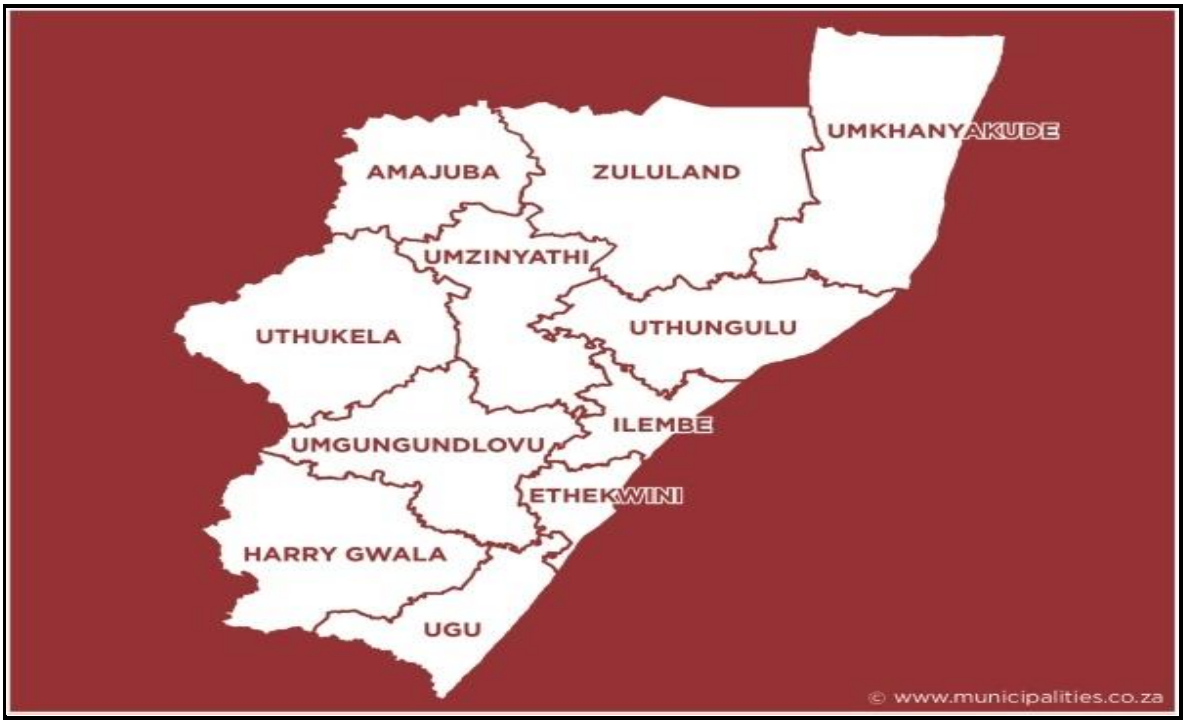


Figure 3.3: Districts of KwaZulu-Natal province (The Local Government Handbook 2016)

Table 3.1: Districts of KwaZulu-Natal province and their local municipalities (The Local Government Handbook 2016; DoH 2014).

DISTRICT	LOCAL MUNICIPALITIES
Ugu	Ezinqoleni, Hibiscus coast, Umdoni, Umuziwabantu, Umzumbe and Vulamehlo
uMgungundlovu	Impendle, Mkhambathini, Mpofana, Msunduzi, Richmond, uMngeni and uMshwathi
uThukela	Emnambiti/Ladysmith, Imbabazane, Okhahlamba and uMtshezi
UMzinyathi	Endumenil, Msinga, Nquthu and Umvoti
Amajuba	Dannhauser, eMadlangeni and Newcastle
Zululand	AbaQulusi, eDumbl, Ulundi and uPhongolo
Umkhanyakude	Hlabisa, Jozini, Mtubatuba, The Big 5 False Bay and uMhlabuyalingana
UThungulu	City of uMhlathuze, Mthonjaneni, Nkandla, Ntambanana, uMfolozi and uMlalazi
ILembe	KwaDukuza, Mandeni, Maphumulo and Ndwedwe
Harry Gwala (previously known as Sisonke)	Greater Kokstad, Ingwe, KwaSani, Ubuhlebezwe and uMzimkulu

KwaZulu-Natal has the second highest total population in SA (Stats SA 2015), with an estimated population size of 11 065 240 people (Stats SA 2016a). This makes up 19.9% of the total population of SA (Stats SA 2016a; DoH 2014). KwaZulu-Natal is comprised of a heterogeneous population from different socio-economic backgrounds (Stats SA 2019a). The language spoken by the majority of the KZN population is isiZulu (82.5%) (Stats SA 2016b). The majority of the population living in KZN are between 15-59 years old. There are more females (52.1%) than males (47.9%) residing in KZN (Stats SA 2016b).

In KZN, there has been a decrease in the number of persons living in informal (8.5%) and traditional (18.1%) dwellings, and an increase in persons residing in formal dwellings (72.7%) (Stats SA 2016a). The 2018 general household survey (GHS) conducted in SA found that an average of six or more people resided in a single household in KZN (Stats SA 2019a).

In 2016, there were 41.3% (n= 6 992 275) female-headed households in SA. KwaZulu-Natal had the third highest percentage of female-headed households (47.4%) (Stats SA 2016a). Within the province, eThekwini (34.8%) had the highest percentage of female-headed households, followed by uMgungundlovu (10.2%) and uThungulu (8.2%). The lowest percentage of female-headed households was recorded in the Amajuba district (4.2%). The increase in the number of female-headed households may be attributed to the migration of males for employment (Stats SA 2016b). A high percentage of the South African population is unemployed and relies solely on grants for income. The number of unemployed individuals in SA increased from 27.2% in 2017 to 29.1% in 2019 (Stats SA 2019b; Stats SA 2017). Additionally, the unemployment rate in KZN increased from 23.0% in 2018 to 25.9% in 2019 (Stats SA 2019b).

In 2019, the GHS indicated that 35.5% of individuals and 57.4% of households received social grants in KZN. Additionally, 51.9% and 3.1% of KZN households relied solely on grant and pension as the main source of income (Stats SA 2019a). Although the 2011 census indicated that the average annual income earned in KZN was R83 050 and the unemployment rate dropped from 39.4% to 33% between 1996 and 2011 (Stats SA 2012), many people still rely on grants for financial support. According to the budget speech of 2020, R445 was allocated for child support grants, R1860 for old age, disability and care dependency grants per month [Republic of South Africa (RSA) 2020]. For economically disadvantaged people who rely solely on grants, the majority of the money received is used to purchase food. With the ongoing rise in food prices, it has become a challenge for economically disadvantaged people to access nutrient-dense foods. As of April 2019, the cost of a food basket in SA had increased to R883.16/month, which may be unaffordable to economically disadvantaged individuals [National Agricultural Marketing Council (NAMC) 2019].

3.2.1 Study sites

Four study sites (Swayimane, Umbumbulu, Tugela Ferry and Fountain Hill Estate) were selected for phase 1 of the study and two study sites (Swayimane and Umbumbulu) were selected for phase 2 of the study. Figure 3.4 illustrates the four study sites selected for the study. As alluded to in Chapter 2, the double burden of malnutrition is prevalent in SA, including KZN. However, the nutritional status of certain areas within KZN is still not known. There is no published data on the nutritional status or dietary patterns of individuals living in the selected research sites, therefore it was imperative to determine this. Furthermore, these study sites were selected as they represent different bioclimatic regions. This was important as this study involved a food-based approach that aimed to introduce biofortified and indigenous crop into the study sites, thus emphasising the importance of agriculture. It is noteworthy that all four sites practiced subsistence farming and Tugela Ferry had irrigation (Mabhaudhi 2020).

3.2.1.1 Swayimane

Swayimane is a rural area in Wartburg (Figure 3.4, A). This area is part of the uMshwathi local municipality and uMgungundlovu District municipality. The uMshwathi municipality has a population of 106 374 people. There is a higher percentage of females (52.5%) than males (47.5%). The majority of the people in this community (population group) are African (95.1%) and the main language spoken is isiZulu (89.6%) (Census 2011a; uMshwathi Municipality 2010/2011).

3.2.1.2 Umbumbulu

Umbumbulu is located 40 km from Durban and forms part of the eThekwini Metro (Figure 3.4, B). Umbumbulu has a population of 2684 people (Census 2011b). There is a higher percentage of females (53.8%) than males (46.2%). The majority of the people in this community are African (98.73%) and the main language spoken in this area is isiZulu (93.4%) (Census 2011b). This study was conducted at Ezigeni location in Umbumbulu.

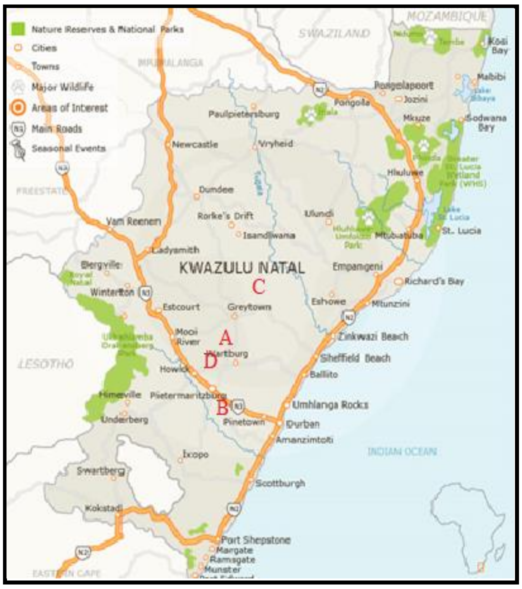


Figure 3.4: Map of KwaZulu-Natal indicating the four research sites [A-Swayimane (29°25′50”S-30°34′32”E), B-Umbumbulu (29°59′0”S-30°42′0”E), C-Tugela Ferry (28° 44' 29.2596"S-30° 27' 14.2560'E), D-Fountain Hill Estate (FHE) (29'27"02.5S- 30'32"42.3E)]

3.2.1.3 Tugela Ferry

Tugela Ferry is a peri-urban settlement, situated on the main R33 road and forms part of the Msinga local municipality and the Umzinyathi district (Figure 3.4, C) (Msinga Local Municipality 2014). The population comprises approximately 177 577 people and 99% of the population live in traditional rural areas. This area has more females (56.6%) than males (43.4%). The most commonly spoken language is isiZulu (96.20%) (Msinga Local Municipality 2014; Census 2011c). Tugela Ferry, Pomeroy and Keate’s Drift are the three main areas in Msinga. The population of Tugela Ferry is 2093 and the majority are African (97.2%)

(Msinga Local Municipality 2014; Census 2011d). Eighteen percent of the income is from farming, 11% from trade and commerce, 10% from manufacturing and construction and 29% of the income are generated from social services and private households. This further indicates the high reliance on social grants for income (Msinga Local Municipality 2014).

3.2.1.4 Fountain Hill Estate

Fountain Hill Estate is a farming estate situated outside Wartburg (Figure 3.4, D). The estate lies in the private Hlambamasoka Game reserve and is a 20 minute drive away from Pietermaritzburg. Mr Ed Gevers who has an M.Sc degree in horticulture [University of KwaZulu-Natal (UKZN) admin 2017], manages FHE. The main agroecosystem noted in FHE are pastures for beef and game, sugar cane and avocados. Eight dams are used during irrigation and the farm relies on dryland production (UKZN admin 2017). Twenty farmworkers reside and work at FHE. These farmworkers are responsible for small-scale agricultural farming and are managed by Mr Ed Gevers. The local language spoken by the farmworkers is isiZulu (Mabhaudhi 2020). The areas that the farmworkers came from, and their financial income were not determined in this study. The farmworkers from FHE were selected for phase 1 of the study as they were involved in agriculture and it was assumed that they would be food secure as they were involved in the production of food. However, research has shown that food insecurity does occur in areas suitable for agriculture. Furthermore, this study was a component of a bigger Water Research Commission (WRC) project that aimed to implement agricultural interventions based on the nutritional status of the farmworkers.

3.3 Approvals to conduct the study

Ethical approval was obtained from the UKZN, Humanities and Social Science Ethics Committee (HSS/0256/016D) (Appendix A). Gatekeeper's permission was obtained from a local authority for Swayimane (Appendix B), Tugela Ferry (Appendix C), Umbumbulu (Appendix D) and FHE (Appendix E). Consent was obtained from recruited participants for each part of the study[9]. A participant consent form was developed in English (Appendix F) and in isiZulu (Appendix G) for interviews. Participant consent forms were developed in English for the sensory evaluation and focus group discussions (Appendix H) and in isiZulu (Appendix I). The consent form was read to the participants in isiZulu so that non-English speaking participants who could not read and write could understand the contents of the consent form.

[9] The first part was the collection of anthropometric and dietary data and the second part was the sensory evaluation, paired preference, focus group discussions and determination of portion sizes.

Thereafter they were shown where to sign or initial on the consent form if they had understood what had been explained. If the study participants did not understand what had been explained, the explanation was repeated. The participants signed the form only after they had understood its contents. In the case of minors, the caregiver gave consent for the minor[10] to participate in the study.

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[10] For the purpose of this study, a minor is any person under the age of 18 years of age.

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CHAPTER 4

ASSESSMENT OF THE NUTRITIONAL STATUS OF FOUR SELECTED RURAL COMMUNITIES IN KWAZULU-NATAL, SOUTH AFRICA

Abstract

All forms of malnutrition are of a serious health concern in developing countries, including South Africa (SA). In SA, the double burden of malnutrition co-exists, and mainly presents as undernutrition in the form of stunting and micronutrient deficiencies, and over-nutrition in the form of overweight and obesity. Vulnerable population groups, including children under the age of five years and pregnant women, are the most affected by malnutrition. Several factors contribute to the double burden of malnutrition. These include poverty, food and nutrition insecurity and lifestyle changes including the replacement of traditional diets with more westernised diets. The objective of the current study was to assess the nutritional status of individuals residing in rural areas of KwaZulu-Natal (KZN), using selected anthropometric indices and dietary assessment methods. Purposive sampling generated a sample of 50 households each in Swayimane, Tugela Ferry and Umbumbulu and 21 households at Fountain Hill Estate. Anthropometric measurements [height, weight, mid-upper arm circumference (MUAC), and waist circumference] and dietary intake data (24-hour repeated recall and food frequency) were collected. The Statistical Package for the Social Sciences (SPSS) version 25 and the Food Finder software of the Medical Research Council (MRC), SA, were used to analyse the dietary intake data, as appropriate. The Estimated Average Requirement (EAR) cut-point method was used to assess the prevalence of inadequate nutrient intake. The results of the study indicated that 17.9 % (n=7), 30.8% (n=12) and 15.5% (n=6) of children under five years were underweight, stunted and overweight, respectively. According to the MUAC measurements, 20.5% (n=8) and 5.1% (n=2) of children under five years had severe acute malnutrition (SAM) and moderate acute malnutrition (MAM), respectively. The Fisher's Exact test found that a significant number (37.5%; n=3) of children with a MUAC below 11.5 cm had a weight-for-height (WFH) Z-score below -3SD of the WHO child growth standards median, indicating severe malnutrition (p=0.046). The majority of the adult participants were either overweight (23.6 %; n=76) or obese (29.5%; n=95), with a higher prevalence of overweight and obesity among females (n=54; 26.1% and n=81; 39.1%, respectively) than males (n=22; 19.1% and n=14; 12.1%, respectively). However, a higher percentage of male adults (12.2%; n=14) were underweight compared to female adults (7.2%; n=15). According

to the Binomial test, a significant number (67.0%; n=213) of adult participants had waist circumference measurements below 88 cm and 102 cm for females and males, respectively ($p<0.05$). The Chi-square test indicated that there was a significant relationship between gender and waist circumference ($p<0.05$). A significant proportion of adult males (92.9%; n=105) had a normal waist circumference and were not at risk of obesity-related diseases, while a significant proportion ($p<0.05$) of adult females (47.3%; n=97) were at risk of obesity-related diseases. Statistical analysis showed that adults that were underweight or had a normal body mass index (BMI) were not at risk for comorbidities and obesity, whilst individuals that were classified as obese class I, II and III had a higher risk for co-morbidities ($p<0.05$). Although not statistically significant, there was a higher prevalence of over-nutrition than undernutrition at all four research sites for females aged 16-35 years old. There was a significant relationship between BMI and the risk associated with a clinically undesirable waist circumference ($p<0.05$). Individuals that were classified as obese class I, II and III was at a significantly higher risk for co-morbidities ($p<0.05$). Results of analysis by the EAR cut-point method indicated that most of the age groups had a high prevalence of inadequate nutrient intake, specifically dietary fibre and several micronutrients, including vitamin A and iron and zinc. Most of the age groups studied frequently consumed food items high in carbohydrates (mainly the cereal grain foods), and low in micronutrients and fibre. The food frequency results indicated that onion, *phutu*, brown bread, tomato, rice, apple, eggs and chicken were the most commonly consumed food items. The study shows that undernutrition, over-nutrition and poor dietary diversity are prevalent in rural KZN. Inadequate nutrient intake was prevalent in most age groups studied. The findings indicate that the nutrition transition has influenced the nutritional status of the rural KZN population groups investigated, thus, there is a need to increase the availability, accessibility, and utilisation of diverse foods through appropriate agricultural and nutritional interventions.

4.1 Introduction

Malnutrition, including both under- and over-nutrition, remains an ongoing challenge worldwide (Development Initiatives 2017), especially in children [Food and Agriculture Organization of the United Nations (FAO), International Fund for Agricultural Development (IFAD), United Nations Children’s Fund (UNICEF), World Food Programme (WFP) & World Health Organization (WHO) 2017]. The 2018 Global nutrition report indicated that stunting and wasting affected 150.8 and 50.5 million children under five years, respectively, while 38.3 million children under the age of five years were overweight (Development Initiatives 2018).

In Africa, the percentage of stunted children under five years of age had increased from 50.6 million in 2000 to 58.7 million in 2017 (Development Initiatives 2018). Child malnutrition is most prevalent in the sub-Saharan African region and there are inter-and-intra-country variations in malnutrition trends (Development Initiatives 2017; FAO *et al* 2017).

As stated in chapter 2, several national studies investigated the nutritional status of the South African population. The 2012 SANHANES-1 study, which investigated the nutritional status of all South Africans, found that underweight (5.5%) and wasting (2.5%) rates had improved in children (Shisana, Labadarios, Rehle, Simbayi, Zuma, Dhansay, Reddy, Parker, Hoosain, Naidoo, Hongoro, Mchiza, Steyn, Dwane, Makoae, Maluleke, Ramlagan, Zungu, Evans, Jacobs, Faber & SANHANES-1 team 2013). While these results showed an improvement compared to previous national studies, the nutritional status of children and other vulnerable population groups such as women of childbearing age is still a cause for concern. The National Food Consumption Survey-Fortification Baseline (NFCS-FB) of 2005 showed that nationally, one out of five and one out of ten South African children were stunted and underweight, respectively (Labadarios, Moodie & Rensburg 2007). The prevalence of stunting among children from the 2012 SANHANES-1 and the 2016 South African Demographic and Health Survey (SADHS), which was 21.6% and 27%, respectively, have worsened since the 2005 NFCS-FB study [National Department of Health (nDoH), Statistics South Africa (Stats SA), South African Medical Research Council (SAMRC) & ICF 2017; Shisana *et al* 2013]. Stunting is a form of undernutrition and can result in fever, dehydration due to diarrhoea, compromised immunity and acute respiratory infections, which could lead to morbidity and mortality [Health Systems Trust (HST) 2016; UNICEF 2016; Escott-Stump 2015, pp28, 645; Manary & Sandige 2008]. This emphasises that stunting is a public health concern (nDoH *et al* 2017; Shisana *et al* 2013; Labadarios *et al* 2007).

National studies conducted in SA between 1994 and 2005 revealed that the prevalence of VAD had doubled amongst children. The 2012 SANHANES-1 study reported that the prevalence of VAD in children was still high, despite a 20% drop since the 2005 NFCS-FB study (Shisana *et al* 2013; Labadarios *et al* 2007; Labadarios, Steyn, Maunder, Macintyre, Swart, Gericke, Huskisson, Dannhauser, Vorster & Nesamvumi 2000; Labadarios & Van Middelkoop 1995). The 2005 NFCS-FB study showed that in children, the intakes of energy and several essential micronutrients including, calcium, iron, selenium, vitamins, D, C and E, riboflavin, niacin, vitamin B_6 and folic acid, was less than two-thirds of the recommended dietary allowance (RDA) (Labadarios *et al* 2007).

Both under- and over-nutrition remain a concern among South African children (Shisana *et al* 2013). Undernutrition leads to several health conditions, including those linked to protein-energy malnutrition (PEM) and micronutrient deficiencies (UNICEF, WHO & World Bank Group 2017; UNICEF 2016; Faber & Wenhold 2007). There are many factors responsible for the vicious cycle of child malnutrition as described by the UNICEF conceptual framework (UNICEF 1998) (Figure 4.1). The main factors include poverty, food and nutrition insecurity, inadequate infrastructure and poor access to health care facilities and limited education (Bain, Awah, Geraldine, Kindong, Siga, Bernard & Tanjeko 2013; Kimani-Murage, Kahn, Pettifor, Tollman, Dunger, Gómez-Olivé & Norris 2010; Chopra, Daviaud, Pattinson, Fonn & Lawn 2009; Manary & Sandige 2008; Smuts, Faber, Schoeman, Laubscher, Oelofse, Benadé & Dhansay 2008).

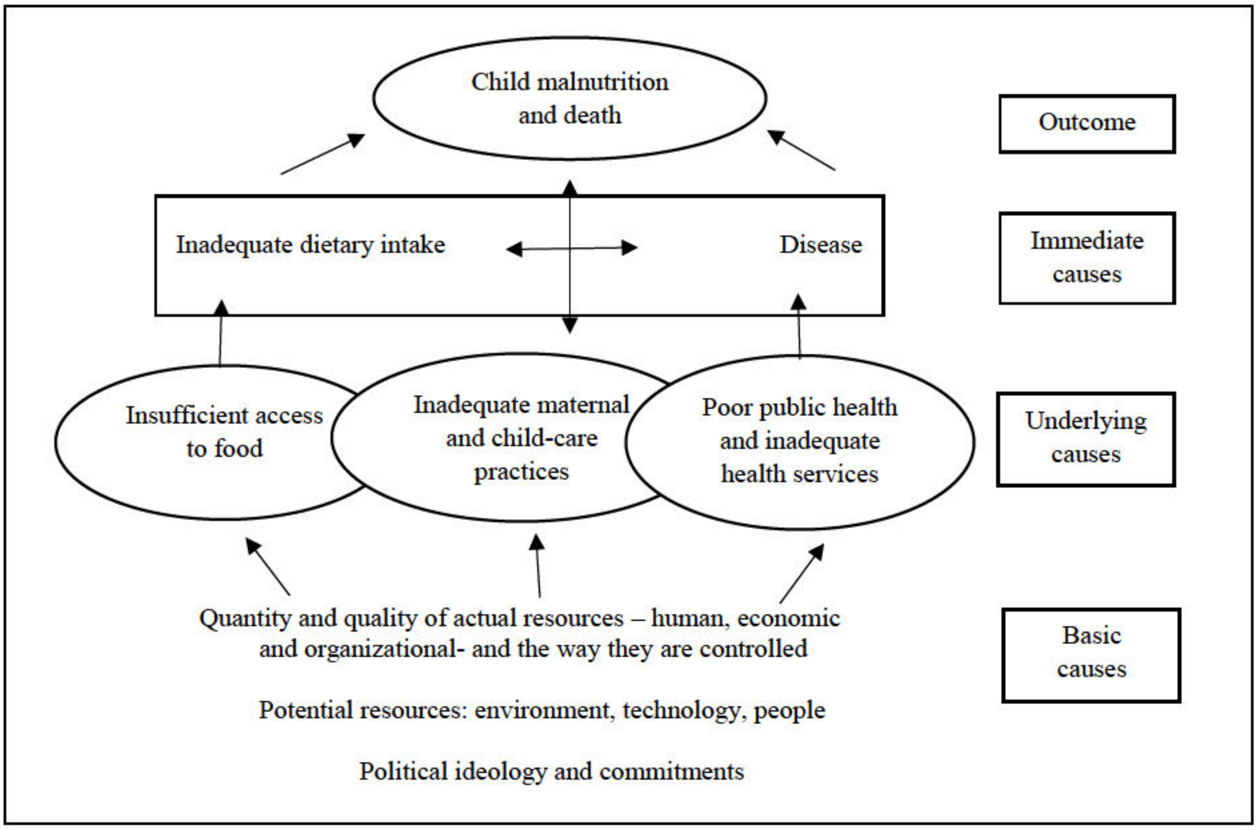

Figure 4.1: The UNICEF conceptual framework illustrating the causes of malnutrition (UNICEF 1998).

There are several possible causes of childhood obesity. These include increased consumption of poor-quality high-energy foods, children born to mothers who were overweight or obese during pregnancy, overweight or obese parents, poor physical activity and metabolic disorders (Escott-Stump 2015, p626). Overweight and obesity are serious health concerns, especially in children, as it increases the risk of other chronic diseases of lifestyle later in life, such as cardiovascular disease, hypertension and diabetes mellitus (Escott-Stump 2015, p626; Joubert, Norman, Bradshaw, Goedecke, Steyn, Puoane & The South African Comparative Group 2007). Stunting in children increases the risk of obesity in adulthood (FAO *et al* 2017).

The 2005 NFCS-FB found that one in ten South African children were overweight (Labadarios, Swart, Maunder, Kruger, Gericke, Kuzwayo, Ntsie, Steyn, Schloss, Dhansay, Jooster, Dannhauser, Nel, Molefe & Kotze 2008). A separate study conducted by Armstrong, Lambert, Sharwood & Lambert (2006), using random sampling in South African children aged 6-13 years in five selected provinces during the Health of the Nation Study (2001-2004), found that the prevalence of overweight and obesity increased with age among African girls. However, the opposite trend was observed with white girls. The combined percentage of overweight and obesity increased from 11.9% in African girls aged six years to 21.8% in African girls aged 13 years (Armstrong *et al* 2006). Similarly, a national study conducted in 2012 in SA, reported that the prevalence of overweight and obesity was lower in boys (11.5% and 4.7%, respectively) than girls (16.5% and 7.1%, respectively). These results were consistent for all age groups. KwaZulu-Natal was one of the provinces with the highest rates of obesity among children. The prevalence of obesity in KZN was 6.1% and 8.5% among boys and girls, respectively (Shisana *et al* 2013). Furthermore, the SADHS study indicated that 13% of children under five years of age were overweight (nDoH *et al* 2017; Shisana *et al* 2013). These studies reiterate that over-nutrition is a serious health concern in children (nDoH *et al* 2017; Shisana *et al* 2013; Armstrong *et al* 2006; Labadarios *et al* 2008).

Over-nutrition is also prevalent among South African adults, especially women. On a national level, the 2016 SADHS indicated that one in five women were severely obese with a BMI > $35kg/m^2$ (nDoH *et al* 2017). The 2012 SANHANES-1 study revealed that the prevalence of overweight and obesity was higher among women (24.8% and 39.2%, respectively), compared to men (20.1% and 10.6%, respectively). The highest prevalence of overweight in men was found in the Western Cape (26.9%), KZN (23.7%) and Gauteng (21.0%). Furthermore, Gauteng (28.1%), Mpumalanga (26.2%) and KZN (25.2%) provinces had the highest prevalence of overweight, while KZN (44.0%), the Free State (43.0%) and the Eastern Cape (41.8%) provinces had the highest prevalence of obesity in SA (Shisana *et al* 2013). There is a high prevalence of overweight and obesity among South African women, which negatively affects their health and nutritional status. Obesity can lead to many health-related issues such as arthritis, sleep apnoea, hypertension, diabetes, heart disease, breast cancer, stroke, gall bladder disease, and non-alcoholic fatty liver disease. Additionally, severely obese individuals are at higher risk of mortality due to the health conditions associated with obesity (Sizer & Whitney 2017, pp345-346). A possible reason for the high rates of obesity seen among the South African population could be as a result of the nutrition transition, whereby refined diets high in sugar, fat and salt have replaced traditional diets, high in fibre (Lutter, Daelmans, De Onis, Kothari, Ruel, Arimond, Deitchler, Dewy, Blössner & Borghi 2011; Schönfeldt, Gibson & Vermeulen 2010; Faber & Wenhold 2007).

In most sub-Saharan African countries, including SA, the majority of rural communities consume diets that are limited in variety and inadequate in fruit and vegetables (WHO 2013). As mentioned earlier, poverty is a major contributing factor to inadequate food intake, which leads to malnutrition. The 2015 statistics indicated that one in every two South Africans is living in poverty, which equates to approximately 30.4 million South Africans [Statistics South Africa (Stats SA) 2017]. Furthermore, South Africans from the African ethnic group are particularly affected by poverty (47-53%) (Argent, Finn, Leibbrandt & Woolard 2009). The largest proportion of economically disadvantaged households are found in the KZN province in SA (Stats SA 2019). Moreover, the KZN province has been one of the poorest provinces in SA since 2011 (Stats SA 2017; Argent *et al* 2009). Economically disadvantaged households are at a high risk of malnutrition, as they cannot afford a diverse diet (Wenhold, Annandale, Faber & Hart 2012; Mabhaudhi, Chibarabada & Modi 2016). Within KZN, in 2018, 51.9% of individuals relied on social grants as a source of income. Social grants such as CSG have become an important income source for economically disadvantaged individuals (Stats SA 2019). The Child Support Grant increased from R430/month in 2019 to R445/month in 2020 [Republic of South Africa (RSA) 2020; RSA 2019]. In some instances, households depend solely on grants for purchasing food. A basic food basket in SA costs approximately R883.16/month and may be unaffordable to many disadvantaged people [National Agricultural Marketing Council (NAMC) 2019]. Several strategies have been proposed to address dietary diversity in economically disadvantaged rural households. These include biofortification and the promotion of underutilised crops that are nutrient-dense (Mabhaudhi *et al* 2016).

It is evident that under- and over-nutrition co-exist in SA. Children are affected by stunting and over-nutrition, whereas adults, especially females, are affected by obesity. The diets consumed, especially by the African rural communities lack dietary diversity. The studies described earlier aimed to determine the nutritional status of the South African population. However, dietary intake and nutritional status vary across the South African provinces, as well as across defined population groups within a province. Nutrition data from specific provinces and defined areas (or population groups) within a province are required, to implement targeted nutritional interventions. From the available literature, it seems that detailed studies of the dietary intake of defined population groups living in specific areas of KZN have not been conducted. To address this shortcoming, the current study aimed to assess the nutritional status of four selected rural communities in KZN, using selected anthropometric indices and dietary assessment methods.

4.2 Methodology

A cross-sectional study design was used for phase 1 of the study. This part of the study aimed to determine the nutritional status of African individuals residing in four rural locations in KZN, using selected anthropometric[11] indices and dietary assessment[12] methods. Purposive sampling was used to generate a sample of 50 households at Swayimane, Umbumbulu and Tugela Ferry and 21 households at Fountain Hill Estate. The sample size of participants was determined for Swayimane, Umbumbulu and Tugela Ferry using convenience sampling. The criteria used for selection of households through purposive sampling was:

- Each study site had a diverse agricultural system and were different bioclimatic regions.
- Individuals from households in Swayimane, Umbumbulu, Tugela Ferry and FHE were from rural areas and were of African ethnicity.
- Specific areas within the target sites were selected:
  - Swayimane: Ward 8
  - Umbumbulu: Exigeni and Ogagwini Villages
  - Tugela Ferry: irrigation scheme and dryland
  - FHE: Farmworkers
- Purposive sampling was used to select households from Swayimane, Umbumbulu and Tugela Ferry to avoid collecting data from extended families and neighbouring households. When the first household was selected, households around that household were not selected as in the areas investigated, these households usually consisted of family members who consumed the same foods. Thus, the next household that was selected was situated a

[11] Weight, height and MUAC measurements were collected from children, while weight, height and waist circumference measurements were collected from adults.
[12] 24-hour repeated recall and a food frequency questionnaire (FFQ).

distance away from the first household selected. This pattern was used to select the households used in the study.

All farmworkers from each household at FHE were selected to participate in the study. All members of the household were invited to participate in the study. However, the following inclusion criteria were used to recruit study participants for different parts of the study. For the food frequency questionnaire (FFQ) and the survey questions, a head of the household or the person responsible for purchasing food items was selected to provide information on food frequency and consumption. Anthropometric measurements and 24-hour repeated recalls were taken from all members of the household. However, the anthropometric results were separated into three categories; children (≥ 1 and ≤ 5 years), adults and women of childbearing age (16-35 years).

Pilot study participants and individuals who were not at home on the first day of data collection were excluded from the study. Specific households were targeted for the pilot study. These households were known to all research assistants and were not visited during data collection for the main study. Members of the household, who were not home on both non-consecutive days of data collection, were excluded as a diet history for two non-consecutive days could not be collected. Children who were at day-care, crèche or on a school feeding program were excluded from the study because caregivers would not know the quantities and types of foods consumed by their children while away from home. As a result, the mothers or caregivers would not have been able to give an accurate 24-hour recall and accurately answer the food frequency questionnaire. Children who were not at a daycare or crèche on the day of data collection or had not attended a school feeding programme the day before were included in the study. Written consent was obtained from all adult participants and caregivers of the children before data collection commenced.

4.2.1 Anthropometry

Anthropometric measurements, which involves measuring the physical attributes of an individual, are one of the easiest, most non-invasive and cost-effective methods to obtain data for assessing the nutritional status of both children and adults [Department of Health (DoH) 2018; Shisana *et al* 2013]. Anthropometric measurements can indicate both under- and over-nutrition in both adults and children. Weight, height, MUAC waist circumference and BMI are common measurements used to assess the nutritional status of both adults and children (DoH 2018; Shisana *et al* 2013).

Four postgraduate students from the University of KwaZulu-Natal (UKZN) and five individuals each from Swayimane, Umbumbulu and Tugela Ferry were extensively trained by the researcher on how to take anthropometric measurements and how to record it on the data collection sheets. A training manual (Appendix J) was developed by the researcher and given to each research assistant to use as a reference during data collection. This was done to ensure that the data was collected correctly. The research assistants were responsible for taking the anthropometric measurements and it took between 5 and 15 minutes to take anthropometric measurements from each child. The trained research assistants collected data from the area that they lived in and the trained research assistants from UKZN assisted at each of the research sites. The trained research assistants from UKZN collected anthropometric data from the FHE farmworkers. The researcher supervised all the research assistants and was actively involved in data collection. The four research assistants from UKZN entered data into a Microsoft Excel spreadsheet and cross-checked the data collection spreadsheets for accuracy and missing data. The researcher conducted a final check of the data collection spreadsheets after the data was entered and cross-checked.

4.2.1.1 Children

Weight, height and MUAC measurements were collected from children ≥ 1 and ≤ 5 years.

Weight

Children in the study were weighed using a Seca 813 scale (GmbH & Co. KG., Hamburg, Germany). The scale was calibrated using a 1 kg packet of porridge at the start of the day, before taking any weight measurements and at the end of the day, after all measurements were taken. The scale read zero before and after each child was weighed. All children were weighed with minimal clothing, including diapers. Children wearing diapers had their diapers changed by their caregivers before the weight measurement was taken. All research assistants followed this standardised procedure and obtained weight measurements to the nearest 100 g. All measurements were taken in triplicate. The World Health Organization (WHO) cut-offs in Table 2.1 (Chapter 2), were used to classify WFA and WFH in this study (WHO 2017).

Length/Height

The length was measured using a Seca 210 (GmbH & Co. KG., Hamburg, Germany) mobile measuring mat for babies and toddlers (< 2 years old) and the height was measured using a Seca 213 (GmbH & Co. KG., Hamburg, Germany) portable stadiometer for children (> 2 years old). The mobile measuring mat was placed on a level sturdy surface before the measurement was taken. The caregiver was asked to remove the child's socks, shoes and any hair ornaments, before the child was placed on the mobile measuring mat. The caregiver placed the child on the mat with the child's head held in a straight position. The research assistant ensured that the child's head was placed against the board. The research assistant then used one hand to hold the child's legs down and the other hand to move the footboard towards the child's heels. The research assistant ensured that the child's knees were not bent during this procedure. If assistance was needed, the research assistant asked the caregiver to help. Trained research assistants measured length in triplicate and measurements were recorded to the nearest 0.1 cm.

When the research assistants measured the standing height, the child stood with his/her feet slightly apart and his/her body in an upright position. The research assistant ensured that the child was relaxed, with their arms at their side. The back of the child's head, shoulders and buttocks were against the board and knees were straight with the child looking straight ahead. The research assistants ensured that the head was in the Frankfort Plane (a horizontal line from the ear canal to the lower border of the eye socket that runs parallel to the board) before the measurement was taken (Lee & Nieman 2010, pp162-163). The child took in a deep breath and the headboard was moved down until it rested firmly on the child's head. For children who could not follow commands, the research assistant pressed the child's tummy gently and moved the headboard down. The height measurement was taken in triplicate to the nearest 0.1cm. The HFA was determined using the height or length measurements. Table 2.2 (Chapter 2) indicates the WHO classification for HFA using Z-scores (WHO 2008a).

Mid-upper arm circumference (MUAC)

The mid-upper arm circumference was taken by research assistants for all children ≥ 1 and ≤ 5 years. A Seca 201 fibreglass non-stretch measuring tape (GmbH & Co. KG., Hamburg, Germany) was used to measure the MUAC. The measurement was taken halfway between the acromion process and the tip of the olecranon process of the left arm. Research assistants ensured that the measuring tape was not too tight or loose when the measurement was taken. All measurements were taken in triplicate to the nearest 0.1 cm. Table 2.3 (Chapter 2) indicates the classification used to assess the MUAC (WHO 2014).

4.2.1.2 Adults

Weight

Weight in adults was measured using a Seca 813 scale (GmbH & Co. KG., Hamburg, Germany). The scale was calibrated using a 1 kg packet of porridge at the start of the day before taking any weight measurements and at the end of the day, after all, measurements were taken. The scale read zero before the participant was weighed. The participant was required to stand in the middle of the scale with his/her feet slightly apart and as still as possible. Similarly, to children, all heavy objects in pockets, excess clothing and shoes were removed before the participant was weighed.

Height

Height was measured in metres (m) using the Seca 213 portable stadiometer (GmbH & Co. KG., Hamburg, Germany). The participant was required to remove hats, hair ornaments and shoes before height was measured. The participant stood in an upright position with his/her feet slightly apart. The participant kept their arms at their side and looked straight ahead. The research assistants ensured that the head was in the Frankfort Plane (a horizontal line from the ear canal to the lower border of the eye socket that runs parallel to the board) before the measurement was taken (Lee & Nieman 2010, pp162-163). The research assistant ensured that the head, shoulders and buttocks were against the board and knees were straight, before the measurement was taken. The participant took in a deep breath and the research assistant moved the headboard down until it rested firmly on the participant’s head. All measurements were taken in triplicate to the nearest 0.1 cm.

Body mass index (BMI)

Weight and height measurements were used to determine body mass index (BMI) for individuals above the age of 18 years. The BMI was calculated by dividing the weight by the height in metres squared. The BMI helps to determine the nutritional status of an individual and risk for obesity-related conditions (Shisana *et al* 2013; Gibson 2005, p262). Table 4.1 indicates the BMI classification for adults ≥ 18 years and Table 4.2 indicates the BMI classification used for individuals >16 and <18 years of age.

<u>Table 4.1:</u> Body mass index classification for adults ≥ 18 years (DoH 2018)

Classification	BMI (kg/m^2)	Risk for co-morbidities
Underweight	< 18.5	Low
Normal	18.5 – 24.9	Average
Overweight	25.0 – 29.9	Increased
Obese class I	30.0 – 34.9	Moderate
Obese class II	35.0 – 39.9	Severe
Obese class III	≥ 40.0	Very severe

Table 4.2: Interpretation of body mass index cut-offs for individuals >16 and <18 years of age (WHO 2017).

Classification	Standard deviation (SD)
Severely underweight	< -3SD
Moderately underweight	< -2SD
Normal	< -2SD < +1SD
Overweight	>+ 1SD
Obese	>+ 2SD

Waist circumference

Waist circumference measurements were taken at the umbilicus level (at the navel) for all participants. A Seca 201 fibreglass non-stretch measuring tape (GmbH & Co. KG., Hamburg, Germany) was placed in a horizontal plane over the navel of the participants, who wore a light layer of clothing when the measurements were taken. Waist circumference measurements were taken to the nearest 0.1 cm, in triplicate. A waist circumference greater than 88 cm in females and greater than 102 cm in males indicates risk for co-morbidities, including obesity (WHO 2008b; Gibson 2005, p282). This classification was used to determine the risk for co-morbidities in this study

4.2.2 Dietary intake

4.2.2.1 24-four-hour repeated recall method

In this study, a 24-hour repeated recall method was used to assess the dietary intake of the target group at a nutrient level. The repeated 24-hour recall method has been successfully used by many researchers to obtain dietary information (Sheehy *et al* 2013; Faber *et al* 2013; Oldewage-Theron & Kruger 2008). This method was selected as it gives a better description of an individual's usual intake, it is relatively quick and inexpensive, can be used to collect information from individuals that cannot read and/or write and data can be collected from the participant’s home, thus no travelling is required for the participant (Coulston, Boushey & Ferruzzi 2013, p8; Lee & Nieman 2010, p74; Gibson 2005, pp 43-44). Trained research assistants interviewed the selected household members to obtain information about the types of foods consumed by individuals over the age of one year, over 24 hours for two non-consecutive days. This data set was collected randomly[13] on all days of the week, including weekends. The primary caregiver was interviewed in the case of children under four years of

[13] There was no specific day allocated for each research assistants to collect data. Data was collected on any day of the week as long as it was two non-consecutive days.

age. Children between 4-8 years of age were interviewed together with their primary caregiver. The information obtained from the 24-hour recall included portion sizes, preparation methods and ingredients used. Portion sizes were determined using measuring cups, plates of different sizes, cups, mugs, glasses, measuring spoons, dishing spoons and rulers. The number of 24-repeated recalls obtained from each household varied depending on the number of individuals living in that particular household. The first step of the 24-hour recall was to determine the time of day and place that the food was consumed. The participants were then asked to list the foods that they consumed at the times documented. Thereafter, participants were asked to describe the preparation methods used to prepare the meals. Participants then provided the research assistants with household measures used to serve the meals, so that portion sizes could be determined. Participants indicated to the research assistant whether this was the usual diet followed. Lastly, participants and caregivers were asked if they gave their children any vitamins or mineral supplements including those collected from clinics or hospitals. This was done because the vitamins or mineral supplements would need to be included in the analysis of dietary intake. The 24-hour recall was conducted using standardised methods, similar to previous studies (Fagúndez, Torres, Sánchez, de Torres Aured, Rodrigo & Rocamora 2015; Sheehy, Kolahdooz, Mtshali, Khamis & Sharma 2013; Faber, Laubscher & Laurie 2013; Spearing, Kolahdooz, Lukasewich, Mathe, Khamis & Sharma 2012; Faber & Kruger 2005). It took the research assistants between 20-40 minutes to administer each 24-hour recall.

4.2.2.2 Qualitative food frequency questionnaire[14]

A food frequency questionnaire is used to assess the frequency with which foods are consumed (Rodrigo, Aranceta, Salvador & Varela-Moreiras 2015). In the current study, a qualitative FFQ was used to collect data to validate the 24-hour recall data (Fagúndez *et al* 2015; Faber *et al* 2013; Faber & Kruger 2005). The FFQ comprised of a list of 94 food items, subdivided into the following groups; cereals and grains, bread, biscuits and snacks, starchy vegetables, starchy foods prepared with fats, fruit, milk and milk products, vegetables, meat and meat substitutes, fats and other carbohydrates. Foods included in the FFQ were commonly consumed food items in SA and culturally acceptable food items in KZN. The frequency was indicated next to each food item listed. The frequency options were; never or less than once a month, 1-3 times a month, 2-4 times a week, 5-6 times a week, 7 times a week, 2-3 times a day, 4-5 times a day or more than 6 times a day. The food frequency questionnaire that was developed was similar

[14] Dietary intake was assessed on a food level (no nutritional analysis was conducted on the food items obtained from the food frequency).

to those used in other studies (Rodrigo *et al* 2015; Coulston *et al* 2013, p9). The trained research assistants recorded the responses of the study participants in the food frequency questionnaire. The limitation to using a FFQ is that it does not always provide the most accurate information as participants can under or over report consumption frequency of a specific food item (Steinemann, Grize, Ziesemer, Kauf, Probst-Hensch & Brombach 2017). Thus, the FFQ was not used on its own but together with a 24-hour recall.

4.2.3 Pilot study

A sample of 18 households was used for the pilot study. The pilot study was conducted to test the feasibility of the study design and the appropriateness of the questionnaires. This allowed for appropriate changes to be made before the main study was conducted. Anthropometric measurements (weight, height and MUAC for children and weight, height and waist circumference for adults) and dietary intake data (24-hour recall and food frequency) were collected at two selected sites (Swayimane and Tugela Ferry). The researcher supervised four research assistants from UKZN on a one-on-one basis during the pilot study to ensure that the correct techniques for collecting anthropometric measurements and dietary intake were being followed. A post-pilot training session was conducted to revise the correct procedures to be followed during data collection. Each research assistant received a training manual at the start of the training session (Appendix J).

4.2.3.1 Findings of the pilot study and consequent changes made to the methods

Several problems were encountered during the pilot study. Areas and households from Swayimane and Tugela Ferry were a far distance away from each other. More time was spent travelling to research sites and less time on data collection. For the main study, five local members each from Swayimane, Umbumbulu and Tugela Ferry were employed to assist with data collection. These members were extensively trained to collect data accurately. This saved on travelling time and more households were reached in a shorter space of time. The recruited research assistants resided in different areas within the study sites, which allowed for more households to be reached. Another problem encountered was that there were only one or two people available in some households, as the members of the household were working or had gone out. To overcome this, the 15 research assistants (as explained above) from Swayimane, Umbumbulu and Tugela were recruited to assist with data collection, which resulted in more members of the household being interviewed at a given time. To ensure that data was collected accurately the trained research assistants from UKZN collected data together with the five research assistants from the local community and helped supervise the community research assistants. All research assistants were supervised by the researcher who was at all research sites to answer any questions and address any problems. The last problem encountered was that the large volume of paperwork involved was confusing to the research assistants. The loose pieces of paper could easily be misplaced. For the main study, data collection sheets were printed in a booklet for each household. This minimised confusion concerning the information that needed to be collected. A training manual (Appendix J) was developed and given to each research assistant to use as a reference during data collection. There were no problems with obtaining the anthropometric measurements, 24-hour recall or FFQ. All foods consumed by the households were found in the FFQ and no substitutes were used.

4.2.4 Data analysis

4.2.4.1 Anthropometry

Only the four trained research assistants[15] from UKZN captured the data onto Microsoft Excel spreadsheets. Each research assistant was responsible for entering data for an allocated research site and the data entry was cross-checked by another research assistant to ensure accuracy of data entry. The researcher conducted a final check of the Microsoft Excel data collection spreadsheets once the data was entered and cross-checked to ensure accuracy of the data entry. All data were entered into two password-protected computers and all Microsoft Excel spreadsheets were password-protected. During data entry, the research assistants and the researcher had access to the passwords and post data entry all passwords were changed and only the researcher had access to these documents. The means and standard deviations for weight, height, MUAC and waist circumference were calculated using Microsoft Excel. The BMI was calculated using the equation, BMI = weight (kg)/height (m)^2. The BMI value obtained was coded and interpreted using the BMI classification (Table 4.1 and Table 4.2) (DoH 2018; WHO 2017).

4.2.4.2 Dietary intake data

The repeated 24-hour recall data was captured onto the Food Finder version 3 software programme of the Medical Research Council (MRC), SA, to determine the nutrients consumed over the two non-consecutive days. The researcher captured all data from the 24-hour recalls for each site into the Food Finder version 3 software programme. Nutrient values for fortified

[15] The researcher trained research assistants from UKZN on how to enter data onto Excel spreadsheets and how to interpret the coded data.

maize and bread were obtained from Food Finder. Data from Food Finder was exported to Microsoft Excel and mean daily nutrient intakes and standard deviations were calculated. Of the four Dietary Reference Intakes (DRIs), the Estimated Average Requirement (EAR) and Adequate Intake (AI) were used to assess the nutrient intake. The EAR was selected as it is the recommended DRI for assessing the nutritional status of population groups, defined by demographic profiles, including age, gender and lifecycle stage (Institute of Medicine 2006, p10). The EAR is the amount of a nutrient that is estimated to meet the needs of 50% of people in a defined population group and can be used to estimate the prevalence of inadequate nutrient intakes (EAR cut-point method). The EAR cut-point method can be used for most nutrients, except energy, as energy intake and expenditure are highly related (Murphy, Guenther & Kretsch 2006; Institute of Medicine 2001a, pp81-88). The AI values were used for nutrients without an EAR. The AI is based on observed or experimentally determined estimates of the average nutrient intake of an apparently healthy population group. It is assumed that if the nutrient intake is above the AI, there is a low risk for inadequate intake (Institute of Medicine 2006, p19; Murphy *et al* 2006; Institute of Medicine 2001a, p110).

4.2.4.3 Statistical analysis

Data were analysed using the Statistical Package for the Social Sciences (SPSS) version 25 (SPSS Inc., Chicago, IL, USA). Descriptive statistics, including means, standard deviations and frequencies, were computed where applicable. The Chi-square test was used to analyse for relationships among anthropometric data: BMI, WFH, BMI-for-age and MUAC. The Chi square test was used to determine whether there were significant associations among the categorical variable responses selected. The binomial test was used to test whether a significant proportion of respondents selected one of two possible responses. When conditions were not met, the Fisher's Exact Test was used. The Chi-square test was also used to analyse for associations between anthropometric data and gender and age. The Fisher's exact test was used for MUAC and gender, MUAC and WFH and BMI and waist circumference. A p-value of <0.05 was considered statistically significant.

4.2.5 Ethical considerations

Ethical approval was obtained from the UKZN, Humanities and Social Science Ethics Committee (HSS/0256/016D) (Appendix A). Gatekeeper's permission was obtained from Swayimane (Appendix B), Tugela Ferry (Appendix C), Umbumbulu (Appendix D) and Fountain Hill Estate (FHE) (Appendix E). Each participant was required to sign a consent form before participating in the study (English version: Appendix F; isiZulu version: Appendix G). In the case of minors, the caregiver gave consent for the minor[16] to participate in the study. The consent form was read to the participants in isiZulu so that non-English speaking participants who could not read and write could understand the content of the consent form. Thereafter, they were shown where to sign or initial on the consent form if they had understood what had been explained. If the study participants did not understand what had been explained, the explanation was repeated. The participants signed the form only after they had understood its contents.

4.3 Results

4.3.1 Demographic characteristics

The demographic characteristics of the study participants are presented in Table 4.3. Of the 466 participants (both adults and children) who participated, 63.7% (n=297) were female and 42.9% (n=200) were from Umbumbulu. Most of the participants were between 19-30 years (23.6%; n=110) and 31-50 years (20.2%; n=94), and the least number of participants were over 70 years old (3.2%; n=15). One hundred and sixty-five households participated in the study (Table 4.4).

[16] For the purpose of this study, a minor is any person under the age of 18 years.

Table 4.3: Demographic characteristics of study participants (n=466)

Characteristics	n	%*
Gender		
Male	169	36.3
Female	297	63.7
Participant distribution by study site **		
Swayimane	139	29.8
Umbumbulu	200	42.9
Tugela Ferry	114	24.5
Fountain Hill Estate***	13	2.8
Age (years)		
1-3	16	3.4
4-8	59	12.7
9-13	51	10.9
14-18	50	10.7
19-30	110	23.6
31-50	94	20.2
51-70	71	15.2
70+	15	3.2

***** Percentage of sample (n=466).

****** The distribution of participants are different in each research site as each household had a different number of participants.

******* All participants from Fountain Hill Estate were adult farmworkers.

Table 4.4: Household distribution by study site (n=165)

Study sites	n	%*
Swayimane	50	30.3
Umbumbulu	53	32.1
Tugela Ferry	49	29.7
Fountain Hill Estate	13	7.9

***** Percentage of sample (n=165).

4.3.2 Anthropometry

4.3.2.1 Children

Weight, height and MUAC were measured in triplicate and the mean was calculated. The weight and height were used to classify WFA, HFA and WFL/WFH in children above one year and under five years of age. The WFL/WFH was used to determine the WHO Z-scores. The WHO classification was used to classify the degree of malnutrition in children. Results obtained are presented in Figure 4.2 (weight-for-age classification), Figure 4.3 (height-for-age classification), Figure 4.4 (weight-for-length classification), and Figure 4.5 (MUAC classification) for children 1-5 years (n=39).

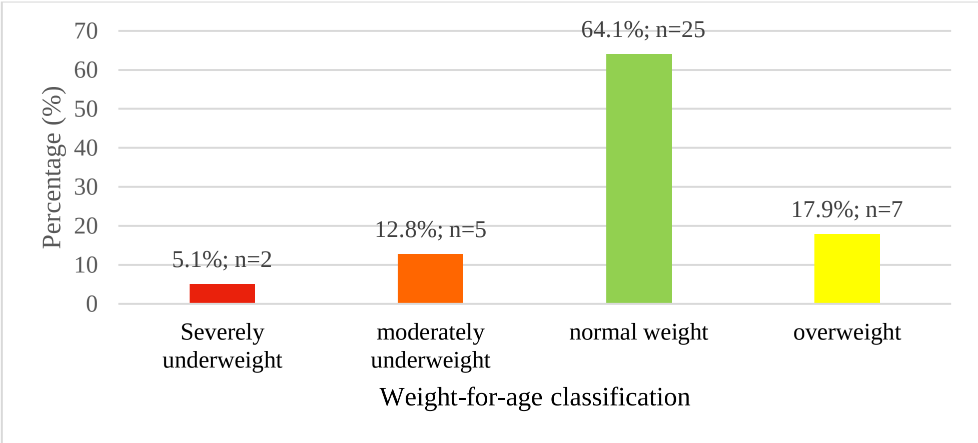

Figure 4.2: Weight-for-age classification for children 1-5 years (n=39)

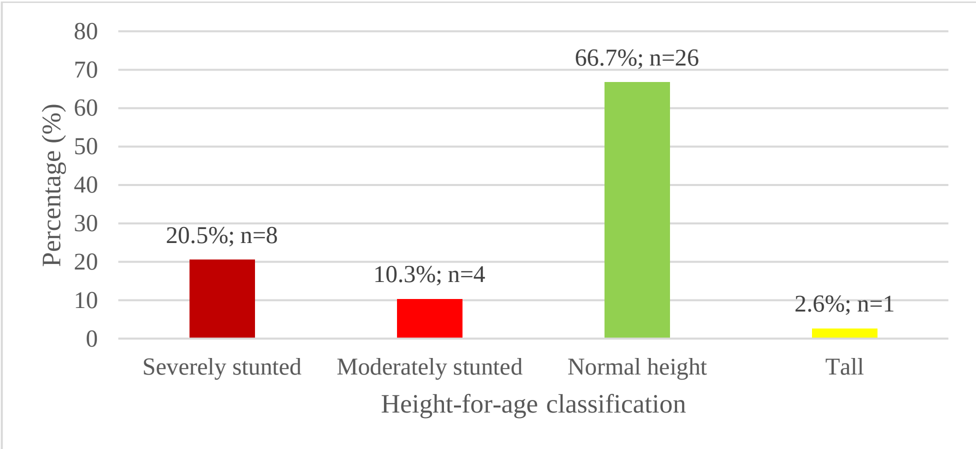

Figure 4.3: Height-for-age classification for children 1-5 years[17] (n=39)

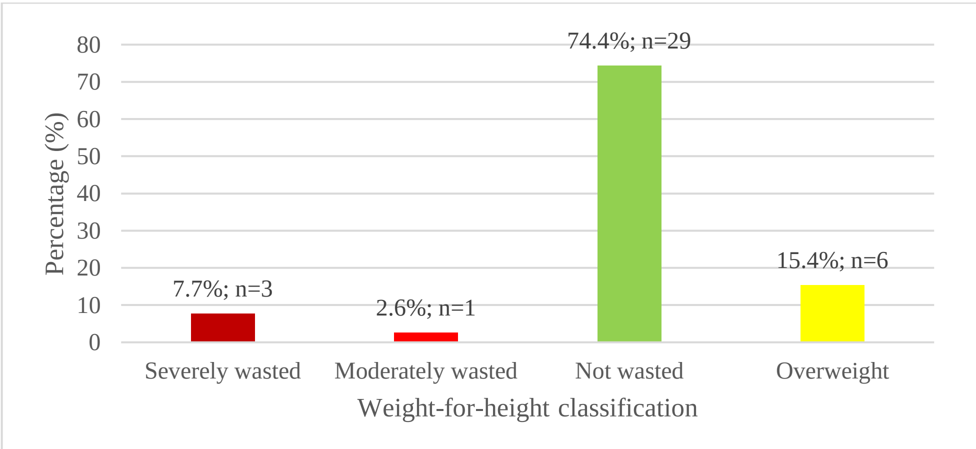

Figure 4.4: Weight-for-height classification in children 1-5 years (n=39)

[17] Children under five years with a HFA greater than the +3SD were classified as tall.

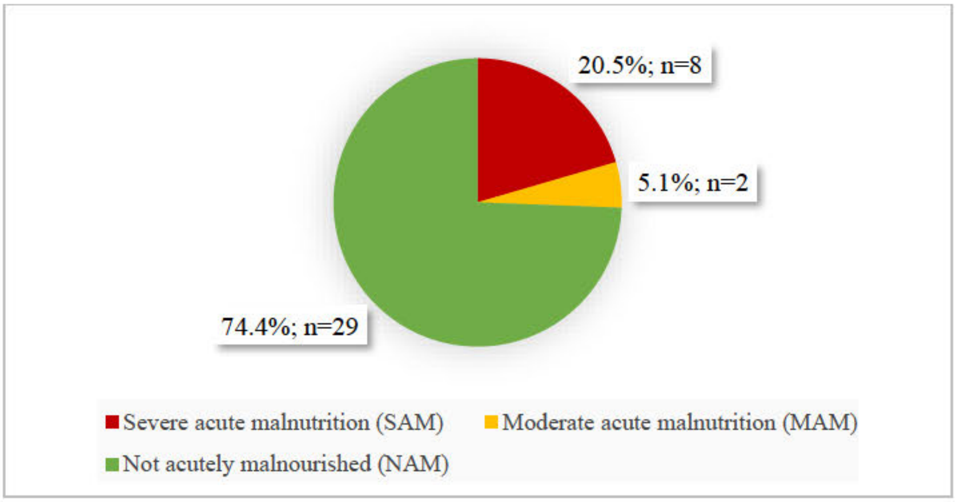

Figure 4.5: Classification of degree of malnutrition using mid-upper arm circumference in children 1-5 years (n=39)

Although not statistically significant, 30.8% (n=12) of children under five years were stunted (Figure 4.3) and 15.4% (n=6) of children under five years were overweight (Figure 4.4). According to the Fisher's exact test, there was a significant relationship ($p<0.05$) between the MUAC and WFH classification for children aged 1-5 years. A significant number (37.5%; n=3) of those with a MUAC below 11.5 cm had a WFH Z-score below -3SD, indicating severe acute malnutrition ($p=0.046$).

4.3.2.2 Adults

BMI

Mean weight and height measurements were used to calculate BMI for adults. BMI distribution for all adults (Figure 4.6) and BMI classification by gender were determined (Table 4.5). Although not significantly different, it is important to note that there was a higher prevalence of over-nutrition than undernutrition at all four research sites (Figure 4.6). The majority of the study participants were either overweight (23.6 %; n=76) or obese (29.5%; n=95), with a higher prevalence of overweight and obesity among females than males. However, the prevalence of underweight was higher in males (12.2%) than females (7.2%). A significant number ($p<0.05$) were found to be normal (n=122; 37.9%).

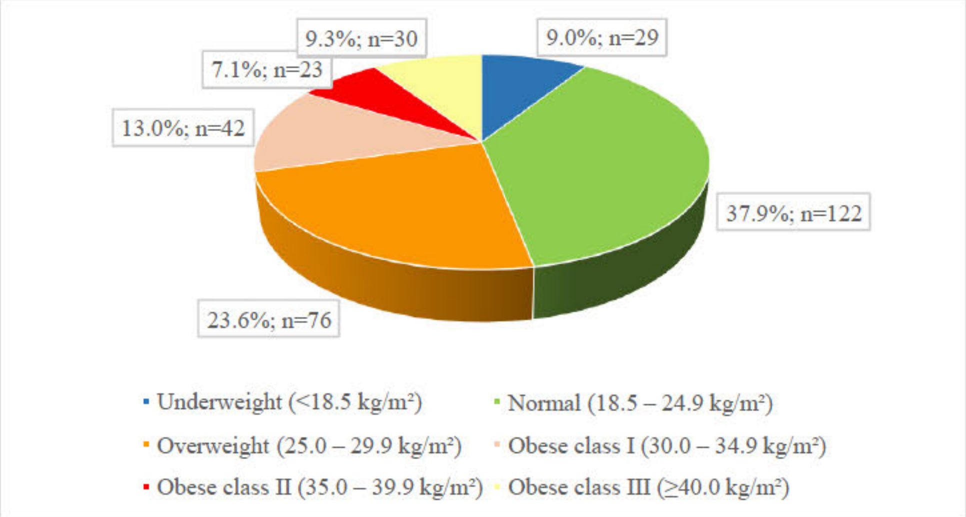

Figure 4.6: Distribution of body mass index for adults from four rural areas of KwaZulu-Natal (n=322)

Table 4.5: Body mass index classification for adults ≥ 18 years by gender (n=322)

	BMI classification (n=322)					
Gender	**Underweight (<18.5 kg/m²)**	**Normal (18.5 – 24.9 kg/m²)**	**Overweight (25.0 – 29.9 kg/m²)**	**Obese class I (30.0 – 34.9 kg/m²)**	**Obese class II (35.0 – 39.9 kg/m²)**	**Obese class III (≥40.0 kg/m²)**
Male (n=115)	14[a] (12.2%)[b]	65 (56.5%)	22 (19.1%)	9 (7.8%)	3 (2.6%)	2 (1.7%)
Female (n=207)	15[c] (7.2%)[d]	57 (27.5%)	54 (26.1%)	33 (15.9%)	20 (9.7%)	28 (13.5%)

BMI=Body mass index; [a] Number of males; [b] Percentage of males; [c] Number of females; [d] Percentage of females

Waist circumference

Figure 4.7 indicates waist circumference classification for adults ≥ 18 years by gender. The total number of weight circumference measurements obtained was lower than the total number of BMI measurements obtained, as the waist circumference measurements were either missing or not taken correctly. The measurements that were not taken correctly were discarded. According to the binomial test, a significant number (67.0%; n=213) had waist circumference measurements below 88 cm and 102 cm for females and males, respectively ($p<0.05$). The Chi-square test of independence indicated that there was a significant relationship between gender and waist circumference ($p<0.05$). A significant proportion of males (92.9%; n=105) had a normal waist circumference and were not at risk for obesity-related diseases, while 47.3% of females (n=97) were ($p<0.05$).

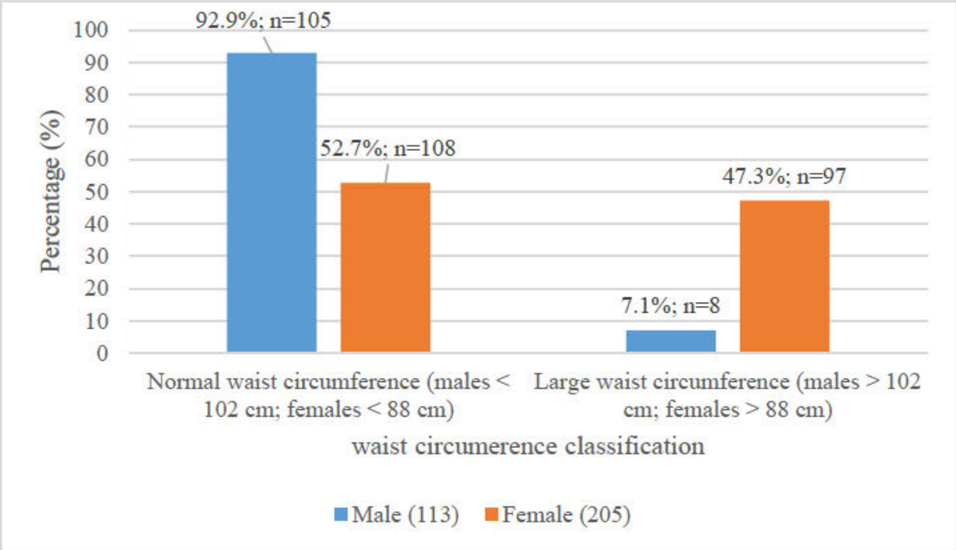

Figure 4.7: Waist circumference classification for adults ≥ 18 years by gender (n=318)

Overweight and obesity

There was a significant relationship between BMI and risk for co-morbidities associated with waist circumference ($p<0.05$). Underweight and normal BMI was not associated with risk for co-morbidities and obesity, while individuals that were classified as obese class I, II and III had a high risk for co-morbidities.

4.3.2.3 Women of child-bearing age (16-35 years)

Body mass index (Figure 4.8) and waist circumference (Figure 4.9) were determined for women aged 16-35 years to classify their nutritional status. Although not statistically significant, there was a higher prevalence of over-nutrition compared to undernutrition at all four research sites for females aged 16-35 years old (Figure 4.8).

Overweight and obesity

There was a significant relationship between BMI and risk associated with waist circumference ($p<0.05$). Individuals that were classified as obese class I, II and III was at high risk for co-morbidities according to waist circumference measurements (Figure 4.9).

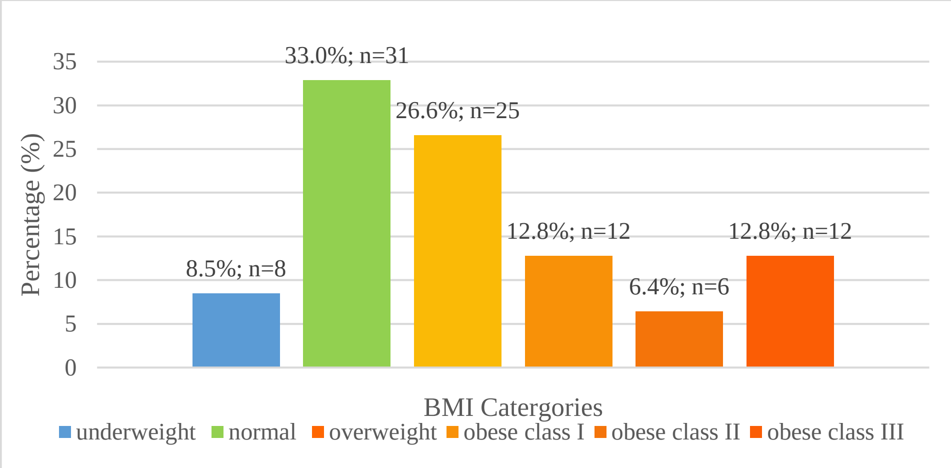

Figure 4.8: Distribution of body mass index for females aged 16-35 years (n=94)

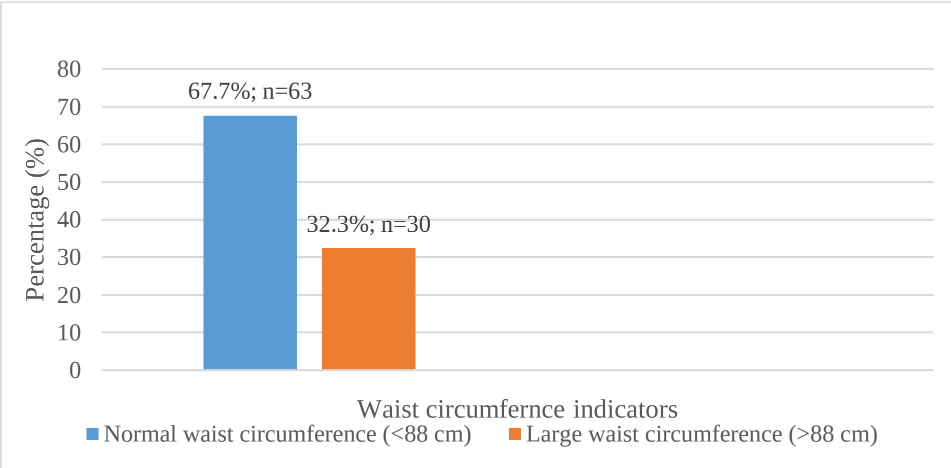

Figure 4.9: Waist circumference classification for females aged 16-35 years (n=93)

4.3.3 Dietary assessment

4.3.3.1 24-hour repeated recall

The 24-hour repeated recalls were analysed using the MRC Food Finder software and the mean nutrient intakes were compared with the EAR, AI and estimated energy requirement (EER), where relevant. The participants were divided into different age categories to determine the prevalence of inadequacy using the EAR cut-point method. The prevalence of inadequacy was considered high if the percentage of inadequacy was above 50%. The mean calcium and vitamin D values were compared against the AI value as there was no EAR value available for these nutrients. Assumptions were not made about the prevalence of inadequacy for calcium and vitamin D when the mean values were below the AI value. Results from the 24-hour repeated recall are presented in Tables 4.6-4.12. The average EER value for specific age groups was compared to the mean energy value for that age group to determine the percentage of EER met for each age group (Table 4.13). Table 4.14 indicates the prevalence of inadequate and adequate nutrient intake for each age and gender group.

The prevalence of inadequate intake of calcium and vitamin D could not be determined for all groups as the mean values for these nutrients were below the AI value, except for the 9-13 year old males. From the results, it can be assumed that the males, 9-13 years old, consumed adequate amounts of vitamin D.

Table 4.6: Comparison of mean nutrient intake with the EAR/AI from two 24-hour repeated recalls for children aged 1-3 years (n=16) and 4-8 years (n=59)

Nutrient	**1-3 YEARS**						**4-8 YEARS**					
	Mean nutrient intake (SD)	**EAR[a-d]**	**AI[e]**	**Percentage of EAR**	**Prevalence of inadequate intake (%)**	**p value[*]**	**Mean nutrient intake (SD)**	**EAR[a-d]**	**AI[e]**	**Percentage of EAR**	**Prevalence of inadequate intake (%)**	**p value[*]**
Total protein (g)	28.2 (30.0)	11	-	256	31.3	**0.036**	35.2 (14.0)	15	-	235	3.4	**< 0.05**
Carbohydrates (g)	105.9 (46.4)	100	-	106	50.0	0.618	166.6 (51.3)	100	-	167	5.1	**< 0.05**
Dietary fibre (g)	8.6 (4.1)	19	-	45	100.0	**<0.05**	11.7 (7.0)	25	-	47	93.2	**< 0.05**
Calcium (mg)	165.3 (89.0)		500			**<0.05**	297 (209.2)		800			**< 0.05**
Magnesium (mg)	115.4 (58.6)	65	-	178	6.3	**0.004**	157.6 (58.3)	110	-	143	16.9	**< 0.05**
Phosphorus (mg)	416 (287.8)	380	-	110	31.3	0.624	578.1 (239.4)	405	-	143	25.4	**< 0.05**
Iron (mg)	3.8 (2.6)	3	-	127	50.0	0.216	5.7 (3.3)	4.1	-	139	33.9	**< 0.05**
Zinc (mg)	4 (4.4)	2.5	-	160	43.8	0.199	4.2 (1.6)	4.0	-	105	54.2	0.272
Thiamine (mg)	0.5 (0.3)	0.4	-	20	50.0	0.400	0.7 (0.3)	0.5	-	140	30.5	**< 0.05**
Riboflavin (mg)	0.4 (0.232)	0.4	-	100	68.8	0.759	0.6 (0.4)	0.5	-	120	52.5	0.060
Niacin (mg)	6.5 (6.8)	5	-	130	68.8	0.404	9.2 (5.0)	6	-	153	27.1	**< 0.05**
Vitamin B6 (mg)	0.6 (0.4)	0.4	-	150	43.8	0.123	0.9 (0.5)	0.5	-	180	20.3	**< 0.05**
Folate (µg)	88.8 (54.6)	120	-	74	62.5	**0.037**	142.3 (92.8)	160	-	89	66.1	0.149
Vitamin B12 (µg)	2.3 (3.1)	0.7	-	329	50.0	0.**054**	3.3 (4.6)	1	-	330	91.5	**< 0.05**
Vitamin C (mg)	32.3 (36.1)	13	-	249	37.5	**0.049**	57.5 (154.1)	22	-	261	52.5	0.082
Vitamin A (µg)	198 (205.1)	210	-	94	68.8	0.818	183.1 (111.6)	275	-	67	78	**< 0.05**
Vitamin D (µg)	2.7 (3.0)	-	5.0	-	-	**0.008**	3.1 (3.5)		5.0	-	-	**< 0.05**
Vitamin E (mg)	2.8 (2.9)	5	-	56	81.3	**0.009**	5.9 (4.3)	6	-	98	59.3	0.856
Vitamin K (µg)	16.2 (22.3)	30	-	54	81.3	**0.026**	76.1 (118.6)	55	-	138	67.8	0.177

[a] Institute of Medicine 2003; [b]Institute of Medicine 2001b; [c]Institute of Medicine 2000; [d]Institute of Medicine 1998; [e]Institute of Medicine 1997; SD: standard deviation; EAR: estimated average requirement; AI: adequate intake; * p values given in bold font indicate that the mean nutrient intake is significantly different from the EAR/AI.

Table 4.7: Comparison of mean nutrient intake with the EAR/AI from two 24-hour repeated recalls for female children aged 9-13 years (n= 37) and male children aged 9-13 years (n=14)

Nutrient	**Females**						**Males**					
	Mean nutrient intake (SD)	**EAR[a-d]**	**AI[e]**	**Percentage of EAR**	**Prevalence of inadequacy (%)**	**p value[*]**	**Mean nutrient intake (SD)**	**EAR[a-d]**	**AI[e]**	**Percentage of EAR**	**Prevalence of inadequacy (%)**	**p value[*]**
Total protein (g)	45.7 (20.2)	28	-	163	29.7	**<0.05**	47.5 (21.0)	27	-	176	14.3	**0.003**
Carbohydrates (g)	183.6 (52.6)	100	-	184	2.7	**<0.05**	201 (57.7)	100	-	201	0	**<0.05**
Dietary fibre (g)	30.7 (52.2)	26	-	118	75.7	0.589	17.9 (7.8)	31	-	58	92.9	**<0.05**
Calcium (mg)	279.5 (240.8)	-	1300	-	-	**<0.05**	334.2 (255.8)		1300	-	-	**<0.05**
Magnesium (mg)	201.5 (99.8)	200	-	101	59.5	0.926	225.4 (50.9)	200	-	113	28.6	0.084
Phosphorus (mg)	722.5 (338.2)	1055	-	65	83.8	**<0.05**	764.6 (308.1)	1055	-	73	78.6	**0.004**
Iron (mg)	14.3 (32.3)	5.7	-	251	35.1	0.113	7.6 (2.8)	5.9	-	129	28.6	**0.048**
Zinc (mg)	14.3 (36.0)	7.0	-	204	62.2	0.224	5.5 (2.0)	7.0	-	79	64.3	**0.015**
Thiamine (mg)	0.8 (0.3)	0.7	-	114	48.6	0.100	4.4 (13.4)	0.7	-	629	42.9	0.325
Riboflavin (mg)	0.8 (1.0)	0.8	-	100	73	0.803	0.6 (0.4)	0.8	-	75	71.4	0.104
Niacin (mg)	12.3 (7.1)	9	-	137	37.8	**0.008**	11.2 (8.3)	9	-	124	57.1	0.329
Vitamin B6 (mg)	1.3 (0.7)	0.8	-	163	18.9	**<0.05**	1.4 (1.1)	0.8	-	175	21.4	0.100
Folate (µg)	193.8 (100.8)	250	-	78	81.1	**0.002**	156.2 (85.3)	250	-	63	92.9	**0.001**
Vitamin B12 (µg)	9 (26.2)	1.5	-	600	48.6	0.089	23.1 (64.2)	1.5	-	1540	50	0.229
Vitamin C (mg)	171.8 (365.1)	39	-	441	54.1	**0.033**	51.1 (96.0)	39	-	131	78.6	0.645
Vitamin A (µg)	176.1 (129.7)	420	-	42	91.9	**<0.05**	250.5 (187.7)	445	-	56	92.9	**0.002**
Vitamin D (µg)	4 (4.4)	-	5.0	-	-	0.161	6.9 (7.4)		5.0	-	-	0.363
Vitamin E (mg)	5.8 (3.5)	9	-	64	78.4	**<0.05**	4.9 (2.9)	9	-	54	85.7	**<0.05**
Vitamin K (µg)	58.1 (103.2)	60	-	97	73	0.912	168.4 (212.2)	60	-	281	57.1	0.078

[a] Institute of Medicine 2003; [b]Institute of Medicine 2001b; [c]Institute of Medicine 2000; [d]Institute of Medicine 1998; [e]Institute of Medicine 1997; SD: standard deviation; EAR: estimated average requirement; AI: adequate intake; * p values given in bold font indicate that the mean nutrient intake is significantly different from the EAR/AI.

Table 4.8: Comparison of mean nutrient intake with the EAR/AI from two 24-hour repeated recalls for female adolescents aged 14-18 years (n=32) and male adolescents aged 14-18 years (n=18)

Nutrient	Females						Males					
	Mean nutrient intake (SD)	EAR[a-d]	AI[e]	Percentage of EAR	Prevalence of inadequacy (%)	p value*	Mean nutrient intake (SD)	EAR[a-d]	AI[e]	Percentage of EAR	Prevalence of inadequacy (%)	p value*
Total protein (g)	43.6 (17.0)	28	-	156	21.9	**<0.05**	43.1 (21.2)	44	-	98	55.6	0.861
Carbohydrates (g)	214.2 (63.3)	100	-	214	3.1	**<0.05**	198.9 (64.3)	100	-	199	5.6	**<0.05**
Dietary fibre (g)	17.4 (9.4)	26		67	81.3	**<0.05**	15.2 (9.5)	38	-	-	94.4	**<0.05**
Calcium (mg)	298.6 (205.0)	-	1300	-	-	**<0.05**	325.9 (344.1)	-	1300	-	-	**<0.05**
Magnesium (mg)	204 (58.5)	300	-	68	93.8	**<0.05**	199 (76.0)	340	-	59	94.4	**<0.05**
Phosphorus (mg)	703.3 (255.1)	1055	-	67	90.6	**<0.05**	684.2 (276.2)	1055	-	65	88.9	**<0.05**
Iron (mg)	7.8 (3.6)	7.9	-	99	53.1	0.872	6.3 (3.1)	7.7	-	82	66.7	0.071
Zinc (mg)	5.6 (2.1)	7.3	-	77	81.3	**<0.05**	6.1 (2.7)	8.5	-	72	94.4	**0.002**
Thiamine (mg)	0.9 (0.4)	0.9	-	100	65.6	0.651	0.7 (0.3)	1.0	-	70	83.3	**0.002**
Riboflavin (mg)	0.7 (0.5)	0.9	-	78	71.9	0.055	0.6 (0.4)	1.1	-	55	83.3	**<0.05**
Niacin (mg)	11.8 (6.7)	11	-	107	59.4	0.527	9.4 (6.6)	12	-	78	77.8	0.111
Vitamin B6 (mg)	1.2 (0.49)	1.0	-	120	37.5	**0.037**	1 (0.5)	1.1	-	91	61.1	0.393
Folate (µg)	202.7 (104.5)	330	-	61	87.5	**<0.05**	159.3 (91.9)	330	-	48	94.4	**<0.05**
Vitamin B12 (µg)	3.6 (5.6)	1.5	-	240	46.9	**0.041**	2.1 (2.9)	2.0	-	105	66.7	0.878
Vitamin C (mg)	104.6 (258.5)	56	-	187	68.8	0.296	57.4 (156.7)	63	-	91	94.4	0.881
Vitamin A (µg)	236 (165.3)	485	-	49	87.5	**<0.05**	225.4 (153.0)	630	-	36	100	**<0.05**
Vitamin D (µg)	4.1 (5.3)	-	5.0	-	-	0.337	2.5 (2.7)	-	5.0	-	-	**0.001**
Vitamin E (mg)	7.4 (5.7)	12	-	62	81.3	**<0.05**	6.2 (4.5)	12	-	52	88.9	**<0.05**
Vitamin K (µg)	143.1 (273.1)	75	-	191	78.1	0.168	103.9 (218.2)	75	-	139	77.8	0.581

[a] Institute of Medicine 2003; [b]Institute of Medicine 2001b; [c]Institute of Medicine 2000; [d]Institute of Medicine 1998; [e]Institute of Medicine 1997; SD: standard deviation; EAR: estimated average requirement; AI: adequate intake; * p values given in bold font indicate that the mean nutrient intake is significantly different from the EAR/AI.

Table 4.9: Comparison of mean nutrient intake with the EAR/AI from two 24-hour repeated recalls for female adults aged 19-30 years (n=67) and male adults aged 19-30 years (n=43)

Nutrient	Females						Males					
	Mean nutrient intake (SD)	EAR[a-d]	AI[e]	Percentage of EAR	Prevalence of inadequacy (%)	p value*	Mean nutrient intake (SD)	EAR[a-d]	AI[e]	Percentage of EAR	Prevalence of inadequacy (%)	p value*
Total protein (g)	49.8 (17.9)	38	-	131	31.3	**<0.05**	51 (22.4)	46	-	111	46.5	0.154
Carbohydrates (g)	205.8 (62.3)	100	-	206	3	**<0.05**	222 (49.3)	100	-	222	0	**<0.05**
Dietary fibre (g)	15.3 (5.9)	25	-	61	92.5	**<0.05**	18.9 (10.5)	38	-	50	93	**<0.05**
Calcium (mg)	312.7 (240.5)	-	1000	-	-	**<0.05**	283.8 (192.2)	-	1000	-	-	**<0.05**
Magnesium (mg)	209.5 (58.9)	255	-	82	74.6	**<0.05**	220.2 (56.4)	330	-	67	97.7	**<0.05**
Phosphorus (mg)	736.5 (223.8)	580	-	289	26.9	**<0.05**	758.3 (246.3)	580	-	131	23.3	**<0.05**
Iron (mg)	6.8 (2.3)	8.1	-	84	64.2	**<0.05**	6.8 (2.5)	6	-	113	37.2	**0.048**
Zinc (mg)	6.7 (3.0)	6.8	-	99	61.2	0.711	6.9 (3.0)	9.4	-	73	79.1	**<0.05**
Thiamine (mg)	0.9 (0.8)	0.9	-	100	70.1	0.957	0.9 (0.3)	1.0	-	90	65.1	**0.006**
Riboflavin (mg)	0.8 (0.7)	0.9	-	89	71.6	0.100	0.6 (0.3)	1.1	-	55	86	**<0.05**
Niacin (mg)	14.8 (22.6)	11	-	135	47.8	0.174	11.9 (6.3)	12	-	99	62.8	0.899
Vitamin B6 (mg)	1 (0.5)	1.1	-	91	52.2	0.103	0.9 (0.5)	1.1	-	82	69.8	**0.041**
Folate (µg)	172.5 (80.1)	320	-	54	95.5	**<0.05**	173.1 (66.0)	320	-	54	97.7	**<0.05**
Vitamin B12 (µg)	6.5 (17.2)	2.0	-	325	53.7	**0.036**	3.2 (5.9)	2.0	-	160	62.8	0.206
Vitamin C (mg)	44.3 (48.9)	60	-	74	77.6	**0.011**	149.9 (415.1)	75	-	200	86	0.243
Vitamin A (µg)	231.2 (184.2)	500	-	46	89.6	**<0.05**	238.3 (134.0)	625	-	38	100	**<0.05**
Vitamin D (µg)	3.1 (4.0)	-	5.0	-	-	**<0.05**	3.5 (4.2)	-	5.0	-	-	**0.022**
Vitamin E (mg)	5.8 (4.3)	12	-	48	89.6	**<0.05**	6.5 (5.7)	12	-	54	86	**<0.05**
Vitamin K (µg)	118.2 (234.0)	90	-	131	76.1	0.327	57.2 (121.0)	120	-	48	93	**0.001**

[a] Institute of Medicine 2003; [b]Institute of Medicine 2001b; [c]Institute of Medicine 2000; [d]Institute of Medicine 1998; [e]Institute of Medicine 1997; SD: standard deviation; EAR: estimated average requirement; AI: adequate intake; * p values given in bold font indicate that the mean nutrient intake is significantly different from the EAR/AI.

Table 4.10: Comparison of mean nutrient intake with the EAR/AI from two 24-hour repeated recalls for female adults aged 31-50 years (n=62) and male adults aged 31-50 years (n=32)

Nutrient	Females						Males					
	Mean nutrient intake (SD)	**EAR[a-d]**	**AI[e]**	**Percentage of EAR**	**Prevalence of inadequacy (%)**	**p value[*]**	**Mean nutrient intake (SD)**	**EAR[a-d]**	**AI[e]**	**Percentage of EAR**	**Prevalence of inadequacy (%)**	**p value[*]**
Total protein (g)	56.4 (26.0)	38	-	148	27.4	**<0.05**	59.7 (33.1)	46	-	130	34.4	**0.026**
Carbohydrates (g)	225.3 (74.8)	100	-	225	1.6	**<0.05**	224.1 (98.5)	100	-	224	6.3	**<0.05**
Dietary fibre (g)	25.9 (63.2)	25	-	104	80.6	0.912	19.3 (15.1)	38	-	51	90.6	**<0.05**
Calcium (mg)	348 (256.6)	-	1000	-	-	**<0.05**	307.9 (252.8)	-	1000	-	-	**<0.05**
Magnesium (mg)	235.4 (84.8)	265	-	89	67.7	**0.008**	248.2 (102.1)	350	-	71	87.5	**<0.05**
Phosphorus (mg)	828.4 (312.6)	580	-	143	17.7	**<0.05**	865 (399.1)	580	-	247	100	**<0.05**
Iron (mg)	7.9 (3.4)	8.1	-	98	62.9	0.648	14 (33.6)	6	-	2333	21.9	0.186
Zinc (mg)	7.3 (3.1)	6.8	-	107	46.8	0.193	7.7 (4.5)	9.4	-	82	78.1	**0.044**
Thiamine (mg)	0.9 (0.3)	0.9	-	100	48.4	0.818	0.9 (0.3)	1.0	-	90	71.9	0.324
Riboflavin (mg)	0.8 (0.5)	0.9	-	89	62.9	0.225	0.8 (1.1)	1.1	-	73	78.1	0.209
Niacin (mg)	13.4 (8.1)	11	-	122	46.8	**0.026**	14.6 (8.9)	12	-	122	50	0.104
Vitamin B6 (mg)	1 (0.5)	1.1	-	91	62.9	0.300	1 (0.6)	1.1	-	91	68.8	0.532
Folate (µg)	223.8 (141.5)	320	-	70	82.3	**<0.05**	180.9 (101.0)	320	-	57	90.6	**<0.05**
Vitamin B12 (µg)	4.2 (8.2)	2.0	-	210	61.3	**0.036**	7.8 (24.8)	2.0	-	390	65.6	0.192
Vitamin C (mg)	72.6 (143.6)	60	-	121	75.8	0.491	35.8 (34.0)	75	-	48	84.4	**<0.05**
Vitamin A (µg)	287.3 (130.3)	500	-	57	88.7	**<0.05**	235.4 (207.3)	625	-	38	90.6	**<0.05**
Vitamin D (µg)	3.6 (4.3)	-	5.0	-	-	**0.013**	4 (4.4)	-	5.0	-	-	0.214
Vitamin E (mg)	7.2 (4.7)	12	-	60	88.7	**<0.05**	7.2 (4.0)	12	-	60	87.5	**<0.05**
Vitamin K (µg)	104.1 (176.1)	90	-	116	75.8	0.531	166.1 (392.1)	120	-	138	81.3	0.511

[a] Institute of Medicine 2003; [b]Institute of Medicine 2001b; [c]Institute of Medicine 2000; [d]Institute of Medicine 1998; [e]Institute of Medicine 1997; SD: standard deviation; EAR: estimated average requirement; AI: adequate intake; * p values given in bold font indicate that the mean nutrient intake is significantly different from the EAR/AI.

Table 4.11: Comparison of mean nutrient intake with the EAR/AI from two 24-hour repeated recalls for female adults aged 51-70 years (n=51) and male adults aged 51-70 years (n=20)

Nutrient	Females						Males					
	Mean nutrient intake (SD)	**EAR[a-d]**	**AI[e]**	**Percentage of EAR**	**Prevalence of inadequacy (%)**	**p value[*]**	**Mean nutrient intake (SD)**	**EAR[a-d]**	**AI[e]**	**Percentage of EAR**	**Prevalence of inadequacy (%)**	**p value[*]**
Total protein (g)	40.8 (20.4)	38	-	107	58.8	0.325	52.7 (21.3)	46	-	115	50	0.174
Carbohydrates (g)	209.3 (53.2)	100	-	209	2	**<0.05**	244.8 (103.3)	100	-	245	5	**<0.05**
Dietary fibre (g)	18.4 (8.4)	25	-	74	84.3	**<0.05**	19.7 (9.9)	38	-	52	95	**<0.05**
Calcium (mg)	347.3 (380.6)	-	1000	-	-	**<0.05**	264.8 (150.5)	-	1000	-	-	**<0.05**
Magnesium (mg)	232.6 (54.9)	255	-	93	66.7	**0.005**	241.3 (93.0)	330	-	73	80	**<0.05**
Phosphorus (mg)	699.1 (255.7)	580	-	121	37.3	**0.002**	793.4 (295.0)	580	-	137	30	**0.004**
Iron (mg)	6 (2.1)	8.1	-	74	82.4	**<0.05**	7.1 (2.5)	6	-	118	55	0.061
Zinc (mg)	5.9 (3.6)	6.8	-	87	74.5	0.070	6.6 (2.5)	9.4	-	70	80	**<0.05**
Thiamine (mg)	0.8 (0.2)	0.9	-	89	70.6	**<0.05**	0.9 (0.4)	1.0	-	90	65	0.271
Riboflavin (mg)	0.6 (0.4)	0.9	-	67	86.3	**<0.05**	0.8 (0.9)	1.1	-	73	90	0.177
Niacin (mg)	8.2 (5.2)	11	-	75	82.4	**<0.05**	12.1 (5.9)	12	-	73	50	0.949
Vitamin B6 (mg)	0.7 (0.3)	1.1	-	64	84.3	**<0.05**	0.9 (0.4)	1.1	-	82	70	**0.021**
Folate (μg)	170.9 (68.2)	320	-	53	98	**<0.05**	204.2 (115.6)	320	-	64	90	**<0.05**
Vitamin B12 (μg)	1.7 (3.8)	2.0	-	85	76.5	0.541	7.1 (23.7)	2.0	-	355	60	0.346
Vitamin C (mg)	70.1 (188.2)	60	-	117	74.5	0.702	33.8 (24.8)	75	-	45	95	**<0.05**
Vitamin A (μg)	293 (183.5)	500	-	59	84.3	**<0.05**	215.7 (141.5)	625	-	35	100	**<0.05**
Vitamin D (μg)	1.6 (2.3)		10	-	-	**<0.05**	2.4 (2.4)	-	10	-	-	**<0.05**
Vitamin E (mg)	6 (4.9)	12	-	60	88.2	**<0.05**	7.3 (7.7)	12	-	61	80	0.013
Vitamin K (μg)	190.2 (265.6)	90	-	211	60.8	**0.010**	76.6 (104.6)	120	-	64	80	0.079

[a] Institute of Medicine 2003; [b]Institute of Medicine 2001b; [c]Institute of Medicine 2000; [d]Institute of Medicine 1998; [e]Institute of Medicine 1997; SD: standard deviation; EAR: estimated average requirement; AI: adequate intake; * p values given in bold font indicate that the mean nutrient intake is significantly different from the EAR/AI.

Table 4.12: Comparison of mean nutrient intake with the EAR/AI from two 24-hour repeated recalls for female adults above 70 years (n=10) and male adults above 70 years (n=5)

Nutrient	**Females**						**Males**					
	Mean nutrient intake (SD)	**EAR[a-d]**	**AI[e]**	**Percentage of EAR**	**Prevalence of inadequacy (%)**	**p value***	**Mean nutrient intake (SD)**	**EAR[a-d]**	**AI[e]**	**Percentage of EAR**	**Prevalence of inadequacy (%)**	**p value***
Total protein (g)	40.3 20.1)	38	-	106	40	0.724	45.5 (29.0)	46	-	99	60	0.971
Carbohydrates (g)	167.4 (92.1)	100	-	167	20	**0.046**	190.1 (39.8)	100	-	190	0	**0.007**
Dietary fibre (g)	15.5 (2.9)	25	-	62	100	**<0.05**	11 (4.6)	38	-	29	100	**<0.05**
Calcium (mg)	175.5 (90.1)	-	1000	-	-	**<0.05**	393.8 (378.9)	-	1000	-	-	**0.023**
Magnesium (mg)	233.6 (58.0)	255	-	92	70	0.274	240 (81.7)	330	-	73	80	0.070
Phosphorus (mg)	594.6 (191.2)	580	-	103	50	0.815	849 (505.1)	580	-	257	20	0.300
Iron (mg)	5.8 (1.4)	8.1	-	72	90	**0.001**	7.3 (4.2)	6	-	122	60	0.524
Zinc (mg)	5.1 (1.9)	6.8	-	75	90	**0.017**	7.6 (4.3)	9.4	-	81	80	0.390
Thiamine (mg)	0.8 (0.2)	0.9	-	89	60	0.109	0.8 (0.2)	1.0	-	80	80	0.119
Riboflavin (mg)	0.4 (0.2)	0.9	-	44	100	**<0.05**	1.8 (3.0)	1.1	-	164	80	0.616
Niacin (mg)	8.1 (6.4)	11	-	74	80	0.179	14.2 (9.3)	12	-	118	40	0.618
Vitamin B6 (mg)	0.6 (0.2)	1.1	-	55	100	**<0.05**	1 (0.8)	1.1	-	91	80	0.730
Folate (µg)	138.2 (64.3)	320	-	43	100	**<0.05**	155.8 (149.8)	320	-	49	80	0.070
Vitamin B12 (µg)	0.6 (0.5)	2.0	-	30	100	**<0.05**	35.2 (70.7)	2.0	-	1760	60	0.353
Vitamin C (mg)	72.1 (127.6)	60	-	120	80	0.771	30.4 (20.5)	75	-	41	100	**0.008**
Vitamin A (µg)	297.3 (177.4)	500	-	60	80	**0.006**	159.6 (141.5)	625	-	26	100	**0.002**
Vitamin D (µg)	0.9 (0.9)	-	15	-	-	**<0.05**	2.3 (3.2)	-	15	-	-	**0.001**
Vitamin E (mg)	7.4 (4.6)	12	-	62	90	**0.012**	4.7 (2.0)	12	-	39	100	**0.001**
Vitamin K (µg)	473.9 (366.8)	90	-	527	20	**0.009**	269.3 (384.7)	120	-	308	60	0.435

[a] Institute of Medicine 2003; [b]Institute of Medicine 2001b; [c]Institute of Medicine 2000; [d]Institute of Medicine 1998; [e]Institute of Medicine 1997; SD: standard deviation; EAR: estimated average requirement; AI: adequate intake; * p values given in bold font indicate that the mean nutrient intake is significantly different from the EAR/AI.

Table 4.13: Comparison of mean energy intake with the EER[a] from two 24-hour repeated recalls for individuals aged ≥1- ≥18 years

Age and gender	n	Energy range (kJ[b])	Mean energy (kJ) (SD[c])	Energy range (kCal[d])	Mean energy (kCal/day)	Average EER[e] requirement (kCal/day)	Percentage of EER met
1-3 years	16	265[f]-11148[g]	3275.90 (2477.65)	63.40-2666.99	783.71	1016.70	77.10
4-8 years	59	669-8965	4735.26 (1591.55)	160.05-2144.74	1132.84	1269.10	89.26
9-13 years, female	37	3088-9688	5529.38 (1508.67)	738.76-2317.70	1322.82	1519.80	87.03
9-13 years, male	14	3892-10427	5712.79 (1666.23)	931.10-2494.50	1366.70	1686.00	81.06
14-18 years, female	32	690-11497	5925.85 (2294.11)	165.07-2750.48	1417.67	1689.60	83.91
14-18 years , male	18	2800-8272	5850.28 (1728.84)	669.86-1978.95	1399.59	2251.40	62.17
19-30 years female	67	3213-11374	6183.39 (1683.39)	768.66-2721.05	1479.28	1974.18	74.93
19-30 years male	43	3445-10660	6857.67 (1724.57)	824.16-2550.24	1640.59	2301.90	71.27
31-50 years, female	62	2985-12651	6830.11(2113.41)	714.11-3026.56	1634.00	1974.18	82.77
31-50 years, male	32	2910-12103	6983.91 (2261.46)	696.17-2895.45	1670.79	2301.90	72.58
51-70 years, female	51	2641-9633	5843.84 (1466.42)	631.82-2304.55	1398.05	1974.18	70.82
51-70 years, male	20	3391-13265	6870.30 (2697.48)	811.24-3173.44	1643.61	2301.90	71.40
Above 70 years, female	10	2866-7551	5443.20 (1483.89)	685.65-1806.46	1302.20	1974.18	65.96
Above 70 years, male	5	3525-9102	6146.60 (2200.72)	843.30-2177.51	1470.48	2301.90	63.88

[a] EER: estimated energy requirement; [b] kJ: Kilojoules; [c] SD: Standard deviation; [d] kCal: Kilocalories; [e] Institute of Medicine 2005; Average values were calculated using sedentary physical activity levels for each of the age groups and the minimum and maximum EER values for normal BMI were used to calculated the average EER for those above 19 years; [f] Minimum energy intake; [g] Maximum energy intake.

Table 4.14: The prevalence of adequate and inadequate nutrient intake for each age and gender group

Age group (yrs)	**n**	**Gender**	**Nutrients with adequate intake**
1-3	16	Male and female	Protein, carbohydrates, magnesium, phosphorus, iron, zinc, thiamine, vitamin B6, B12 and C.
4-8	59	Male and female	Protein, carbohydrates, magnesium, phosphorus, iron, thiamine, niacin and vitamin B6.
9-13	37	Female	Protein, carbohydrates, iron, thiamine, niacin, vitamin B6 and B12.
9-13	14	Male	Protein, carbohydrates, magnesium, iron, thiamine, vitamin B6 and B12.
14-18	32	Female	Protein, carbohydrate, vitamin B6 and B12.
14-18	18	Male	Carbohydrates
19-30	67	Female	Protein, carbohydrates, phosphorus and niacin.
19-30	43	Male	Protein, carbohydrates, phosphorous and iron.
31-50	62	Female	Protein, carbohydrates, phosphorus, zinc, thiamine and niacin.
31-50	32	Male	Protein, carbohydrates, iron and niacin.
51-70	51	Female	Carbohydrates and phosphorus.
51-70	20	Male	Protein, carbohydrates, magnesium and niacin.
Above 70	10	Female	Protein, carbohydrates, phosphorus and vitamin K.
Above 70	5	Male	Carbohydrates, phosphorus and niacin.
Age group (yrs)	**n**	**Gender**	**Nutrients with inadequate intake**
1-3	16	Male and female	Dietary fibre, riboflavin, niacin, folate, vitamins A, E and K.
4-8	59	Male and female	Dietary fibre, zinc, riboflavin, folate, vitamins B_{12}, vitamin C, A, E and K.
9-13	37	Female	Dietary fibre, magnesium, phosphorous, zinc, riboflavin, folate, vitamins C, A, E and K.
9-13	14	Male	Dietary fibre, phosphorus, zinc, riboflavin, niacin, folate, vitamins C, A, E and K.
14-18	32	Female	Dietary fibre, magnesium, phosphorous, iron, zinc, thiamine, riboflavin, niacin, folate, vitamins C, A, E and K.
14-18	18	Male	Total protein, dietary fibre, magnesium, phosphorous, iron, zinc, thiamine, riboflavin, niacin, folate, vitamins B_6, B_{12}, C, A, E and K.
19-30	67	Female	Dietary fibre, magnesium, iron, zinc, thiamine, riboflavin, folate, vitamins B_6, B_{12}, C, A, E and K.
19-30	43	Male	Dietary fibre, magnesium, zinc, thiamine, riboflavin, niacin, folate, vitamins B_6, B_{12}, C, A, E and K.
31-50	62	Female	Dietary fibre, magnesium, iron, riboflavin, folate, vitamins B_6, B_{12}, C, A, E and K.
31-50	32	Male	Dietary fibre, magnesium, phosphorous, zinc, thiamine, riboflavin, folate, vitamins B_6, B_{12}, C, A, E and K.
51-70	51	Female	Dietary fibre, magnesium, iron, zinc, thiamine, riboflavin, niacin, folate, vitamins B_6, B_{12}, C, A, E and K.
51-70	20	Male	Dietary fibre, magnesium, iron, zinc, thiamine, riboflavin, folate, vitamins B_6, B_{12}, C, A, E and K.
Above 70	10	Female	Dietary fibre, magnesium, iron, zinc, thiamine, riboflavin, niacin, folate, vitamins B_6, B_{12}, C, A and E.
Above 70	5	Male	Total protein, dietary fibre, magnesium, iron, zinc, thiamine, riboflavin, folate, vitamins B_6, B_{12}, C, A, E and K.

4.3.3.2 Food frequency questionnaire results

The food frequency questionnaire data were collected from either the head of the household or the person responsible for purchasing the groceries for the household. Table 4.15 indicates the food items consumed by households and the frequency of consumption. Table 4.16 indicates the average frequency score using an ordinal scale. The mean value was determined using the average frequency scores. These scores were used to identify which food items were consumed the most and the least.

Table 4.15: Results of the food frequency analysis[18]

Food Item	Never/ less than once a month		1-3 times per month		Once a week		2-4 times per week		5-6 times per week		7 times per week		2-3 times per day		4-5 times per day		>6 times per day	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Cereals and grains																		
Cornflakes	71	44.4	20	12.5	19	11.9	29	18.1	4	2.5	15	9.4	1	0.6	1	0.6	0	0.0
Future life	106	74.1	16	11.2	11	7.7	4	2.8	2	1.4	3	2.1	1	0.7	0	0.0	0	0.0
Mageu	57	35.8	20	12.6	24	15.1	31	19.5	16	10.1	5	3.1	4	2.5	1	0.6	1	0.6
Maize meal, stiff	47	29.7	16	10.1	35	22.2	36	22.8	12	7.6	9	5.7	3	1.9	0	0.0	0	0.0
Maize meal porridge	62	39.5	30	19.1	27	17.2	24	15.3	8	5.1	3	1.9	3	1.9	0	0.0	0	0.0
Maltabella	116	73.9	14	8.9	9	5.7	10	6.4	2	1.3	6	3.8	0	0.0	0	0.0	0	0.0
Oats	130	82.8	6	3.8	13	8.3	6	3.8	1	0.6	1	0.6	0	0.0	0	0.0	0	0.0
Pasta	107	66.9	12	7.5	5	3.1	17	10.6	13	8.1	4	2.5	2	1.3	0	0.0	0	0.0
Phutu	42	26.6	5	3.2	12	7.6	44	27.8	39	24.7	2	1.3	10	6.3	3	1.9	1	0.6
Pronutro	136	87.2	4	2.6	6	3.8	3	1.9	5	3.2	0	0.0	2	1.3	0	0.0	0	0.0
Rice, brown	108	68.4	4	2.5	6	3.8	27	17.1	10	6.3	1	0.6	0	0.0	1	0.6	1	0.6
Rice, white	37	23.7	17	10.9	26	16.7	52	33.3	15	9.6	4	2.6	4	2.6	1	0.6	0	0.0
Samp and beans	50	31.3	43	26.9	43	26.9	15	9.4	3	1.9	4	2.5	1	0.6	1	0.6	0	0.0
Weetbix	73	47.1	13	8.4	20	12.9	23	14.8	15	9.7	10	6.5	1	0.6	0	0.0	0	0.0
Bread																		
Brown bread/roll	29	20.0	21	14.5	20	13.8	42	29.0	17	11.7	13	9.0	3	2.1	0	0.0	0	0.0
Ujeqe	46	46.5	8	8.1	21	21.2	15	15.2	8	8.1	0	0.0	1	1.0	0	0.0	0	0.0
White bread/roll	45	28.7	24	15.3	25	15.9	29	18.5	20	12.7	12	7.6	2	1.3	0	0.0	0	0.0
Biscuits and snacks																		
Biscuit, filling	67	44.7	40	26.7	26	17.3	12	8.0	2	1.3	2	1.3	1	0.7	0	0.0	0	0.0
Biscuit	71	44.4	42	26.3	23	14.4	11	6.9	7	4.4	4	2.5	1	0.6	0	0.0	1	0.6
Cream crackers	112	70.0	27	16.9	9	5.6	5	3.1	2	1.3	2	1.3	2	1.3	0	0.0	1	0.6
Starchy vegetables																		
Amadumbe	52	32.7	47	29.6	22	13.8	18	11.3	8	5.0	4	2.5	4	2.5	1	0.6	3	1.9
Mealie/corn (on cob)	49	31.4	33	21.2	28	17.9	33	21.2	4	2.6	3	1.9	6	3.8	0	0.0	0	0.0

[18] The researcher had prior knowledge that bambara groundnut was unfamiliar and not commonly consumed by the individuals residing in the study sites investigated. However, this is a limitation to the study and bambara groundnut should have been included in the FFQ.

Table 4.15: Results of the food frequency analysis continued

	Never/ less than once a month		1-3 times per month		Once a week		2-4 times per week		5-6 times per week		7 times per week		2-3 times per day		4-5 times per day		>6 times per day	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Peas, green	102	65.0	22	14.0	14	8.9	14	8.9	2	1.3	1	0.6	0	0.0	0	0.0	1	0.6
Potato, mashed, boiled, pumpkin, winter squash	37	23.3	28	17.6	35	22.0	45	28.3	7	4.4	3	1.9	3	1.9	0	0.0	1	0.6
Sweet potato	34	21.7	44	28.0	41	26.1	29	18.5	5	3.2	3	1.9	1	0.6	0	0.0	0	0.0
Starchy foods prepared with fats																		
Fried chips	54	34.2	31	19.6	33	20.9	28	17.7	5	3.2	6	3.8	1	0.6	0	0.0	0	0.0
Instant noodles	82	51.9	23	14.6	22	13.9	17	10.8	4	2.5	6	3.8	4	2.5	0	0.0	0	0.0
Popcorn with oil	95	60.1	31	19.6	16	10.1	14	8.9	2	1.3	0	0.0	0	0.0	0	0.0	0	0.0
Scone	57	35.8	57	35.8	23	14.5	12	7.5	4	2.5	4	2.5	1	0.6	1	0.6	0	0.0
Vetkoek	37	25.7	54	37.5	23	16.0	17	11.8	8	5.6	2	1.4	3	2.1	0	0.0	0	0.0
Fruit																		
Apple, unpeeled medium	29	18.2	38	23.9	30	18.9	35	22.0	7	4.4	12	7.5	8	5.0	0	0.0	0	0.0
Banana, small	37	23.4	26	16.5	49	31.0	29	18.4	8	5.1	7	4.4	2	1.3	0	0.0	0	0.0
Canned fruit	75	47.2	46	28.9	15	9.4	14	8.8	3	1.9	4	2.5	1	0.6	0	0.0	1	0.6
Fruit juice	58	36.5	30	18.9	25	15.7	18	11.3	9	5.7	9	5.7	10	6.3	0	0.0	0	0.0
Fruit salad, fresh	82	51.6	43	27.0	20	12.6	4	2.5	3	1.9	3	1.9	2	1.3	1	0.6	1	0.6
Grapes, small	52	33.1	63	40.1	21	13.4	6	3.8	4	2.5	8	5.1	2	1.3	0	0.0	1	0.6
Orange	38	24.4	44	28.2	31	19.9	24	15.4	4	2.6	8	5.1	5	3.2	1	0.6	1	0.6
Pear	73	46.8	40	25.6	19	12.2	15	9.6	2	1.3	4	2.6	2	1.3	1	0.6	0	0.0
Guava	9	81.8	1	9.1	0	0.0	0	0.0	0	0.0	1	9.1	0	0.0	0	0.0	0	0.0
Milk and milk products																		
Custard sweetened full cream	98	62.4	34	21.7	16	10.2	3	1.9	2	1.3	2	1.3	1	0.6	1	0.6	0	0.0
Custard Ultra Mel	70	44.0	42	26.4	29	18.2	7	4.4	5	3.1	4	2.5	1	0.6	1	0.6	0	0.0
Full cream milk	62	38.8	26	16.3	14	8.8	24	15.0	13	8.1	7	4.4	9	5.6	2	1.3	3	1.9
Low fat milk	92	57.5	26	16.3	10	6.3	16	10.0	8	5.0	5	3.1	2	1.3	0	0.0	1	0.6
Maas	52	33.3	30	19.2	24	15.4	31	19.9	8	5.1	4	2.6	4	2.6	0	0.0	3	1.9
Yoghurt flavoured	82	52.2	34	21.7	26	16.6	9	5.7	0	0.0	3	1.9	2	1.3	0	0.0	1	0.6
Yoghurt low fat	120	75.9	17	10.8	11	7.0	7	4.4	2	1.3	1	0.6	0	0.0	0	0.0	0	0.0
Yoghurt plain	123	77.8	20	12.7	12	7.6	1	0.6	1	0.6	1	0.6	0	0.0	0	0.0	0	0.0

Table 4.15: Results of the food frequency analysis continued

	Never/ less than once a month		1-3 times per month		Once a week		2-4 times per week		5-6 times per week		7 times per week		2-3 times per day		4-5 times per day		>6 times per day	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Vegetables																		
Beans, green	97	61.4	17	10.8	29	18.4	14	8.9	0	0.0	1	0.6	0	0.0	0	0.0	0	0.0
Beetroot	73	46.8	36	23.1	29	18.6	9	5.8	6	3.8	0	0.0	2	1.3	0	0.0	1	0.6
Broccoli	113	71.1	18	11.3	15	9.4	9	5.7	3	1.9	0	0.0	1	0.6	0	0.0	0	0.0
Cabbage	47	29.2	24	14.9	44	27.3	31	19.3	11	6.8	2	1.2	2	1.2	0	0.0	0	0.0
Cauliflower	132	82.5	11	6.9	10	6.3	4	2.5	0	0.0	3	1.9	0	0.0	0	0.0	0	0.0
Imifino (Indigenous leafy vegetables)	10	43.5	4	17.4	4	17.4	5	21.7	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Lettuce	104	65.0	19	11.9	16	10.0	8	5.0	6	3.8	1	0.6	5	3.1	1	0.6	0	0.0
Mixed vegetable	68	42.5	15	9.4	15	9.4	26	16.3	17	10.6	7	4.4	11	6.9	0	0.0	1	0.6
Mushroom	116	73.4	19	12.0	7	4.4	9	5.7	3	1.9	2	1.3	1	0.6	0	0.0	1	0.6
Peppers	72	45.3	12	7.5	10	6.3	14	8.8	30	18.9	8	5.0	8	5.0	2	1.3	3	1.9
Onions	25	15.7	18	11.3	11	6.9	16	10.1	54	34.0	8	5.0	16	10.1	2	1.3	9	5.7
Spinach	34	21.9	38	24.5	41	26.5	25	16.1	9	5.8	2	1.3	3	1.9	1	0.6	2	1.3
Tomato	26	16.6	29	18.5	27	17.2	43	27.4	20	12.7	6	3.8	4	2.5	2	1.3	0	0.0
Meat and meat substitutes																		
Baked beans	56	35.0	27	16.9	37	23.1	30	18.8	3	1.9	5	3.1	0	0.0	0	0.0	1	0.6
Beans, lentils and peas	87	54.4	31	19.4	26	16.3	12	7.5	1	0.6	1	0.6	2	1.3	0	0.0	0	0.0
Bean salad, no oil	85	53.5	28	17.6	37	23.3	7	4.4	0	0.0	0	0.0	2	1.3	0	0.0	0	0.0
Beef, cuts	46	28.6	35	21.7	41	25.5	26	16.1	6	3.7	6	3.7	1	0.6	0	0.0	0	0.0
Beef, mince	84	52.8	34	21.4	26	16.4	12	7.5	2	1.3	0	0.0	0	0.0	0	0.0	1	0.6
Beef, patty	90	57.0	20	12.7	36	22.8	7	4.4	2	1.3	1	0.6	1	0.6	0	0.0	1	0.6
Beef sausage	57	35.6	32	20.0	35	21.9	26	16.3	7	4.4	3	1.9	0	0.0	0	0.0	0	0.0
Cheese, cheddar	69	43.1	26	16.3	19	11.9	32	20.0	8	5.0	3	1.9	2	1.3	0	0.0	1	0.6
Chicken, cooked	22	13.7	29	18.0	47	29.2	49	30.4	11	6.8	1	.6	2	1.2	0	0.0	0	0.0
Chicken, stewed	30	18.9	22	13.8	44	27.7	40	25.2	14	8.8	6	3.8	2	1.3	1	0.6	0	0.0
Chicken, feet	38	23.9	44	27.7	28	17.6	37	23.3	6	3.8	2	1.3	3	1.9	1	0.6	0	0.0
Eggs	48	30.4	21	13.3	16	10.1	35	22.2	22	13.9	10	6.3	4	2.5	1	0.6	1	0.6
Fish, hake	99	62.7	28	17.7	15	9.5	10	6.3	4	2.5	1	0.6	1	0.6	0	0.0	0	0.0

Table 4.15: Results of the food frequency analysis continued

	Never/ less than once a month		1-3 times per month		Once a week		2-4 times per week		5-6 times per week		7 times per week		2-3 times per day		4-5 times per day		>6 times per day	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Fish, tuna	114	73.1	12	7.7	11	7.1	13	8.3	4	2.6	2	1.3	0	0.0	0	0.0	0	0.0
Lentils	134	84.3	13	8.2	5	3.1	3	1.9	2	1.3	2	1.3	0	0.0	0	0.0	0	0.0
Organ meat (liver, kidney, heart)	48	29.8	65	40.4	27	16.8	13	8.1	4	2.5	2	1.2	0	0.0	2	1.2%	0	.0%
Peanut butter	81	50.3	21	13.0	22	13.7	22	13.7	4	2.5	7	4.3	2	1.2	0	0.0	2	1.2
Pilchards, canned	60	37.3	27	16.8	36	22.4	28	17.4	6	3.7	1	0.6	2	1.2	1	0.6	0	0.0
Polony	45	28.3	30	18.9	29	18.2	22	13.8	22	13.8	10	6.3	1	0.6	0	0.0	0	0.0
Pork, bacon	112	70.0	20	12.5	13	8.1	10	6.3	2	1.3	1	0.6	2	1.3	0	0.0	0	0.0
Pork, ham	121	76.6	16	10.1	7	4.4	5	3.2	7	4.4	2	1.3	0	0.0	0	0.0	0	0.0
Pork, sausages	126	78.3	18	11.2	7	4.3	6	3.7	2	1.2	1	0.6	0	0.0	0	0.0	1	0.6
Viennas	79	49.7	34	21.4	23	14.5	16	10.1	4	2.5	3	1.9	0	0.0	0	0.0	0	0.0
Fats																		
Avocado, medium	72	45.9	33	21.0	15	9.6	20	12.7	7	4.5	7	4.5	3	1.9	0	0.0	0	0.0
Holsum	110	69.2	19	11.9	10	6.3	9	5.7	8	5.0	3	1.9	0	0.0	0	0.0	0	0.0
Margarine, brick	83	51.9	19	11.9	6	3.8	15	9.4	18	11.3	12	7.5	6	3.8	1	0.6	0	0.0
Margarine, tub	89	56.0	22	13.8	7	4.4	21	13.2	12	7.5	5	3.1	2	1.3	0	0.0	1	0.6
Mayonnaise	44	27.7	22	13.8	20	12.6	31	19.5	24	15.1	6	3.8	7	4.4	1	0.6	4	2.5
Oil	37	23.7	20	12.8	4	2.6	10	6.4	45	28.8	14	9.0	15	9.6	3	1.9	7	4.5
Other carbohydrates																		
Cake, icing	90	55.9	42	26.1	13	8.1	7	4.3	4	2.5	4	2.5	0	0.0	0	0.0	1	0.6
Cake, plain	69	43.1	52	32.5	15	9.4	10	6.3	6	3.8	2	1.3	4	2.5	0	0.0	2	1.3
Chocolate	76	47.5	46	28.8	22	13.8	11	6.9	1	0.6	3	1.9	0	0.0	1	0.6	0	0.0
Cupcake	95	59.7	35	22.0	15	9.4	9	5.7	3	1.9	2	1.3	0	0.0	0	0.0	0	0.0
Chips (Simba)	45	28.8	40	25.6	25	16.0	29	18.6	8	5.1	6	3.8	3	1.9	0	0.0	0	0.0
Sweets	33	21.9	28	18.5	21	13.9	30	19.9	21	13.9	5	3.3	7	4.6	4	2.6	2	1.3

Table 4.16: The mean frequency scores for commonly consumed food items

Food items	n[19]	Mean[20]	Food items	n	Mean	Food items	n	Mean
Oil	156	3.37	*Mageu*[21]	159	1.82	Beef, sausage	160	1.39
Onions	159	3.31	Orange	156	1.79	Samp and beans	160	1.37
Phutu[22]	158	2.63	*Maas*[23]	156	1.74	Steamed bread (*Ujeqe*)	99	1.34
Sweets	151	2.35	Fruit juice	159	1.73	Peanut butter	161	1.30
Brown bread/roll	145	2.33	Chicken, feet	159	1.70	Avocado, medium	157	1.30
Tomato	157	2.29	Cabbage	161	1.68	Grapes, small	157	1.27
Mayonnaise	159	2.28	Potato crisps	156	1.65	Organ meat (liver, kidney, heart)	161	1.23
Rice, white	156	2.15	Mealie/corn (on cob)	156	1.63	*Isijingi*[24]	24	1.21
Apple, unpeeled medium	159	2.13	Baked beans	160	1.61	Margarine, tub	159	1.21
Eggs	158	2.12	Sweet potato	157	1.62	Instant noodles	158	1.19
Chicken, stewed	159	2.11	Squash, butternut, pumpkin, winter squash	159	1.59	Scone	159	1.18
Chicken, cooked	161	2.06	*Amadumbe*[25]	159	1.58	*Imifino* (Indigenous green leafy vegetables)	23	1.17
Pepper	159	2.01	Beef, cuts	161	1.58	Cake, plain	160	1.16
White bread/roll	157	1.99	Margarine, brick	160	1.57	Biscuit	160	1.14
Maize meal porridge	158	1.93	Cornflakes	160	1.56	Ice cream	158	1.09
Full cream milk	160	1.91	Weetbix	155	1.54	Custard Ultra Mel	159	1.09
Potato, pumpkin	159	1.90	Fried chips	158	1.50	Pear	156	1.09
Mixed vegetable	160	1.88	Vetkoek (*amagwinya*)[26]	144	1.47	Low fat milk	160	1.07
Polony	159	1.87	Pilchards, canned	161	1.43	Beetroot	156	1.06
Banana, small	158	1.84	Cheese, cheddar	160	1.42	Canned fruit	159	1.03
Spinach	155	1.82	Maize meal, stiff	157	1.41	Biscuit, filling	150	1.01

[19] n: Indicates the number of households that consumed that particular food item.
[20] The mean is expressed as an average score.
[21] *Mageu*: fermented maize meal.
[22] *Phutu*: maize meal cooked into a crumbly porridge.
[23] *Maas*: fermented milk product.
[24] *Isijingi*: soft porridge made with pumpkin.
[25] *Amadumbe*: a tuber that grows underground.
[26] *Amagwinya*: traditional fried bread made with flour, yeast, sugar and salt.

Table 4.16: The mean frequency scores for commonly consumed food items continued

Food items	n	Mean	Food items	n	Mean	Food items	n	Mean
Viennas	159	1.00	Beans, green	158	0.77	Future life	143	0.55
Rice, brown	158	0.99	Fish, hake	158	0.73	Guava	11	0.55
Pasta	160	0.98	Cupcake	159	0.72	Pork, ham	158	0.53
Yoghurt, flavoured	157	0.94	Popcorn with oil	158	0.72	Yoghurt low fat	158	0.46
Fruit salad, fresh	159	0.94	Holsum	159	0.71	Pork sausage	161	0.44
Chocolate	160	0.93	Custard, sweetened full cream	157	0.68	Morvite	12	0.42
Beef, patty	158	0.89	Cucumber	160	0.65	Oats	157	0.38
Lettuce	160	0.88	Maltabella	157	0.64	Pronutro	156	0.37
Beans, lentils and peas (cooked)	160	0.88	Fish, tuna	156	0.63	Cauliflower	160	0.36
Beef mince	159	0.87	Pork, bacon	160	0.63	Yoghurt plain	158	0.35
Peas, green	157	0.86	Mushroom	158	0.61	Lentils	159	0.31
Bean salad, no oil	159	0.85	Cream crackers	160	0.61			
Cake, with icing	161	0.83	Broccoli	159	0.58			

4.4 Discussion

The purpose of this study was to assess the nutritional status of communities residing in four rural areas of KZN using selected anthropometric indices and dietary assessment methods.

4.4.1 Anthropometry

4.4.1.1 Children

The results indicate that under- and over-nutrition co-exist in children. In comparison to other South African studies, the prevalence of stunting in children (30.8%) in the current study was higher than the 2016 SADHS, which found that 27% of children under five years were stunted (nDoH *et al* 2017). The prevalence of stunting in children in the current study was also higher than that reported by earlier national studies. The 2005 NFCS-FB study, indicated that one in five children in SA was stunted, and the SANHANES-1 study indicated that 26.5% of South African children aged 1-3 years were stunted (Shisana *et al* 2013; Labadarios *et al* 2008). This study also found a higher prevalence of stunting in children compared to a study conducted in the UMkhanyakude and Zululand districts of KZN, which found that 24% and 26% of children were stunted, respectively (Schoeman, Faber, Adams, Smuts, Ford-Ngomane, Laubscher & Dhansay 2010). However, the results of the current study should be interpreted with caution because a small sample was taken from the population of children under five years of age. Another limitation was that anthropometric data were collected only from children who were present at the time of the study. It is recommended that these limitations be addressed in future studies.

Stunting is a chronic form of undernutrition which is classified by a HFA < -2SD and results from a lack of adequate energy or nutrient intake for a prolonged period (WHO 2008a). Environmental factors that have the potential to contribute to stunting include a lack of hygiene and poor sanitation (Danaei, Andrews, Sudfeld, Fink, McCoy, Peet, Sania, Fawzi, Ezzati & Fawzi 2016). There are many negative consequences to stunting and it can be detrimental. It can lead to poor performance in school and poor social and mental development, resulting in a poor quality of life (HST 2016; UNICEF 2016; Escott-Stump, 2015, pp28, 645). Furthermore, stunting could lead to obesity in adulthood, which increases the risk for health-related conditions (HST 2016; UNICEF 2016; Escott-Stump, 2015, pp28, 645). The effects of stunting become irreversible after two years of age (HST 2016).

Although undernutrition is a serious problem in SA, over-nutrition is also of concern. This study found that 15.5% (n=6) of children under five years were overweight. This result was expected as Southern Africa accounts for 12% of overweight children in Africa (FAO *et al* 2017). The current study results for overweight in children under five years was higher than other national studies (nDoH *et al* 2017; Shisana *et al* 2013; Labadarios *et al* 2008). The 2005 NFCS-FB found that one in ten South African children were overweight (Labadarios *et al* 2008), whereas the 2016 SADHS found that 13% of children under five years old were overweight (nDoH *et al* 2017). The percentage of overweight children increased between 2005 and 2016 (Shisana *et al* 2013; Labadarios *et al* 2008). Furthermore, the 2012 SANHANES-1 study indicated that KZN was one of the provinces with the highest rates of obesity among children (Shisana *et al* 2013). As mentioned earlier, in the current study, measurements were obtained from a small sample and results should be interpreted with caution. However, obesity in childhood is still an issue and is on the rise in SA, especially in KZN. Childhood obesity has been linked to several chronic diseases in adulthood such as cardiovascular disease, hypertension and diabetes mellitus (Escott-Stump 2015, p626).

It is important to remember that caregivers are responsible for the types of food and portion sizes given to children (Omidire, AnnaMosia & Mampane 2015). Food choice is influenced by many factors such as affordability, seasonality, cultural practices and personal preferences (Emily, Huggins, Huggins, McCaffrey, Palermo & Bonham 2017; Kamphuis, de Bekker-Grob & Van Lenthe 2015; Wenhold *et al* 2012; Kearney 2010). Caregivers are more likely to give their child a food item that is affordable and positively affects their child's health (Govender, Pillay, Siwela & Derera 2014). Thus, if caregivers are educated on nutritious foods they would be able to make more informed choices, leading to an improved nutritional status for their children. A good nutritional status can be achieved not only by having access to nutritious foods but also by correct utilisation of these foods. Many rural communities cannot afford a variety of foods. However, if healthier cheaper food types were provided such as underutilised and biofortified crops and caregivers were educated on the correct processing and preparation methods of these crops, the nutritional status of vulnerable children could be improved.

4.4.1.2 Adults

The prevalence of obesity among females (39.1%) in the current study is similar to the 2016 SADHS, which found that one in five women were severely obese and the SANHANES-1 study, which found that 31.8% of females living in rural areas were obese (nDoH *et al* 2017;

Shisana *et al* 2013). African women have been previously reported to be most at risk of obesity (Senekal, Steyn & Nel 2003; Puoane, Steyn, Bradshaw, Laubscher, Fourie, Lambert & Mbananga 2002), similar to the current study. The prevalence of overweight and obesity was higher in females than males in the current study, which was similar to the 2016 SADHS and 2012 SANHANES-1 study (nDoH *et al* 2017; Shisana *et al* 2013). The prevalence of overweight and obesity is on the rise in all provinces of SA, with the KZN province having the second highest prevalence (Shisana *et al* 2013; Ziraba, Fotso & Ochako 2009). This is a major concern as overweight and obesity increases the risk of non-communicable diseases such as cardiovascular disease (CVD), certain cancers, type 2 diabetes and musculoskeletal disorders (Nyberg, Batty, Pentti, Virtanen, Alfredsson, Fransson, Goldberg, Heikkilä, Jokela, Knutsson, Koskenvuo, Lallukka, Leineweber, Lindbohm, Madsen, Hanson, Nordin, Oksanen, Pietiläinen, Rahkonen, Rugulies, Shipley, Stenholm, Suominen, Theorell, Vahtera, Westerholm, Westerlund, Zins, Hamer, Singh-Manoux, Bell, Ferrie & Kivimäki 2018; WHO 2011a).

Waist circumference measurements and BMI confirmed that females were more at risk for chronic diseases of lifestyle than males. This is a problem as obesity affects women at every stage of the life cycle (Hawkins, Oken & Gillman 2018, pp170-175). It can have economic, biological and psychosocial implications. A child born to a pregnant, obese mother is at increased risk of chronic diseases, thus negatively affecting the health of future generations (Hawkins *et al* 2018, pp170-175). This study indicated that individuals with a higher BMI also had a higher waist circumference, indicating an increased risk for obesity-related diseases. A study by Zhu, Heshka, Wang, Shen, Allison, Ross & Heymsfield (2004), conducted on 8712 white men and women indicated that a combination of both a high BMI and waist circumference could increase the risk for CVD (Zhu *et al* 2004). Another study by Gierach, Gierach, Ewertowska, Arndt & Junik (2014), found a direct relationship between waist circumference and BMI. High amounts of abdominal fat were noted in overweight males and normal females (Gierach *et al* 2014). The risk for comorbidities due to a large waist circumference can be independent of BMI (Wildman, Gu, Reynolds, Duan, Wu & He 2005; Jansen, Heymsfield, Allison, Kotler & Ross 2002).

The study findings indicate that there is an urgent need for interventions to address the high prevalence of overweight and obesity. The prevalence of obesity could be reduced by educating the affected population groups on optimum methods of food preparation and processing, and emphasising healthier cheaper food types and control of portion sizes. As part of community initiatives or community resource programmes, a potential strategy could be to introduce biofortified and underutilised crops as an accessible and affordable option into the diets of vulnerable individuals and teach these individuals how to utilise these crops to improve the nutrient density of their meals. However, the acceptance of alternative food types would need to be investigated.

4.4.1.3 Women of childbearing age (16-35 years)

As mentioned earlier, African women were reported to be at greatest risk for obesity in SA (Senekal *et al* 2003; Puoane *et al* 2002). This study found that among the females aged 16-35 years, there was a higher prevalence of overweight and obesity (n=55; 58.5%) than underweight (n=8; 8.5%). This was an expected result for rural areas of KZN as the 2012 SANHANES-1 study reported that, on a national level, the prevalence of obesity in women from the rural formal and rural informal populations was 31.8% and 37.6%, respectively (Shisana *et al* 2013). Furthermore, the SANHANES-1 study found that the prevalence of overweight and obesity was high among women (24.8% and 39.2%, respectively), which was similar to findings of the current study (26.6% and 31.9%, respectively). Additionally, the prevalence of overweight and obesity has been found to increase with age in African females (Duncan, Howe, Manukusa & Purdy 2014; Devanathan, Esterhuizen & Govender 2013; Zhu *et al* 2012; Smuts *et al* 2008).

A possible reason for the increase in obesity could be due to incorrect perceptions. Many women residing in rural areas often do not perceive themselves as being overweight or obese and do not consider their weight to be a problem (Okop, Mukumbang, Mathole, Levitt & Puoane 2016; Duncan *et al* 2014; Devanathan *et al* 2013). Another reason could be due to the negative stigma associated with thinness. In some cultures, thinness is associated with being sick, whereas obesity is associated with wealth, happiness and good health (Duncan *et al* 2014; Devanathan *et al* 2013).

The results of this study indicate that there is a need to address obesity, especially in KZN. It is a challenge to address the problem of incorrect perceptions of body weight as rural African women have strong cultural beliefs (Duncan *et al* 2014). In most cases, individuals that are most affected by overweight and obesity are women that have less than a primary school education (Ziraba *et al* 2009). Thus, nutrition education has the potential to contribute to improving the nutritional status of these communities. Women are usually responsible for preparing meals and for feeding children. If nutrition education is targeted at women and they are taught how to modify their diets or prepare nutritious underutilised crops, they are more likely to prepare this for themselves and their families, which may result in an improved nutritional status (Omidire *et al* 2015). Although the impact of education on food choice was not assessed in the current study, the low level of education of a substantial proportion of the study participants could have contributed to the over-nutrition and undernutrition observed. This hypothesis should be tested in future studies.

4.4.2 Dietary assessment

4.4.2.1 24-hour repeated recall

The results from the 24-hour repeated recall suggest that not all age groups met their nutritional requirements. Protein and carbohydrates were consumed in large quantities, whilst the diet lacked adequate amounts of dietary fibre in most age groups. All age groups met between 62.17-89.26% of the average EER. The maximum energy intake for all age groups was higher than the average EER for all age groups. Although protein was consumed in larger amounts, it was obtained mainly from plant sources, rather than animal sources. These results were similar to results from a study conducted by Kolahdooz, Spearing & Sharma (2013), where most of the study participants consumed protein from plant sources. Animal sources of protein are known to contain essential micronutrients, fatty acids and high-quality protein (Schönfeldt, Pretorius & Hall 2013). The poor dietary intake of animal proteins could be due to poor availability and accessibility, especially in rural areas (Schönfeldt & Hall 2012). Many rural communities do not have access to a variety of foods and rely solely on *Spaza* shops (informal convenience shops found in rural areas that sell a small range of food items). These shops do not sell a variety of food items and the food that they stock are seemingly sold at increased prices and are most often unaffordable (Charman, Bacq & Brown 2019). Many rural households purchase foods that are starch-based such as maize meal, as these are cheaper when bought in bulk (Battersby & Peyton 2014; Temple & Steyn 2009). A review conducted by Schönfeldt & Hall (2012), points out that plant-based shelf-stable staples are a predominant part of the diet in disadvantaged communities (Schönfeldt *et al* 2013). In this study, the food frequency confirmed that *phutu* (n=158) which is made from maize meal, was one of the most frequently consumed food items.

Starch-based foods consumed alone are not nutritionally adequate. However, animal-based proteins are unaffordable to most people. Legumes could be considered as a good alternative to animal protein (Huma, Anjum, Sehar, Khan & Hussain 2008). It contains protein as well as fibre which contributes to satiety, resulting in the consumption of smaller portions of food

(Slavin & Green 2007), thus preventing overeating and weight gain. When a starch-based food is consumed together with legumes, it provides complementary proteins. Starch-based foods lack lysine and tryptophan that is found in legumes, and the sulphur-containing amino acids that are limiting in legumes are found in starch-based foods (Serna-Saldivar 2010, p98). The combination of legumes and starch-based foods together could be considered a more nutritious alternative to starch-based foods consumed alone.

The provision of nutrition education on dietary modification of foods currently consumed and portion control are other strategies to improve nutritional status. Portion control can help to maintain weight. If more calories are consumed than expended, it would result in weight gain (Hawkins *et al* 2018, p179). Educating individuals on the correct portion sizes and affordable healthy food choices could result in a change in lifestyle, resulting in a reduction in obesity. However, education alone is not enough as compliance is not always guaranteed. Thus, follow-up sessions and monitoring dietary intake for a certain period could help improve eating habits and reduce obesity. Sixty minutes a day of physical activity should be promoted in order to assist with weight loss (Hawkins *et al* 2018, p179).

More than 50% of the sample of children and adults had inadequate intake of the following nutrients: magnesium, phosphorus, zinc, riboflavin, niacin, folate, vitamin B_{12}, vitamin A, vitamin C, vitamin E and vitamin K, for most of the age groups. These results were similar to results from the 1999 NFCS, which indicated that South African children, especially rural children, had a low intake of the following micronutrients: vitamin A, calcium, iron, zinc, folate, vitamin B_6, niacin, riboflavin, vitamin C and vitamin E (Labadarios *et al* 2000). Possible reasons for the inadequate nutrient intake could be due to the seasonal availability of foods or foods not consumed at the time of data collection. The current study results should be interpreted with caution as 24-hour recalls were only collected for two days. Dietary data is very subjective and there is room for inaccurate reporting and analysis (Shim, Oh & Kim 2014).

Micronutrient deficiency is defined as an inadequate status of one or more micronutrients and is just as serious as under- and over-nutrition. Although micronutrient deficiency is a problem, it is not routinely treated in developing countries. It can result in several health conditions, including growth retardation and delayed development (Bain *et al* 2013). Thus, it is important for individuals to consume good quality, nutrient-dense foods in order to avoid micronutrient deficiencies, however, this is not always possible due to the high cost of these foods. The most common micronutrient deficiencies observed in developing countries are iron, iodine, zinc and vitamin A (Bailey, West Jr & Black 2015). Amongst the micronutrient deficiencies, iron and vitamin A are of concern in South Africa. Many South African national studies have shown this to be true, especially in vulnerable groups such as women and children (Shisana *et al* 2013; Bain *et al* 2013; Smuts, Dhansay, Faber, Van Stuivenberg, Swanevelder, Gross & Benadé 2005; Labadarios *et al* 2000; Labadarios & Van Middelkoop 1995).

The current study results indicated that 50% of the females aged 14 to > 70 years had an inadequate intake of iron. The low intake could be due to the high cost of iron-rich foods. As mentioned, many rural communities rely predominantly on starch-based diets, which contain limited amounts of fruits, vegetables and animal protein (Shisana *et al* 2013). A study conducted in 2016 on 651 healthy South African adults indicated that the prevalence of anaemia was 12.6%, which was lower than the findings of the 2012 SANHANES-1 study (Phatlhane, Zemlin, Matsha, Hoffmann, Naidoo, Ichihara, Smit & Erasmus 2016). Further, both studies found the prevalence of anaemia to be higher among females than males (Phatlhane *et al* 2016; Shisana *et al* 2013). This study showed that dietary intake of iron was low and females were at higher risk of becoming iron deficient or further worsening their already poor iron status. This is a major concern especially for pregnant women as iron requirements are increased during pregnancy. If a mother has a poor nutritional status, she is at increased risk of giving birth to a malnourished child (King 2016). Furthermore, if a mother has iron-deficiency anaemia during pregnancy, it can result in fetal and maternal mortality, morbidity, pre-eclampsia, bleeding and infection (Abu-Ouf & Jan 2015). A possible long-term strategy that could be explored to help address iron deficiency is dietary diversification, through the promotion of household and community food gardens, utilisation of indigenous crops and consumption of biofortified foods.

Vitamin A deficiency (VAD) is a major health concern in SA. In this study, vitamin A intake was inadequate in all of the age groups due to poor intake of animal-based foods, fruits and vegetables. Furthermore, no participants had reported that they were taking any vitamin or mineral supplements at the time of data collection. Thus, the analysis of vitamin A did not include any vitamin A supplements. This low intake is in line with national data, which indicated that the vitamin A status of South African children had worsened between 1994 and 2005 (Labadarios *et al* 2008; Labadarios *et al* 2000; Labadarios & Van Middelkoop 1995). Further, the 2005 NFCS-FB study indicated that one in 10 women were vitamin A deficient in KZN (Labadarios *et al* 2008). The 2012 SANHANES-1 study reported high rates of VAD throughout SA, however, it noted an improvement in the status of women residing in KZN

(Shisana *et al* 2013). As alluded to earlier, the South African government has employed a number of interventions to combat VAD, including food fortification, vitamin A supplementation and dietary diversity (WHO 2011b; Swart, Sanders & McLachlan 2008; DoH & UNICEF 2007). The current study indicates that although these interventions are in place, vitamin A intake remains inadequate. Possible complementary strategies such as biofortification of already consumed staple foods such as maize with vitamin A, or increased usage of underutilised crops, could be used together with already existing strategies in KZN, to improve vitamin A intake.

4.4.2.2 Food frequency

The food frequency results indicated that onion, *phutu*, brown bread, tomato, rice, apple, eggs and chicken were the most commonly consumed food items. This was similar to studies conducted in SA which documented that mealie meal, white sugar, tea, brown bread, non-dairy creamer, brick margarine, chicken meat, full cream milk and dark green leafy vegetables were frequently consumed (Steyn, Nel & Casey 2003; Labadarios *et al* 2000). Similarly, another study conducted in KZN, by Faber *et al* (2013), found that sugar, maize meal porridge, bread, rice, cordial squash, hard margarine, tea and legumes were the most commonly consumed food items. Additionally, a study conducted by Faber, Van Jaarsveld, Kunneke, Kruger, Schoeman & Van Stuivenberg (2015), found that 50.5% of participants from rural KZN consumed both bread and maize meal (Faber *et al* 2015). From this, it is evident that in SA, more specifically in rural areas of KZN, most diets comprise of starch-based foods, either a maize-based dish, bread or rice. This could lead to an excessive intake of carbohydrates and energy, thus contributing to a high prevalence of obesity (Hawkins *et al* 2018, p179).

Consumption of high amounts of refined carbohydrates has been associated with an increased risk of coronary heart disease, insulin resistance, obesity, diabetes, hypertension and stroke (Okop *et al* 2016; Li, Hruby, Bernstein, Lev, Wang, Chiuve, Sampson, Rexrode, Rimm, Willett & Hu 2015; López-Alarcón, Perichrat-Perera, Flores-Huerta, Inda-Icaza, Rodríguez-Cruz, Armenta-Álvarez, Bram-Falcón & Mayorga-Ochoa 2014). Study participants who were overweight and obese were at increased risk of conditions such as cardiovascular disease (CVD), certain cancers, type 2 diabetes and hypertension. A possible reason for this high prevalence could be due to poor food choices, sedentary lifestyle or lack of physical activity (Hawkins *et al* 2018, p179; Fabbri & Crosby 2016; Wiklund 2016). Increasing physical activity and energy expenditure could be another way of reducing the rates of obesity (Wiklund 2016).

However, this study did not investigate physical activity. Most study participants consumed processed foods or purchased foods prepared with large amounts of fat and sugar, resulting in high energy intake. Sweets were one of the most commonly consumed unhealthy food items in this study. If more fruit were consumed in place of high-energy snacks and if preparation methods such as steaming, baking and boiling, rather than frying were incorporated into daily cooking, this could aid in reducing the prevalence of obesity in the long-term (Fabbri & Crosby 2016; He, Hu, Colditz, Manson, Willett & Liu 2004). Rural communities could achieve this if they saved the money that is usually spent on unhealthy snacks to buy fruits that are in season and cheaper. If produce is grown, individuals could sell leftover produce and use the money to purchase healthier, affordable snacks.

4.5 Conclusions

The results of the current study indicate that under- and over-nutrition co-exist in the African rural communities of KZN studied. Stunting was prevalent among children under five years of age, whilst obesity affected children under five years of age and adults, especially females aged 16-35 years. There was frequent consumption of food items high in carbohydrates (mainly the cereal grain foods) and low in fibre and micronutrients such as vitamin A. The findings suggest that the nutrition transition has influenced the nutritional status of the rural KZN population groups investigated. The use of agriculture to improve the availability of and access to diverse, affordable and nutrient-dense foods should be explored. In this regard, the inclusion of several nutritious underutilised crops in such agricultural interventions should be encouraged. Future studies should explore improving current diets with PVA-biofortified maize and OFSP and underutilised protein-rich crops such as bambara groundnut. Furthermore, there is a need to investigate the nutritional composition of these crops so that these crops can be incorporated into the diets of vulnerable population groups to improve their nutritional status.

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CHAPTER 5

EFFECT OF REPLACING NON-BIOFORTIFIED WHITE MAIZE AND SWEET POTATO WITH PROVITAMIN A-BIOFORTIFIED MAIZE AND ORANGE-FLESHED SWEET POTATO ON THE NUTRITIONAL COMPOSITION OF POPULAR TRADITIONAL FOODS OF KWAZULU-NATAL PROVINCE, SOUTH AFRICA[27]

Abstract

Biofortification is an emerging strategy that has the potential to improve micronutrient deficiencies, such as vitamin A deficiency (VAD), which is particularly prevalent among rural communities in sub-Saharan Africa (SSA). Three crops have been identified for provitamin A (PVA)-biofortification namely; cassava, maize and sweet potato. From these three crops, maize is a commonly consumed staple food in South Africa (SA). Additionally, sweet potato is also consumed in SA, but not as regularly as maize. Thus, maize and sweet potato are ideal for PVA-biofortification. Provitamin A-biofortified foods can exhibit undesirable sensory properties due to carotenoid pigments present in PVA-biofortified foods, which results in poor consumer acceptance. However, consumer acceptance of these foods could be improved by serving PVA-biofortified foods with other commonly consumed food items. Thus, this study aimed to investigate the effect of replacing white maize and cream-fleshed sweet potato (CFSP) with PVA-biofortified maize and orange-fleshed sweet potato (OFSP) on the nutritional composition of popular traditional South African dishes.

A survey[28] was conducted in KwaZulu-Natal (KZN), to identify the food items that were the most frequently consumed together with white *phutu*. Based on the survey results, *phutu* served with curried[29] chicken and *phutu* served with curried cabbage were selected for this study. Bambara groundnut was selected for this study as it is an affordable, good source of several nutrients, including protein, but is underutilised in KZN. Two varieties of sweet potato (OFSP and CFSP) were selected for the study. The nutritional composition of uncooked and cooked food samples was determined using standard or referenced methods. Before nutritional

[27] Publication based on this research chapter:
Govender L, Pillay K, Siwela M, Modi A, Mabhaudhi T (2019). Improving the dietary vitamin A content of rural communities in South Africa by replacing non-biofortified white maize and sweet potato with biofortified maize and sweet potato in traditional dishes. **Nutrients** 11:1198 doi:10.3390/nu11061198.
[28] Survey details presented in section 6.4.1.
[29] Curry was selected as the preparation method as it was reported by study participants as the most common way in which the food items were prepared.

analysis, raw (uncooked) and cooked food samples with a high moisture content (all cooked samples, as well as uncooked PVA-biofortified and white maize meal) were freeze-dried. Two replicates of each sample were analysed to ensure accurate results. Usual portion sizes were obtained from caregivers for 65 children aged 1-5 years. The mean usual intake was calculated for each of the composite dishes and OFSP for each age category. These values were used to determine if the usual portion sizes for the different age groups met the Estimated Average Requirement (EAR) for vitamin A.

The protein, fibre, total mineral (ash), lysine, and iron concentrations of the PVA-biofortified *phutu* (traditional crumbly porridge) composite dishes, were not significantly different from those of white maize *phutu* composite dishes (control) ($p>0.05$). However, there were significant differences in mean PVA concentration across the composite dishes containing PVA-biofortified *phutu* and each sample had a higher mean PVA concentration than its control ($p<0.05$). The PVA concentration of PVA maize *phutu* composite dishes was higher than that of white maize *phutu* composite dishes. The OFSP had a significantly lower protein concentration, but a significantly higher fibre, ash, lysine, isoleucine, leucine, and PVA concentration, relative to CFSP ($p<0.05$). It was found that although all three PVA composite dishes contained a higher vitamin A concentration, these combinations did not meet the EAR for the 1-3 and 4-5 year age groups. The PVA carotenoid concentration of OFSP was much higher than that of CFSP. Additionally, the consumption of usual portions of OFSP by the 1-3 and 4-5 year age groups met three times the EAR value for vitamin A.

Overall, the findings of the current study have indicated that PVA-biofortified *phutu*, when combined with other foods, such as curried cabbage, chicken or bambara groundnut as well as OFSP, have the potential to improve nutrient intake and dietary diversity of rural population groups in KZN and other rural areas of SA. The proposed composite foods (PVA-biofortified *phutu* with either curried cabbage, chicken or bambara groundnut) would be new to the target population groups, as such it is not known whether they would be acceptable to the consumers. Thus, the study indicated that composite dishes in which white maize is replaced with PVA-biofortified maize, and CFSP with OFSP, could contribute to combating VAD in SA, and in other developing countries where these foods are consumed.

5.1 Introduction

Biofortification is a process that improves the nutrient content of staple crops through plant breeding or recombinant deoxyribonucleic acid (rDNA) technology. Biofortified crops could play a vital role in improving the nutritional status of vulnerable population groups, where supplementation, conventional fortification, or dietary diversity is limited or problematic to implement [World Health Organization (WHO) 2018]. HarvestPlus, a global Challenge Programme, aims to reduce micronutrient malnutrition by developing crops that are higher in vitamin A, iron and zinc and have selected seven crops for biofortification, namely: beans (*Phaseolus vulgaris*), maize (*Zea mays*), pearl millet (*Pennisetum glaucum*), wheat (*Triticum aestivum*), cassava (*Manihot esculenta*), sweet potato (*Ipomoea batatas*), and rice (*Oryza sativa*). Of these crops, cassava, maize and sweet potato have been selected for PVA-biofortification (HarvestPlus 2018; WHO 2018). The current PVA breeding targets for maize and sweet potato are 15 µg/g and 32 µg/g, respectively (HarvestPlus 2009a; HarvestPlus 2009b). White maize and cream-fleshed sweet potato (CFSP) are two commonly grown and consumed crops in SA [Department of Agriculture, Forestry and Fisheries (DAFF) 2017; Low, Mwanga, Andrade, Carey & Ball 2017] and are therefore ideal for PVA-biofortification (DAFF 2017; Low *et al* Ball 2017; Mitra 2012). Although these crops are widely consumed in SA, they are deficient in PVA carotenoids, the precursors of vitamin A found in plants (Low *et al* 2017; Mitra 2012). This could partly explain the slow improvement in the vitamin A status of the South African population, especially children (Shisana, Labadarios, Rehle, Simbayi, Zuma, Dhansay, Reddy, Parker, Hoosain, Naidoo, Hongoro, Mchiza, Steyn, Dwane, Makoea, Maluleke, Ramlagan, Zungu, Evans, Jacobs, Faber & SANHANES-1 Team 2013).

Vitamin A is an essential micronutrient that has several physiological roles including immunity, vision and protein synthesis (Sizer & Whitney 2017, pp244-245). In SA, between 1994 and 2005, the number of children that had VAD increased from 33.3% to 63.6% (Labadarios, Swart, Maunder, Kruger, Gericke, Kuzwayo, Ntsie, Steyn, Schloss, Dhansay, Jooste, Dannhauser, Nel, Molefe & Kotze 2008; Labadarios & Van Middelkoop 1995). Although, the results from the 2012 SANHANES-1 study showed a decrease in VAD prevalence from the 2005 NFCS-FB, the prevalence of VAD is still high (43.6%) (Shisana *et al* 2013; Labadarios *et al* 2008). Biofortification could be used as a complementary strategy to reduce VAD in vulnerable population groups. However, PVA-biofortified foods, especially maize, have been found less acceptable compared to their non-PVA-biofortified counterparts. This has been attributed to the unfamiliar sensory attributes imparted by carotenoid pigments present in PVA-biofortified foods (Talsma, Melse-Boonstra & Brouwer 2017; Nuss, Arscott, Bresnahan, Pixley, Rocheford, Hotz, Siamusantu, Chileshe & Tanumihardjo 2012; De Groote, Kimenju & Morawetz 2011; De Groote, Tomlins, Haleegoah, Awool, Frimpong, Banerji, Chowdury & Meenakshi 2010; De Groote & Kimenju 2008). Consumer acceptability of PVA-biofortified foods could be improved by combining them with other commonly consumed food items (plant or animal based) as they could mask the undesirable properties of PVA-biofortified foods. A published South African study that investigated the acceptance of combining PVA-biofortified foods with other foods, reported an improvement in consumer acceptability. *Phutu*, a traditional crumbly porridge made from PVA-maize was well accepted when it was combined with chicken stew (Amod, Pillay, Siwela & Kolanisi 2016).

Animal food products such as chicken are a good source of protein, however, with the increase in food prices, it has become costly for the economically disadvantaged household [National Agricultural Marketing Council (NAMC) 2019]. Although there has also been a price increase in plant-based foods items such as legumes, it is still more affordable than animal-based protein food items (NAMC 2019). Legumes contain protein, carbohydrates, vitamins and minerals (Maphosa & Jideani 2017, p104) and when eaten together with maize, they form a complementary protein (Insel, Ross, McMahon & Bernstein 2017, p238). Bambara groundnut (*Vigna subterranean*) is an example of an underutilised and neglected legume found in SSA (Chivenge, Mabhaudhi, Modi & Mafongoya 2015). This exemplar legume contains the amino acid methionine, thus making this legume more nutritionally complete in comparison to other legumes (Stone, Massey, Theobald, Styslinger, Kane, Kandy, Tung, Adekoya, Madan & Davert 2011, p3). The combination of PVA-biofortified maize and bambara groundnut could not only improve the vitamin A intake but also the protein quality of the diets of economically disadvantaged individuals. Despite bambara groundnut being nutrient-dense, it is underutilised due to its hard-to-mill, anti-nutritional and hard-to-cook properties (Ndidi, Ndidi, Aimola, Bassa, Mankilik & Adamu 2014; Boye, Zare & Pletch 2010; Uvere, Uwaegbute & Adedeji 1999). Furthermore, bambara groundnut is an unfamiliar crop to South Africans (Oyeyinka, Pillay & Siwela 2017). Unlike biofortified maize, OFSP has been well accepted by consumers (Pillay, Khanyile & Siwela 2018; Laurie & Van Heerden 2012; Chowdhury, Meenakshi, Tomlins & Owori 2011; Low & Van Jaarsveld 2008; Tomlins, Ndunguru, Stambul, Joshua, Ngendello, Rwiza, Amour, Ramadhani, Kapande & Westby 2007). Therefore, there are fewer challenges with the consumer acceptability of OFSP.

Apart from increasing the PVA content of popular vitamin A-deficient traditional and indigenous plant-based dishes of KZN, PVA-biofortified maize and OFSP are also likely to significantly affect the concentration of other nutrients in the dishes. The study objective was to determine the effect of replacing white maize and CFSP with PVA-biofortified maize and

OFSP, respectively, on the nutritional composition of traditional dishes of KZN province of SA. The food products studied were *phutu*[30]prepared with white maize meal and PVA-biofortified maize meal served with curried[31] chicken, cabbage or bambara groundnut[32] and boiled sweet potato[33] (CFSP and OFSP). The *phutu* combinations were selected based on a survey that was conducted in four selected rural study sites in KZN.[34]

5.2 Methodology

5.2.1 Study design

This study employed a cross-sectional survey and experimental study design. The conceptual framework of the study flow is illustrated in Figure 5.1.

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[30] Maize meal cooked into a crumbly porridge.
[31] Curried was selected as the preparation method as it was reported by study participants as the most common way in which the food items were prepared.
[32] Curried bambara groundnut was selected for this study as South Africans are accustomed to consuming curried beans. It was decided that bambara groundnut would be substituted for beans in a traditional curry recipe to improve the acceptability.
[33] Prepared using the boiling method.
[34] More details are found in section 6.4.1.

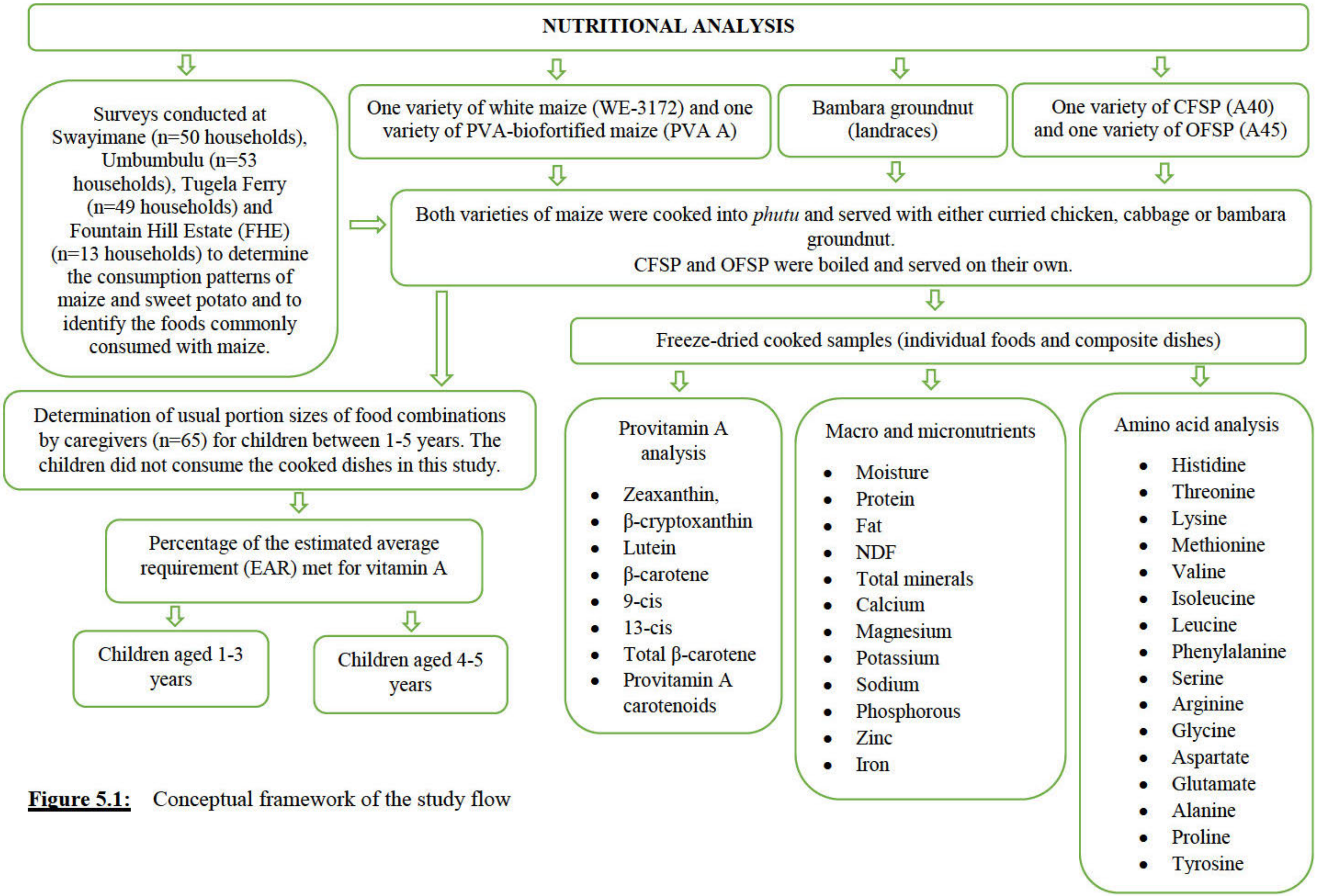

Figure 5.1: Conceptual framework of the study flow

5.2.2 Plant materials

5.2.2.1 Maize

Dried (about 10% moisture) grain of two maize varieties, a PVA-biofortified variety (PVA A) (Figure 5.2) and white variety (WE-3172) (control) (Figure 5.3) were used in this study. Plant breeders at the UKZN produced the maize grains. Orange maize inbred lines were developed through pedigree breeding. During phenotypic selection, emphasis was placed on grain colour intensity such that lines exhibiting deep orange colour were advanced to the next generation. The deep orange grain colour is positively correlated with total carotenoid content in maize grain (Rajagopal, Prasanna & Hossain 2013). Experimental F1 maize hybrids were then developed by cross-pollination of the inbred lines. The hybrids were divided into three groups depending on the colour intensity as follows: Group A-deep orange, B-medium and C-light orange. Each group was used to make a synthetic population by mixing the grain of the hybrids and allowing them to mate randomly. For the purpose of the study, the one synthetic population was designated PVA A. The maize varieties were grown at the UKZN Ukulinga Research Farm, Pietermaritzburg, SA. Standard cultural practices for maize production were followed. The maize was harvested manually and left to dry under ambient conditions (±25 °C) for 21 days at the Ukulinga Research Farm. The maize was then threshed by hand and the grain was stored in a cold room (approximately +4 °C) at Ukulinga Research Farm until it was required for the research.

Figure 5.2: Provitamin A-biofortified maize (PVA A)

Figure 5.3: White maize (WE-3172) (control)

A grain cleaner (R.G Garvie and sons, Agricultural Engineers, Aberdeen, Scotland, UK) was used to clean the maize grains. After cleaning the grains, moisture was adjusted to 15 % (w/v). A hammer roller (Zhauns Business Opportunities & Engineering, Cape Town, SA) was then used to mill the maize grains. This maize meal passed through a 1 mm hammer mill screen.

5.2.2.2 Sweet potato

The OFSP (A45) (Figure 5.4) and CFSP (A40) (Figure 5.5) genotypes were developed by controlled pollination. The female and male parent was known. The parents of A40 were Merikan x Yan Shu 1 and A45 were Excel x Xushu 18. They were among the progeny of the first set of crosses conducted among elite parental lines imported from the International Potato Centre (CIP), Peru. This first series of crosses were referred to as the "A" series and proved the most successful with seven crosses being released and grown by small and large-scale farmers. The OFSP used in this study were grown for experimental purposes, therefore availability and price of the experimental OFSP were not determined.

Figure 5.4: Orange-fleshed sweet potato (A45)

Figure 5.5: Cream-fleshed sweet potato (A40) (control)

5.2.2.3 Bambara groundnut

The bambara groundnut landrace was purchased from Umvoti beans in Moolla industrial township, Stanger, KwaDukuza (Figure 5.6). Bambara groundnut is sold dry, therefore it is available all year round. There was no expiry date available on the packaging of the bambara groundnut. The bambara groundnut landraces were stored at room temperature in an airtight container until ready to cook.

Figure 5.6: Bambara groundnut used in the study

5.2.2.4 Cabbage

White cabbage was purchased from a local (Pietermaritzburg) supermarket for the study.

5.2.3 Preparation of food products

Phutu was prepared from the maize meal of the two maize varieties [the PVA-biofortified variety and the white maize variety (control)] using a standardised recipe (Appendix K). The *phutu* was served with curried cabbage (Appendix L), chicken (Appendix M), and bambara groundnut (Appendix N) and prepared using standardised recipes. *Phutu* served with either curried cabbage or chicken were selected because they are popular traditional dishes in KZN. The *phutu* and curried bambara groundnut were selected as a plant-based alternative to animal food sources (chicken) that are usually combined with *phutu*. The two varieties of sweet potato were boiled separately using a standardised recipe (Appendix O) and served on their own, i.e. they were not composited with other food items. Full details on the preparation of food products are presented in section 6.4.4.2.

5.2.4 Nutritional composition of maize composite dishes and sweet potato

The nutritional composition of uncooked and cooked food samples was determined using standard or referenced methods. Before nutritional analysis, raw (uncooked) and cooked food samples with high moisture content (all cooked samples, as well as uncooked PVA-biofortified and white maize meal) were freeze-dried. Two replicates of each sample were analysed.

5.2.4.1 Protein

The protein content of the samples was measured with a LECO Truspec Nitrogen Analyser (LECO Corporation, St Joseph, Michigan, USA) using the Association of Official Analytical Chemists (AOAC) Official Method 990.03 (AOAC 2003). Controls and samples were measured in duplicate and placed into a combustion chamber at 950 °C with an autoloader. Analysis was conducted in duplicate to ensure accuracy. It would have been ideal to conduct the nutritional analysis in triplicate; however, this was not possible due to financial restrictions. The following equation (AOAC 2003) was used to calculate the percentage of protein:

$$\%\, crude\ protein = \%\, N \times 6.25 \quad (1)$$

5.2.4.2 Fat

The fat content of the samples was determined following the Soxhlet procedure. The Büchi 810 Soxhlet Fat extractor (Büchi, Flawil, Switzerland) was used for the analysis according to the AOAC Official Method 920.39 (AOAC 2003). Petroleum ether was used for extraction, and the percentage of crude fat was calculated using the following equation (AOAC 2003):

$$\% \, crude \, fat = \frac{beaker + fat - beaker \times 100}{sample \, mass} \qquad (2)$$

5.2.4.3 Moisture

The moisture content of the samples was measured using the AOAC Official Method 934.01 (AOAC 2003). The samples were dried at 95 °C for 72 hours in an air-circulated oven. Thereafter, the weight loss of the samples was used to calculate the moisture content. The following equation (AOAC 2003) was used to calculate the moisture content:

$$\% \, moisture = \frac{(mass \, of \, the \, sample + dish) - (mass \, of \, sample \, after \, drying)}{(mass \, of \, the \, sample + dish) - (mass \, of \, petri \, dish \, without \, the \, lid)} \times 100 \qquad (3)$$

5.2.4.4 Total mineral content (ash)

The total mineral content of the samples was determined using the AOAC Official Method 942.05 (AOAC 2003). The samples were weighed and placed in a furnace at 550 °C for 24 hours. The minerals remained as a residue of ash in the crucibles after the volatilisation of the organic matter from the samples. The following equation (AOAC 2003) was used to determine the percentage of ash:

$$\% \, ash = \frac{(mass \, of \, sample + crucible \, after \, ashing) - (mass \, of \, pre-dried \, crucible)}{(mass \, of \, sample + crucible) - (mass \, of \, pre-dried \, crucible)} \times 100 \qquad (4)$$

5.2.4.5 Fibre

Fibre was determined as neutral detergent fibre (NDF) using the Van Soest method (FAO 2011; Van Soest & Robertson 1979; Van Soest 1963). The sample was weighed using an analytical balance and 0.5 g was added into a scintered glass crucible (34 × 2.8mm, porosity 2). Neutral detergent solution (NDS) (50 ml) and a marble/buffer beads were added to the glass crucible holder. The NDS was prepared with 124 g ethylene diamine tetra-acetic acid, 45.3 g disodium tetraborate, 200 g sodium lauryl sulphate, 67 ml 2-ethoxy ethanol and 30.4 g disodium hydrogen phosphate. Thereafter, the crucible containing the sample was placed into the glass crucible holder. The crucible holder with crucible, sample and NDS were placed into a digestive block set at 110 °C. Subsequently, 1 ml of termamyl (α-amylase) was added and covered with stoppers. After 1 hour 10 minutes, the glass crucible holder containing the crucible, sample, and NDS was removed and placed into the glass crucible holder rack. Next, the glass crucible was removed and placed on a draining rack. The sample was then suctioned in a filtration unit which was connected to a vacuum system and washed three times with boiling water. The sample and sides of the crucible were rinsed with acetone. Thereafter, samples were placed in a drying oven set that was maintained at 105 °C for at least 4 hours. The sample was then removed from the oven and placed in a desiccator to cool. The crucible was weighed and the following equation was used to calculate the NDF of the sample (Van Soest, Robertson & Lewis 1991):

$$\% \, NDF = \frac{(crucible + dry\ residue) - (crucible + ash)}{sample\ mass} \times 100 \quad (5)$$

5.2.4.6 Amino Acids

Amino acids were analysed by the hierarchical clustering linear combination (HCLC) method after HCl hydrolysis and derivatization. The method was according to the International Analytical Group (International Analytical Group 2016) and is briefly described below. The freeze-dried sample was added to a glass vial and 6 N HCl was added. Thereafter, the vial was flushed with argon or nitrogen gas to eliminate oxygen, before the lid was closed. The vial was placed in an oven at 110 °C for 18-24 hours. The vial was removed from the oven and allowed to cool. The hydrolysate was filtered using centrifuge tube filters (Corning® Costar® Spin-X tubes, Sigma-Aldrich, St. Louis, MO, USA). The filtrate was transferred to Eppendorf tubes and allowed to dry using a speedvac and thereafter reconstituted in borate buffer for derivatization. The borate buffer was transferred into a 200 µl glass insert in a 2 ml glass vial, and 10 µl of either standard solution or diluted sample was added. The 6-aminoquinolyl-N-hydroxysccinimidyl carbamate (AQC) reagent was added, and then the vial was placed in a vortex to ensure that the sample was mixed properly. The vial was then placed in an oven at 55 °C for 10 minutes, and then loaded into the autosampler tray for analysis. An H-class Waters Acquity ultra performance liquid chromatography (UPLC) linked to a Waters photodiode array detector (Waters, Milford, MA, USA), was used for high-resolution UPLC-UV analysis. The separation was achieved on an Acquity UPLC BEH C18 (2.1 × 150 mm; 1.7 µm particle size) column at 60 °C and a flow rate of 0.4 ml/min. Data were collected at a wavelength of 254 nm. An injection volume of 1 µl was used, and gradient separation was performed using Solvents A and B from the Waters Accutag kit.

5.2.4.7 Mineral elements

Calcium, phosphorous, iron, and zinc, were analysed using the Agricultural Laboratory Association of Southern Africa (ALASA) Method 6.1.1 (ALASA 1998). The first step of this process was to freeze-dry the samples in a freeze drier (Edwards, High vacuum international, Sussex, England). Samples were ashed for 24 hours at 550 °C in a furnace. The samples were dissolved in HCl and then HNO_3 was added. The samples were analysed using an atomic absorption spectrophotometer. Calcium and phosphorus were determined using the Analytik Jena Spekol 1300 spectrophotometer (Analytik Jena AG, Achtung, Germany). Iron was determined with the Varian SpectrAA atomic absorption spectrophotometer (Varian Australia Pty Ltd, Mulgrave, Victoria), and zinc with the GBC 905AA spectrophotometer (GBC Scientific Equipment Pty Ltd., Dandenong, Victoria, Australia).

5.2.4.8 Provitamin A

The provitamin A content of the food samples was determined by high-performance liquid chromatography (HPLC), according to the procedures described by Lacker, Strohschein & Albert (1999).

5.2.5 Determining usual portion sizes for children aged 1-5 years

Usual portion sizes of composite dishes (*phutu* and curried cabbage, *phutu* and curried chicken and *phutu* and curried bambara) and boiled CFSP was obtained from caregivers of children aged 1-5 years, as part of the consumer acceptability study (Chapter 6). Portion sizes were obtained from caregivers for 65 children aged 1-5 years. Table 5.1 indicates the number of portion sizes obtained for each age group.

<u>Table 5.1:</u> The number of portions sizes obtained for each age category (n=65)

Age group	n (%)
1-3 years	37 (56.9)
4-5 years	28 (43.1)

Caregivers were provided with a bowl or plate and a dishing spoon and were required to plate the amount of *phutu* and curry together, that they would usually serve the child in their care. Additionally, the caregivers selected the size of CFSP that they felt best resembled the usual portion they would serve the child. The food portions were then weighed using an electronic scale (Soehnle, Leifheit AG 56377, Nassau, Germany) and the measurements recorded. The mean usual intake was calculated for each of the composite dishes. Tables 5.2 and 5.3 presents the mean usual portion sizes for each age category. These values were used to determine if the usual portion sizes for the different age groups met the EAR for vitamin A for children in the different age groups.

The caregivers served the children the same portion of *phutu* with either curried cabbage, chicken or bambara groundnut. The independent samples t-test indicated that only the chicken portions were significantly different for the two age groups ($p<0.05$). The chicken portion served to 4-5 year olds was significantly greater than the portion served to 1-3 year olds ($p<0.05$).

5.2.6 Data quality control

A template was designed for data collection and checked by the statistician to ensure that all relevant variables were included in the template. Data from the nutritional analysis was entered into two Microsoft Excel spreadsheets with the same template. These two spreadsheets were compared to ensure that there were no discrepancies. Thereafter, the two spreadsheets were consolidated into one and analysed statistically.

5.2.7 Reduction of experimental errors

Several steps were taken to reduce experimental errors. All food was prepared using the same brands of ingredients, measuring cups, spoons, pots and model of the stove. All dry ingredients were measured on a calibrated food scale. Samples of the cooked dishes were taken on the day it was prepared and freeze-dried to stop the cooking process and prevent any chemical changes. Nutritional analysis was conducted in duplicate, using standardised methods.

5.2.8 Statistical analysis

Nutritional composition data were analysed using the Statistical Package for Social Science (SPSS) (version 25.0 SPSS Inc, Chicago III USA). Mean values and standard deviations were determined for all duplicate measurements for 13 cooked and uncooked samples. The Kruskal Wallis non-parametric test was used to determine if there were significant differences in nutritional composition across uncooked and cooked food products.

Table 5.2: Mean usual portion sizes of meals prepared with *phutu* and combined with either curried chicken, cabbage or bambara groundnut reported by caregivers (n=65) of children aged 1-5 years

1-3 YEARS OLD				4-5 YEARS OLD			
Composite dish	**n**	**Usual portion (g)**	**Weight range of usual portions (g)**	**Composite dish**	**n**	**Usual portion (g)**	**Weight range of usual portions (g)**
Phutu (92.59 g) and curried chicken (65.95 g)	37	158.54[a] (40.80)[b]	72-236	*Phutu* (110.50 g) and curried chicken (77.57 g)	28	188.07 (60.30)	100-386
Phutu (92.59 g) and curried cabbage (72.65 g)	37	165.24 (52.05)	84-268	*Phutu* (110.50 g) and curried cabbage (85.14 g)	28	195.64 (65.96)	110-394
Phutu (92.59 g) and curried bambara groundnut (83.92 g)	37	176.51 (59.56)	67-278	*Phutu* (110.50 g) and curried bambara groundnut (89.75 g)	28	200.25 (78.38)	106-452

[a] Mean weight (g); [b] Standard deviation.

Table 5.3: Mean usual portion sizes of sweet potato reported by caregivers (n=65) of children aged 1-5 years

Age	**n**	**Usual portion (g)**	**Weight range of usual portion (g)**
1-3 years	37	142.73[a] (97.50)[b]	40-360
4-5 years	28	179.50 (95.13)	50-448

[a] Mean weight (g); [b] Standard deviation.

Where significant differences were identified, the Mann-Whitney U test was used to determine the specific differences. The Mann-Whitney U test was also used to determine significant differences in nutritional composition across the two sweet potato varieties. Significance was measured at the 5% level throughout. Data for the usual portion size was analysed using the statistical package, SPSS (version 25.0 SPSS Inc, Chicago III USA). Mean values and standard deviations were determined for all duplicate measurements. The independent samples t-test was used to test for significant differences in mean values between the portion size of the *phutu* composite dishes and sweet potato for the two age groups (1-3 years and 4-5 years).

5.3 Results

5.3.1 Proximate composition of uncooked and cooked food samples

The concentration of all the nutrients analysed differed significantly according to the Kruskal Wallis test: $p<0.05$, across the 10 food samples (Table 5.4). Following further analysis with the Mann-Whitney U test, specific differences are described below.

The protein concentration of PVA-biofortified maize meal/flour (8.68 g/100 g) was not significantly different from that of white maize meal/flour (10.22 g/100 g) ($p=1.000$) (Table 5.4). Provitamin A-biofortified *phutu* served with either curried cabbage, chicken or bambara groundnut did not have a significantly different protein concentration in comparison to white *phutu*, served with either curried cabbage, chicken or bambara groundnut ($p=1.000$, $p=0.954$ and $p=1.000$, respectively).

When comparing the three PVA biofortified composite dishes, there were no significant differences in the protein concentration ($p>0.05$). The fibre concentration of PVA-biofortified maize/flour (13.53 g/100 g) was not significantly different from that of white maize meal/flour (control) (5.44 g/100 g) (Table 5.4) ($p=0.998$). Replacing white maize *phutu* (control) with PVA *phutu* in the composite dishes had no effect on the fibre concentration of PVA *phutu* and curried chicken; PVA *phutu* and curried cabbage; or white *phutu* and curried bambara groundnut ($p=1.000$, $p=1.000$ and $p=0.993$, respectively).

Table 5.4: Proximate composition of uncooked and cooked food samples, except for sweet potato

Sample	Moisture (%)	Protein (g/100 g, DW[a])	Fat (g/100 g, DW)	NDF[b] (g/100 g, DW)	Total mineral content (ash) (mg/100 g, DW)
Raw maize meal/flour					
White maize flour (control)	9.88[c] (0.59)[d]	10.22 (0.21)	3.89 (0.61)	5.44 (6.62)	1.21 (0.12)
PVA[e]-biofortified maize flour	9.20 (1.77)	8.68 (0.01)	2.97 (0.15)	13.53 (0.85)	1.35 (0.04)
Phutu					
White *phutu* (control)	4.88 (0.17)	9.71 (0.15)	2.48 (0.21)	9.65 (0.62)	5.10 (0.37)
PVA-biofortified *phutu*	4.91 (0.50)	8.74 (0.03)	2.70 (0.28)	17.45 (0.66)	2.64 (0.15)
Curried dishes					
Curried cabbage	15.48 (1.68)	13.04 (0.56)	20.56 (0.03)	28.64 (1.75)	11.19 (0.28)
Curried chicken	9.17 (1.18)	71.23 (9.43)	22.62 (3.03)	40.82 (17.47)	14.15 (0.74)
Curried bambara groundnut	8.00 (0.27)	17.00 (0.17)	12.13 (0.97)	29.21 (4.71)	8.00 (0.27)
Composite dishes					
White *phutu* (59.0 g) and curried chicken (41.0 g)	4.17 (0.00)	28.60 (2.59)	7.27 (0.13)	10.77 (1.43)	3.42 (0.24)
PVA *phutu* (59.0 g) and curried chicken (41.0 g)	4.38 (0.54)	22.86 (0.87)	8.87 (1.29)	15.94 (4.55)	3.46 (0.06)
White *phutu* (61.5 g) and curried cabbage (38.5 g)	6.83 (0.82)	10.10 (0.11)	9.19 (0.35)	18.95 (2.81)	4.18 (0.25)
PVA *phutu* (61.5 g) and curried cabbage (38.5 g)	6.70 (0.63)	9.00 (0.15)	9.46 (0.10)	18.63 (0.23)	4.63 (0.17)
White *phutu* (56.3 g) and curried bambara groundnut (43.7 g)	7.14 (1.44)	13.29 (0.15)	8.98 (0.38)	17.45 (0.10)	3.24 (0.09)
PVA *phutu* (56.3 g) and curried bambara groundnut (43.7 g)	4.51 (2.75)	12.86 (0.93)	8.00 (0.77)	26.63 (2.19)	3.45 (0.11)
P-value[f]	**0.036**	**0.017**	**0.019**	**0.029**	**0.017**

[a] DW: dry weight basis; [b] NDF: Neutral detergent fibre; [c] Mean of duplicate values; [d] Standard deviation; [e] PVA: Provitamin A; [f] Kruskal Wallis test; Values in bold indicate $p<0.05$.

Table 5.5: Nutritional composition of cooked orange-fleshed sweet potato compared to the cream-fleshed sweet potato (control)

Sweet Potato	**Moisture (%)**	**Protein (g/100 g, DW[a])**	**Fat (g/100 g, DW)**	**NDF[b] (g/100 g, DW)**	**Total mineral content (ash) (mg/100 g, DW)**
Boiled OFSP[c]	4.88[d] (0.17)[e]	4.51 (0.30)	0.64 (0.17)	5.97 (0.25)	5.83 (1.45)
Boiled CFSP[f]	3.90 (0.64)	6.38 (0.32)	0.50 (0.11)	4.14 (0.18)	3.28 (0.92)
P-value[g]	**<0.05**	**<0.05**	1.000	**<0.05**	**<0.05**

[a] DW: dry weight basis; [b] NDF: Neutral detergent fibre; [c] OFSP: Orange-fleshed sweet potato; [d] Mean of duplicate values; [e] Standard deviation; [f] CFSP: Cream-fleshed sweet potato; [g] Mann-Whitney U test; Values in bold indicate p<0.05.

A similar fibre concentration was observed in all three composite dishes containing PVA-biofortified *phutu* (p>0.05). The total mineral content (ash) of white maize meal/flour (control) (1.21 mg/100 g) was not significantly different from that of PVA-biofortified maize meal/flour (1.35 mg/100 g) (Table 5.4) (p=1.000). The ash content did not change significantly when white *phutu* was replaced with PVA-biofortified *phutu* in the three composite dishes (p>0.05). Orange-fleshed sweet potato had a significantly lower protein concentration relative to the CFSP, but a significantly higher fibre and total mineral concentration (ash) (Table 5.5) (p<0.05).

5.3.2 Amino acid content of uncooked and cooked food samples

Results from the Kruskal Wallis test showed that the concentration of the essential amino acids histidine, lysine, and phenylalanine (Table 5.6) differed significantly (p<0.05) across the 10 food samples analysed (Table 5.7). Further analysis with the Mann-Whitney U test revealed specific differences in nutrient concentrations, which are described below.

Lysine concentration in white maize meal/flour (control) (0.40 g/100 g) was not significantly different from the lysine concentration in PVA-biofortified maize meal/flour (0.36 g/100 g) (p=1.000). Although not statistically significant, the mean lysine concentration was higher in curried bambara groundnut (1.80 g/100g) than in curried cabbage (0.59 g/100g). The lysine concentration did not change when white *phutu* (control) was replaced with PVA-biofortified *phutu* in all three composite dishes. When comparing the three composite dishes containing PVA-biofortified *phutu*, it was evident that there was no significant difference in the lysine concentration (p>0.05). Orange-fleshed sweet potato had higher lysine, isoleucine, leucine, aspartate, glutamate and alanine concentration, but a lower phenylalanine concentration than CFSP (Tables 5.8 and 5.9) (p<0.05).

Table 5.6: Essential amino acid composition of uncooked and cooked samples, except sweet potato (g/100 g, DW[a])

Sample	Histidine	Threonine	Lysine	Methionine	Valine	Isoleucine	Leucine	Phenylalanine
Raw milled maize meal/flour								
White maize flour (control)	0.27[b] (0.04)[c]	0.33 (0.04)	0.40 (0.03)	ND[d]	0.38 (0.06)	0.58 (0.06)	0.78 (0.01)	0.81 (0.11)
PVA[e]-biofortified maize flour	0.20 (0.03)	0.27 (0.04)	0.36 (0.01)	ND	0.35 (0.05)	0.59 (0.10)	0.71 (0.11)	0.71 (0.02)
Phutu								
White *phutu* (control)	0.28 (0.02)	0.35 (0.11)	0.45 (0.11)	0.06 (0.08)	0.40 (0.19)	0.66 (0.59)	0.81 (0.37)	0.91 (0.05)
PVA-biofortified *phutu*	0.20 (0.01)	0.27 (0.03)	0.28 (0.00)	0.08 (0.00)	0.35 (0.01)	0.43 (0.06)	0.67 (0.10)	0.68 (0.08)
Curried dishes								
Curried cabbage	0.15 (0.05)	0.33 (0.06)	0.59 (0.06)	0.05 (0.03)	0.36 (0.04)	0.63 (0.24)	0.30 (0.08)	0.59 (0.07)
Curried chicken	2.01 (0.07)	3.98 (0.27)	11.81(0.67)	2.27 (0.25)	3.18 (0.39)	7.63 (0.68)	4.69 (0.17)	3.02 (0.13)
Curried bambara groundnut	0.44 (0.06)	0.63 (0.07)	1.80 (0.04)	0.13 (0.02)	0.78 (0.06)	1.56 (0.14)	0.97 (0.08)	1.40 (0.35)
Composite dishes								
White *phutu* (59.0 g) and curried chicken (41.0 g)	0.55 (0.13)	1.03 (0.30)	2.23 (0.73)	0.36 (0.12)	0.88 (0.15)	1.95 (0.30)	1.52 (0.40)	1.31 (0.10)
PVA *phutu* (59.0 g) and curried chicken (41.0 g)	0.42 (0.12)	0.83 (0.16)	1.85 (0.61)	0.34 (0.07)	0.69 (0.12)	1.40 (0.63)	1.13 (0.28)	1.07 (0.06)
White *phutu* (61.5 g) and curried cabbage (38.5 g)	0.21 (0.05)	0.34 (0.05)	0.45 (0.03)	0.05 (0.01)	0.43 (0.02)	0.85 (0.13)	0.71 (0.00)	0.77 (0.12)
PVA *phutu* (61.5 g) and curried cabbage (38.5 g)	0.17 (0.08)	0.26 (0.06)	0.27 (0.15)	ND	0.35 (0.10)	0.38 (0.12)	0.59 (0.16)	0.97 (0.11)
White *phutu* (56.3 g) and curried bambara groundnut (43.7 g)	0.32 (0.04)	0.36 (0.06)	0.69 (0.22)	0.09 (0.02)	0.48 (0.08)	1.03 (0.10)	0.79 (0.02)	1.17 (0.11)
PVA *phutu* (56.3 g) and curried bambara groundnut (43.7 g)	0.25 (0.03)	0.32 (0.10)	0.69 (0.20)	0.08 (0.01)	0.45 (0.13)	0.73 (0.03)	0.62 (0.07)	1.09 (0.13)
P-value[f]	**0.030**	0.072	**0.021**	0.065	0.080	0.050	0.053	**0.024**

[a] DW: dry weight basis; [b] Mean of duplicate values; [c] Standard deviation; [d] ND: Not detected; [e] PVA: Provitamin A; [f] Kruskal Wallis test; Values in bold indicate $p<0.05$.

Table 5.7: Non-essential amino acid composition of uncooked and cooked samples, except for sweet potato (g/100 g, DW[a])

Sample	Serine	Arginine	Glycine	Aspartate	Glutamate	Alanine	Proline	Tyrosine
Raw milled maize meal/flour								
White maize flour (control)	0.60[b] (0.01)[c]	0.42 (0.01)	0.76 (0.01)	0.45 (0.04)	1.89 (0.03)	0.66 (0.01)	0.76 (0.00)	0.15 (0.21)
PVA[d]-biofortified maize flour	0.53 (0.06)	0.25 (0.05)	0.67 (0.16)	0.40 (0.05)	1.72 (0.30)	0.65 (0.07)	0.71 (0.11)	0.10 (0.13)
Phutu								
White *phutu* (control)	0.65 (0.30)	0.34 (0.09)	0.77 (0.22)	0.64 (0.29)	2.06 (1.01)	0.74 (0.32)	0.85 (0.28)	0.12 (N/A[e])
PVA-biofortified *phutu*	0.48 (0.04)	0.24 (0.00)	0.66 (0.03)	0.47 (0.06)	1.64 (0.23)	0.58 (0.04)	0.68 (0.01)	0.24 (N/A)
Curried dishes								
Curried cabbage	0.52 (0.06)	0.38 (0.05)	0.71 (0.21)	0.71 (0.04)	2.84 (0.47)	0.48 (0.06)	0.48 (0.13)	ND[f]
Curried chicken	4.29 (0.18)	4.09 (0.08)	7.49 (0.59)	6.92 (0.26)	14.67 (0.59)	5.19 (0.23)	2.64 (0.16)	2.27 (0.07)
Curried bambara groundnut	1.26 (0.18)	0.88 (0.08)	1.45 (0.24)	1.81 (0.16)	3.68 (0.23)	0.85 (0.04)	0.68 (0.15)	0.46 (0.04)
Composite dishes								
White *phutu* (59.0 g) and curried chicken (41.0 g)	1.30 (0.31)	1.02 (0.30)	2.34 (0.27)	1.62 (0.49)	4.37 (1.21)	1.62 (0.32)	1.15 (0.12)	0.53 (0.14)
PVA *phutu* (59.0 g) and curried chicken (41.0 g)	1.08 (0.20)	0.78 (0.14)	1.79 (0.28)	1.26 (0.33)	3.48 (0.98)	1.32 (0.23)	0.96 (0.16)	ND
White *phutu* (61.5 g) and curried cabbage (38.5 g)	0.65 (0.01)	0.27 (0.05)	0.77 (0.01)	0.57 (0.02)	2.28 (0.12)	0.71 (0.06)	0.77 (0.01)	ND
PVA *phutu* (61.5 g) and curried cabbage (38.5 g)	0.52 (0.12)	0.24 (0.13)	0.63 (0.16)	0.50 (0.18)	1.99 (0.62)	0.61 (0.17)	0.67 (0.14)	ND
White *phutu* (56.3 g) and curried bambara groundnut (43.7 g)	0.75 (0.09)	0.47 (0.07)	0.96 (0.04)	0.83 (0.12)	2.22 (0.47)	0.71 (0.04)	0.69 (0.01)	0.32 (0.02)
PVA *phutu* (56.3 g) and curried bambara groundnut (43.7 g)	0.76 (0.20)	0.42 (0.16)	0.83 (0.22)	0.89 (0.15)	1.90 (0.42)	0.61 (0.09)	0.57 (0.04)	0.22 (0.02)
P-value[g]	**0.043**	**0.032**	0.063	**0.032**	0.068	0.074	0.088	0.088

[a] DW: dry weight basis; [b] Mean of duplicate values; [c] Standard deviation; [d] PVA: Provitamin A; [e] N/A: Not applicable; [f] ND: Not detected; [g] Kruskal Wallis test; Values in bold indicate $p<0.05$.

Table 5.8: Essential amino acid composition of cooked orange-fleshed sweet potato compared to the cream-fleshed sweet potato (control) (g/100 g, DW[a])

Sweet potato	Histidine	Threonine	Lysine	Methionine	Valine	Isoleucine	Leucine	Phenylalanine
Boiled OFSP[b]	0.05[c] (0.01)[d]	0.19 (0.06)	0.38 (0.04)	ND	0.20 (0.06)	0.26 (0.02)	0.16 (0.04)	0.32 (0.03)
Boiled CFSP[e]	ND[f]	0.13 (0.03)	0.24 (0.04)	ND	0.20 (0.05)	0.14 (0.04)	0.08 (0.01)	0.66 (0.03)
P-value[g]		0.500	**< 0.05**		1.500	**< 0.05**	**< 0.05**	**< 0.05**

[a] DW: dry weight basis; [b] OFSP: Orange-fleshed sweet potato; [c] Mean of duplicate values; [d] Standard deviation; [e] CFSP: Cream-fleshed sweet potato; [f] ND: Not detected; [g] Mann-Whitney U test; Values in bold indicate p<0.05.

Table 5.9: Non-essential amino acid composition of cooked orange-fleshed sweet potato compared to the cream-fleshed sweet potato (control) (g/100 g, DW[a])

Sweet potato	Serine	Arginine	Glycine	Aspartate	Glutamate	Alanine	Proline	Tyrosine
Boiled OFSP[b]	0.33[c] (0.10)[d]	0.12 (0.03)	0.39 (0.10)	0.77 (0.15)	0.59 (0.11)	0.30 (0.03)	0.13 (0.04)	0.04 (N/A[e])
Boiled CFSP[f]	0.30 (0.04)	0.09 (0.02)	0.34 (0.07)	0.48 (0.08)	0.35 (0.06)	0.26 (0.01)	0.09 (0.01)	ND[g]
P-value[h]	2.000	0.500	1.000	**< 0.05**	**< 0.05**	**< 0.05**	0.500	

[a] DW: dry weight basis; [b] OFSP: Orange-fleshed sweet potato; [c] Mean of duplicate values; [d] Standard deviation; [e] N/A: Not applicable; [f] CFSP: Cream-fleshed sweet potato; [g] ND: Not detected; [h] Mann-Whitney U test; Values in bold indicate p<0.05.

5.3.3 Mineral composition of uncooked and cooked food samples

Results from the Kruskal Wallis test showed that the concentration of selected mineral elements analysed differed significantly across all the 10 food samples ($p<0.05$), except zinc concentration, for which no significant difference was found (Table 5.10). The Mann-Whitney U test showed specific differences and these are described below.

Iron concentration in white maize meal/flour (control) was not significantly different from iron concentration in the PVA-biofortified maize meal/flour ($p=1.000$). The iron concentration did not change significantly when white *phutu* was replaced with PVA *phutu* in the three composite dishes. A similar iron concentration was found in all three composite dishes containing PVA-biofortified *phutu*. The iron concentration was lower in PVA-biofortified *phutu* than curried chicken curry, therefore, combining PVA-biofortified *phutu* and curried chicken reduced the overall iron concentration of the composite dish. Another reason for the reduced iron could be due to the preparation method. The concentration of haem iron found in chicken was found to decrease considerably when cooked (Lombardi-Boccia, Dominguez & Aguzzi 2002). The zinc concentration of CFSP was significantly higher than that of OFSP, but the OFSP had a significantly higher iron concentration than the CFSP ($p<0.05$) (Table 5.11).

Table 5.10: Selected mineral content of uncooked and cooked food samples, except sweet potato (mg/100 g, DW[a])

Sample	Calcium	Magnesium	Potassium	Sodium	Phosphorous	Zinc	Iron
Raw milled maize meal/flour							
White maize flour (control)	0.00[b](0.00)[c]	0.11 (0.01)	0.31 (0.01)	0.00 (0.00)	0.26 (0.01)	1.80 (0.14)	2.05 (2.21)
PVA[d]-biofortified maize flour	0.01 (0.01)	0.11 (0.00)	0.33 (0.01)	0.00 (0.00)	0.27 (0.01)	1.80 (0.14)	2.10 (0.28)
phutu							
White *phutu* (control)	0.01 (0.00)	0.10 (0.00)	0.36 (0.01)	1.73 (0.02)	0.25 (0.01)	1.55 (0.07)	1.60 (0.00)
PVA biofortified *phutu*	0.01 (0.00)	0.11 (0.01)	0.34 (0.01)	0.60 (0.00)	0.26 (0.01)	1.70 (0.00)	1.70 (0.42)
Curried dishes							
Curried cabbage	0.35 (0.00)	0.15 (0.00)	1.56 (0.01)	2.75 (0.02)	0.27 (0.00)	1.60 (0.14)	3.25 (0.07)
Curried chicken	1.52 (0.67)	1.90 (0.10)	29.20 (2.44)	28.02 (3.92)	13.82 (0.81)	3.33 (1.45)	98.50 (39.46)
Curried bambara groundnut	0.04 (0.00)	0.15 (0.01)	1.60 (0.45)	2.00 (0.11)	0.25 (0.00)	1.90 (0.14)	1.90 (0.00)
Composite dishes							
White *phutu* (59.0 g) and curried chicken (41.0 g)	0.10 (0.03)	0.11 (0.01)	0.60 (0.01)	0.71 (0.00)	0.38 (0.03)	1.80 (0.00)	2.15 (0.07)
PVA *phutu* (59.0 g) and curried chicken (41.0 g)	0.03 (0.00)	0.10 (0.00)	0.59 (0.05)	0.75 (0.03)	0.36 (0.00)	2.40 (0.42)	2.75 (0.07)
White *phutu* (61.5 g) and curried cabbage (38.5 g)	0.08 (0.00)	0.11 (0.01)	0.56 (0.01)	0.92 (0.00)	0.25 (0.01)	2.15 (0.64)	2.65 (0.21)
PVA *phutu* (61.5 g) and curried cabbage (38.5 g)	0.10 (0.01)	0.11 (0.01)	0.58 (0.01)	1.07 (0.04)	0.23 (0.00)	1.70 (0.14)	2.25 (0.21)
White *phutu* (56.3 g) and curried bambara groundnut (43.7 g)	0.02 (0.00)	0.13 (0.00)	0.78 (0.01)	0.44 (0.00)	0.28 (0.01)	2.05 (0.21)	2.15 (0.07)
PVA *phutu* (56.3 g) and curried bambara groundnut (43.7 g)	0.02 (0.00)	0.12 (0.00)	0.73 (0.04)	0.47 (0.02)	0.26 (0.00)	1.80 (0.00)	2.10 (0.14)
P-value[e]	**0.016**	**0.037**	**0.018**	**0.015**	**0.024**	0.085	**0.042**

[a] DW: dry weight basis; [b] Mean of duplicate values; [c] Standard deviation; [d] PVA: Provitamin A; [e] Kruskal Wallis test; Values in bold indicate p<0.05.

Table 5.11: Selected mineral content of cooked orange-fleshed sweet potato compared to the cream-fleshed sweet potato (control) (mg/100 g, DW[a])

Sweet potato	Calcium	Magnesium	Potassium	Sodium	Phosphorous	Zinc	Iron
Boiled OFSP[b]	0.06[c] (0.00)[d]	0.09 (0.00)	1.70 (0.01)	0.03 (0.01)	0.15 (0.00)	0.45 (0.64)	2.55 (0.07)
Boiled CFSP[e]	0.13 (0.02)	0.13 (0.01)	1.35 (0.03)	0.07 (0.01)	0.21 (0.00)	1.30 (0.14)	2.25 (0.21)
P-value[f]	**< 0.05**	**< 0.05**	**< 0.05**	**< 0.05**	**< 0.05**	**< 0.05**	**< 0.05**

[a] DW: dry weight basis; [b] OFSP: Orange-fleshed sweet potato; [c]Mean of duplicate values; [d] Standard deviation; [e] CFSP: Cream-fleshed sweet potato; [f] Mann-Whitney U test; Values in bold indicate p<0.05.

5.3.4 Provitamin A (PVA) carotenoid composition of uncooked and cooked food samples

Results from the Kruskal Wallis test showed that the concentration of PVA carotenoids analysed differed significantly across the 10 food samples analysed (Table 5.12) ($p<0.05$). The Mann-Whitney U test showed specific differences in nutrient concentration, as described below.

Provitamin A-biofortified maize meal/flour had a much higher PVA carotenoid concentration (1.43 µg/g) than white maize meal/flour (control) (0.62 µg/g) ($p<0.05$). The composite dish that comprised PVA-biofortified *phutu* and curried chicken (1.12 µg/g) had a significantly higher PVA carotenoid concentration than the composite dish of white *phutu* and curried chicken (control) (0.60 µg/g) ($p=0.002$). The PVA carotenoid concentration increased by 0.36 µg/g when white *phutu* was replaced with PVA-biofortified *phutu* in the composite dish containing curried bambara groundnut ($p=0.047$). The PVA carotenoid concentration of the OFSP (55.84 µg/g DW) was much higher than that of the CFSP (0.77 µg/g DW) (control) (Table 5.13) ($p<0.05$).

Table 5.12: Provitamin A content of provitamin A-biofortified maize composite dishes (µg/g, DW[a])

Sample	Zeaxanthin	β-cryptoxanthin	Lutein	β-carotene isomers			Total β-carotene[b]	Provitamin A carotenoids[c]	Total carotenoids[d]
				β-carotene	9-cis	13-cis			
Raw milled maize meal/flour									
White maize flour (control)	0.27[e] (0.02)[f]	0.00 (0.00)	0.03 (0.00)	0.22 (0.01)	0.20 (0.01)	0.20 (0.01)	0.62 (0.04)	0.62 (0.04)	0.92 (0.06)
PVA[g]-biofortified maize flour	6.35 (0.46)	0.53(0.42)	1.12 (0.08)	0.51 (0.04)	0.36 (0.03)	0.29 (0.02)	1.16 (0.09)	1.43 (0.11)	9.15 (0.67)
Phutu									
White *phutu* (control)	0.20 (0.01)	0.00 (0.00)	0.03 (0.00)	0.21 (0.01)	0.20 (0.01)	0.19 (0.01)	0.60 (0.04)	0.60 (0.04)	0.83 (0.05)
PVA-biofortified *phutu*	2.44 (0.16)	0.51 (0.04)	0.74 (0.04)	0.47 (0.04)	0.35 (0.03)	0.26 (0.01)	1.08 (0.08)	1.34 (0.09)	4.76 (0.32)
Curried dishes									
Curried cabbage	0.92 (0.09)	0.10 (0.14)	0.16 (0.02)	0.43 (0.04)	0.26 (0.02)	0.23 (0.03)	0.92 (0.09)	0.97 (0.11)	2.09 (0.22)
Curried chicken	0.70 (0.04)	0.00 (0.00)	0.03 (0.00)	0.21 (0.01)	0.00 (0.00)	0.00 (0.00)	0.21 (0.01)	0.21 (0.01)	0.94 (0.05)
Curried bambara groundnut	0.20 (0.01)	0.00 (0.00)	0.03 (0.00)	0.23 (0.01)	0.20 (0.01)	0.20 (0.01)	0.63 (0.04)	0.63 (0.04)	0.85 (0.04)
Composite dishes									
White *phutu* (59.0 g) and curried chicken (41.0 g)	0.50 (0.04)	0.00 (0.00)	0.14 (0.01)	0.20 (0.01)	0.20 (0.01)	0.18 (0.05)	0.58 (0.08)	0.60 (0.05)	1.21 (0.12)
PVA *phutu* (59.0 g) and curried chicken (41.0 g)	1.35 (0.09)	0.35 (0.02)	0.43 (0.28)	0.39 (0.03)	0.32 (0.02)	0.24 (0.01)	0.95 (0.06)	1.12 (0.07)	3.07 (0.21)
White *phutu* (61.5 g) and curried cabbage (38.5 g)	1.25 (0.08)	0.00 (0.00)	0.28 (0.02)	0.20 (0.01)	0.20 (0.01)	0.20 (0.01)	0.60 (0.04)	0.60 (0.04)	2.12 (0.14)
PVA *phutu* (61.5 g) and curried cabbage (38.5 g)	0.81 (0.06)	0.14 (0.01)	0.17 (0.01)	0.27 (0.02)	0.23 (0.01)	0.21(0.01)	0.71 (0.05)	0.78 (0.06)	1.83 (0.13)
White *phutu* (56.3 g) and curried bambara groundnut (43.7 g)	0.16 (0.01)	0.00 (0.00)	0.03 (0.00)	0.20 (0.01)	0.21 (0.01)	0.20 (0.01)	0.61 (0.04)	0.61 (0.04)	0.79 (0.04)
PVA *phutu* (56.3 g) and curried bambara groundnut (43.7 g)	1.02 (0.06)	0.25 (0.01)	0.30 (0.02)	0.34 (0.02)	0.28 (0.01)	0.23 (0.01)	0.85 (0.05)	0.97 (0.06)	2.41 (0.15)
P-value[h]	**0.016**	**0.015**	**0.016**	**0.028**	**0.028**	0.055	**0.029**	**0.028**	**0.017**

[a] DW: dry weight basis; [b] (β-carotene + 9-cis +13-cis); [c] (β-cryptoxanthin/2 + β-carotene + 9-cis + 13-cis); [d] (Total β carotene + Zeaxanthin, + β-cryptoxanthin + Lutein);
[e] Mean of duplicate values; [f] Standard deviation; [g] PVA: Provitamin A; [h] Kruskal Wallis test; Values in bold indicate p<0.05.

Table 5.13: Provitamin A content of cooked orange-fleshed sweet potato compared to the cream-fleshed sweet potato (control) (µg/g, DW[a])

Sweet potato	**Zeaxanthin**	**β-cryptoxanthin**	**Lutein**	**β-carotene isomers**			**Total β-carotene[b]**	**Provitamin A carotenoids[c]**	**Total carotenoids[d]**
				β-carotene	**9-*cis***	**13-*cis***			
Boiled OFSP[e]	0.40[f] (0.02)[g]	0.35 (0.14)	0.05 (0.01)	43.29 (1.99)	3.18 (0.15)	9.20 (0.42)	55.67 (2.57)	55.84 (2.57)	56.46 (2.61)
Boiled CFSP[h]	0.20 (0.01)	0.10 (0.01)	0.03 (0.00)	0.27 (0.01)	0.22 (0.01)	0.23 (0.01)	0.72 (0.04)	0.77 (0.04)	1.05 (0.06)
P-value[i]	**< 0.05**	**< 0.05**	**< 0.05**	**< 0.05**	**< 0.05**	**< 0.05**	**< 0.05**	**< 0.05**	**< 0.05**

[a] DW: dry weight basis; [b] (β-carotene + 9-cis +13-cis); [c] (β-cryptoxanthin/2 + β-carotene + 9-cis + 13-cis); [d] (Total β carotene + Zeaxanthin, + β-cryptoxanthin + Lutein); [e] OFSP: Orange-fleshed sweet potato; [f] Mean of duplicate values; [g] Standard deviation; [h] CFSP: Cream-fleshed sweet potato; [i] Mann-Whitney U test; Values in bold indicate p<0.05.

5.3.5 Determining the percentage of EAR met for vitamin A from cooked *phutu* composite dishes and sweet potato

Table 5.14 presents the percentage of EAR met for vitamin A for children aged 1-5 years. The usual portion size is based on Table 5.2 and 5.3. Table 5.14 indicates that all PVA-biofortified *phutu* composite dishes did not meet the EAR for vitamin A. However, the OFSP met approximately three times the EAR for vitamin A for children aged 1-3 years and 4-5 years.

Table 5.14: Percentage of the Estimated Average Requirement met for vitamin A for children aged 1-5 years from the consumption of usual portions of cooked *phutu* composite dishes and boiled sweet potato

Food combinations[35]	**1-3 years**			**4-5 years**		
	Vitamin A content (µg/RAE)[a]	**EAR[b] (µg/day)**	**% of EAR met**	**Vitamin A content (µg/RAE)**	**EAR (µg/day)**	**% of EAR met**
Non-biofortified maize composite dishes						
White *phutu* and curried cabbage	8.26	210	3.9	9.78	275	3.6
White *phutu* and curried chicken	7.66	210	3.6	9.09	275	3.3
White *phutu* and curried bambara groundnut	8.97	210	4.3	10.18	275	3.7
CFSP[c]	9.16	210	7.6	11.52	275	4.2
Biofortified maize composite dishes						
PVA[d]-biofortified *phutu* and curried cabbage	10.74	210	5.1	12.72	275	4.6
PVA-biofortified *phutu* and curried chicken	14.86	210	7.1	17.63	275	6.4
PVA-biofortified *phutu* and curried bambara groundnut	14.34	210	6.8	16.27	275	5.9
OFSP[e]	664.23	210	316.3	835.35	275	303.8

[a] RAE (Retinol activity equivalents): 12µg β-carotene = 1 RAE; 24 µg β-cryptoxanthin = 1 RAE. Sum of β-carotene and β-cryptoxanthin using values presented in Tables 5.2, 5.3, 5.12 and 5.13. (Institute of Medicine 2006, p530); [b] EAR (Estimated average requirement) (Institute of Medicine 2006, p530); [c] CFSP: Cream-fleshed sweet potato; [d] PVA: Provitamin A; [e] OFSP: Orange-fleshed sweet potato.

[35] Tables 5.2 and 5.3 presents the usual portion sizes.

5.4 Discussion

Globally, about two billion people suffer from micronutrient malnutrition, mainly because of low dietary diversity (Bain, Awah, Geraldine, Kindong, Sigal, Bernard & Tanjeko 2013; Smuts, Dhansay, Faber, Van Stuijvenberg, Swanevelder, Gross & Benadé 2005). Undernutrition, particularly protein-energy malnutrition (PEM) and micronutrient deficiencies are more prevalent in developing regions, especially SSA, where a significant proportion of the population groups are poor and food insecure (Bain *et al* 2013; Pinstrup-Andersen 2009; Smuts *et al* 2005; Labadarios & Van Middelkoop 1995). Economically disadvantaged communities cannot afford a nutritious, diversified diet and are heavily reliant on monotonous diets of starchy staples, which are generally low in essential nutrients, including micronutrients and protein [Statistics South Africa (Stats SA) 2018; Stats SA 2017; Altman, Hart & Jacobs 2009]. The leading micronutrient deficiencies are vitamin A, iron and zinc (WHO 2015). This emphasises the need to provide affordable, alternative food sources of essential nutrients, such as vitamin A, zinc, iron, and protein. Biofortified staple crops, which are being developed to contain much higher concentrations of target nutrients, like vitamins and minerals, compared to the corresponding non-biofortified crops, if consumed regularly, would result in significant improvements in human health and nutrition (WHO 2018).

As is the case with most of the countries in the SSA region, micronutrient deficiencies, especially vitamin A deficiency (VAD), are a significant problem in SA (Shisana *et al* 2013; Labadarios *et al* 2008; Labadarios & Van Middelkoop 1995). The KZN province has the largest proportion of economically disadvantaged households in SA and has been one of the poorest provinces in SA since 2011 (Stats SA 2017; Argent, Finn, Leibbrandt & Woolard 2009). Many of these economically disadvantaged communities are unable to purchase foods that form a diversified diet and end up consuming mainly starch-based foods (Smuts *et al* 2005). A basic food basket in SA, comprising 28 items costs about R883.16/month, which is unaffordable to most rural population groups [National agricultural marketing council (NAMC) 2019]. Economically disadvantaged households are at a high risk of malnutrition, as they cannot afford a diversified diet (Mabhaudhi, Chibarabada & Modi 2016; Wenhold, Annandale, Faber & Hart 2012). Increasing the concentration of provitamin A carotenoids in staple crops through biofortification is a promising strategy for contribution to combating VAD. The results of this study are encouraging, as they indicate that PVA-biofortified maize contained a much higher

PVA carotenoid concentration compared to white maize (control), which is consistent with a previous study (Pillay, Siwela, Derera & Veldman 2014).

It appears that, currently, there are no published data on the nutritional composition of composite dishes containing PVA-biofortified maize food products like *phutu* together with other commonly consumed food items. However, in this study when either curried cabbage, chicken, or bambara groundnut were combined with PVA-biofortified *phutu*, the PVA carotenoid concentration of the composite dishes was higher than that of the corresponding composite dishes containing white maize (controls). The results indicate that composite dishes in which PVA-biofortified *phutu* is combined with other commonly consumed food items would be suitable carriers of provitamin A, for delivery to the target population groups, such as the disadvantaged, rural communities of KZN. In the current study, bambara groundnut was included in the dishes containing maize, because it could be used as an affordable protein source, which has the added advantage of thriving in the predominantly harsh agro-ecological conditions of most of the marginal rural areas of sub-Saharan African countries, including the rural areas of KZN (Chibarabada, Modi & Mabaudhi 2017). Previous consumer acceptability studies conducted on bambara groundnut showed promising results, but the studies investigated bambara groundnut food types different from that of the current study (Oyeyinka, Tijani, Oyeyinka, Arise, Balogun, Kolawole, Obalowu & Joseph 2018; Oyeyinka, Pillay & Siwela 2017; Okafor, Okafor, Leelavathi, Bhagya & Elemo 2015). In terms of nutritional composition, the composite dish consisting of PVA-biofortified *phutu* and curried bambara groundnut shows potential for improving the vitamin A and protein status of vulnerable population groups, but the acceptability of such dishes to the target population groups should be investigated because bambara groundnut is not a familiar food item to the majority of South Africans (Oyeyinka *et al* 2017).

While it is important to note that PVA carotenoids must be converted into vitamin A to be used by the human body (La Frano, De Moura, Boy, Lönnerdal & Burri 2014), a study conducted by Palmer, Siamusantu, Chileshe, Schulze, Barffour, Craft, Molobeka, Kalungwana, Arguello, Mitra, Casewell, Klemm & West Jr (2016), found improved serum β-carotene levels in Zambian pre-school children that routinely consumed dishes prepared with biofortified maize (Palmer *et al* 2016). Other studies have found that the consumption of biofortified maize resulted in an effective conversion of PVA into vitamin A (Muzhingi, Gadaga, Siwela, Grusak, Russel & Tang 2011; Li, Nugroho, Rocheford & White 2010). These results reinforce the hypothesis that PVA biofortified maize could be used as a sustainable and effective complementary strategy to address VAD. This study further investigated the percentage of the EAR for vitamin A that could be met in the 1-3 and 4-5 year age groups with the consumption of usual portions of PVA-biofortified *phutu* and curried cabbage, PVA-biofortified *phutu* and curried chicken and PVA-biofortified *phutu* and curried bambara groundnut. It was found that although all three PVA-biofortified *phutu* composite dishes contained a higher vitamin A concentration, these combinations did not meet the EAR for vitamin A for the 1-3 and 4-5 year age groups. This was different from a study conducted by Pillay (2011), who found that the consumption of usual portions of PVA-biofortified maize products (thin porridge, *phutu* and samp) would meet a significant portion of the EAR for vitamin A if consumed three times a day. A limitation of the current study was that only one variety of PVA-biofortified maize was served with either curried cabbage, chicken or bambara groundnut. If other maize varieties with a higher PVA carotenoid content were served with other commonly consumed items three times a day, a similar result to Pillay (2011) could have been obtained. However, the consumption of maize three times a day could result in a monotonous diet therefore, cooked maize meal should be prepared in various ways and consumed with underutilised and/or indigenous crops to improve variety. This would not only improve vitamin A intake but also dietary diversity.

The PVA carotenoid concentration of OFSP was much higher than that of the CFSP, which, was expected. The PVA values obtained for CFSP in the current study agree with values reported in the literature (Williams, Soares, Pereira, Belo, Soares, Setiawan, Browne, Nesbitt & Erskine 2013). The high PVA carotenoid concentration in OFSP could contribute to reducing VAD in vulnerable population groups. Another strategy that could be investigated is combining OFSP with other commonly consumed food item/s to enhance the nutrient content of the dishes, including provitamin A as well as other micronutrients with a high prevalence of deficiency. However, this study did not investigate the nutritional composition of composite dishes of OFSP combined with other commonly consumed food items, and, therefore, further investigations are required.

The study further investigated whether the consumption of usual portions of OFSP by the 1-3 and 4-5 year age groups would meet the EAR for vitamin A and found that it met more than three times the EAR value for vitamin A for both age groups. When comparing the vitamin A values with the tolerable upper intake level (UL), it was found that the vitamin A intake from

OFSP was higher than the UL for the 1-3 year age group (600 µg/day), but lower than the UL for the 4-5 year age group (900 µg/day). Although the vitamin A intake was higher than the UL in the 1-3 year age group, it will not cause any adverse effects. Orange-fleshed sweet potato contains vitamin A in the form of PVA carotenoids. In the human body PVA carotenoids are converted to vitamin A as required, thus consuming foods that are high in PVA carotenoids will not cause toxicity (Mezzomo & Ferreira 2016). The current study results are encouraging as it indicates that OFSP could possibly be used to reduce the VAD prevalence in children under the age of five years, investigated in this study.

As stated earlier, mineral deficiencies, especially iron and zinc deficiencies, are a serious health problem in SSA countries, including SA, but, unfortunately, they are often unnoticed and are not routinely treated. In the current study, the total mineral content (ash) of the individual curries (cabbage, chicken, and bambara groundnut, separately) was higher than that of PVA-biofortified *phutu*, which implies that the mineral content would be increased if either of the three curries were combined with PVA-biofortified *phutu.* Yet again, the curried chicken was the best option to improve the mineral content. Biofortified crops, if consumed in the correct quantities, could improve the micronutrient status of the affected communities (Govender, Pillay, Siwela, Modi & Mabhaudhi 2017). Unlike a study conducted by Pillay, Siwela, Derera & Veldman (2013), which found that the concentration of iron was lower in PVA-biofortified maize than the white maize (Pillay *et al* 2013), the current study found no significant difference in iron concentration between white maize and PVA-biofortified maize. Furthermore, the results of the current study indicate that there would be no benefit in replacing white *phutu* with PVA-biofortified *phutu* in the composite dishes, with respect to the iron and zinc concentration (Table 5.10). However, the curried chicken had a higher iron content, thus implying that if it were consumed together with PVA-biofortified *phutu*, this could improve the iron intake of vulnerable populations. However, as mentioned earlier, chicken is unaffordable to many economically disadvantaged rural communities. Therefore, the more affordable combination of *phutu* and curried bambara groundnut could be an alternative to improve the protein and micronutrient content of human diets. However, it needs to be emphasised that there is an urgent need to test the consumer acceptability of this composite dish as it is not commonly consumed, especially in SA. Further studies should also investigate the effect of combining iron biofortified beans with PVA-biofortified *phutu*, on the iron concentration in composite dishes.

Although fibre and total mineral concentrations were higher in OFSP than CFSP, the protein content of the OFSP was lower (Table 5.5). The OFSP used in this study was high in iron (2.55 mg/100g) but lower in zinc (0.45 mg/100g), compared to the CFSP (2.25 mg/100g; 1.30 mg/100g, respectively) (Table 5.11). The results suggest that the OFSP could be used to improve the iron content of dishes in which sweet potato is a major ingredient, and, thereby, contribute to the alleviation of iron deficiency among target communities. The OFSP could be composited with locally available, affordable food item/s rich in zinc, to simultaneously address zinc deficiency.

Although the protein content of the OFSP used in this study was lower than that of the CFSP, it was higher than the values reported by Sanoussi, Dansi, Ahissou, Adebowale, Sanni, Orobiyi, Dansi, Azokpota & Sanni (2016), who found that the protein content ranged from 2.03-4.19 g/100 g, DW in pale-dark orange sweet potato (Sanoussi *et al* 2016). The results of the current study and previous studies indicate that OFSP generally has a low protein content, and there is a need to develop the OFSP further to increase its protein content. Despite its low overall protein content, the concentration of the essential amino acid lysine was higher in OFSP than in the CFSP (Table 5.8). The consumption of OFSP could contribute to improving the fibre and iron content in the diets of vulnerable individuals. The current study did not investigate the nutritional composition of composite dishes comprised of OFSP and other locally available, affordable food items. Sweet potato-containing composite dishes were not investigated because the most common way that sweet potato is prepared and consumed in SA is boiling and then serving it as a snack, side dish with a mail meal, or served cold with tea (Leighton 2007). Furthermore, consumer acceptability of OFSP should be investigated and, if necessary, improved to ensure that OFSP would be consumed by the target population groups.

This study investigated the effect of replacing white maize and CFSP with PVA-biofortified maize and OFSP on the nutritional composition of traditional dishes. With respect to the protein and lysine concentration, the results of the current study indicate that there would not be an advantage in replacing white maize with PVA-biofortified maize (Table 5.4). This result is obviously because the protein content in white maize was not significantly different from PVA-biofortified maize. In contrast, Pillay *et al* (2013) found that PVA-biofortified maize had a higher protein concentration than white maize (Pillay *et al* 2013), whereas Oluba & Oredokun-Lache (2018) found that white maize had a significantly higher protein value than PVA-biofortified maize. The reason for the differences seen in protein concentration could be attributed to genetic and/or environmental factors (Nhamo, Matchaya, Mabhaudhi, Nhlengethwa, Nhemachena & Mpandeli 2019). However, this study did not develop PVA-biofortified maize to improve the protein content but focused on whether the PVA carotenoid and micronutrient content would be increased. This was the reason why the results also indicated that PVA-biofortified maize had a similar lysine concentration to white maize (Table 5.7).

The protein content of dishes containing PVA-biofortified maize could be increased by combining the biofortified maize with protein-rich food items. For example, in the current study, when PVA-biofortified *phutu* was combined with curried chicken, the composite dish had a higher protein content compared to the PVA-biofortified *phutu* alone. This was expected, because, generally an animal food product such as chicken contains a higher protein content and quality than plant products. Thus, combining PVA-biofortified *phutu* with curried chicken would result in an improved protein content of the composite dish. However, with the rise in food costs, chicken has become expensive and maybe unaffordable to economically disadvantaged individuals (NAMC 2019; Stats SA 2017; Argent *et al* 2009), especially those living in rural areas of KZN, where poverty and food insecurity are prevalent (NAMC 2019; Stats SA 2017; Argent *et al* 2009). Although the protein concentration of the two composite dishes, PVA-biofortified *phutu* and curried cabbage, and PVA-biofortified *phutu* and curried bambara groundnut were not significantly different (Table 5.4), the protein concentration of the composite dish containing curried bambara groundnut was higher numerically.

It is well known that legumes generally contain higher concentrations of protein than leafy vegetables (Maphosa & Jideani 2017, p106). Furthermore, legumes contain adequate concentrations of lysine and tryptophan, whereas cereal grains contain an adequate concentration of methionine, but lysine and tryptophan are limiting (FAO 1992). Combining maize with a food item that is higher in lysine and tryptophan would improve the protein quality of the diet (Sizer & Whitney 2017, pp222-224). The deviation from this norm observed in this study could be attributed to the statistically small sample size. Therefore, it is still recommended that PVA-biofortified *phutu* should be combined with curried bambara groundnut rather than curried cabbage to improve the lysine concentration, thus improving the overall protein quality of the composite dish. Composite dishes with an improved protein content would be highly beneficial, especially to individuals that suffer from protein-energy malnutrition (PEM). This condition is caused predominately by a deficiency in protein and energy and leads to several serious health conditions (Sizer & Whitney 2017, pp222-224). Providing an affordable composite dish that combines PVA-biofortified *phutu* and curried bambara groundnut would not only contribute to reducing VAD, but also PEM. The main challenge with incorporating bambara groundnut into the diet of vulnerable groups is that this legume is not a common food source in SA (Oyeyinka *et al* 2017). It seems there are no published studies on the consumer acceptability of composite dishes in which PVA-biofortified *phutu* is combined with other food items such as cabbage and bambara groundnut. Thus, further investigation of consumer acceptability of these composite dishes is required.

5.5 Conclusions

The introduction of biofortified crops could provide nutritious, affordable food sources whose consumption would contribute significantly to improving the vitamin A status of vulnerable population groups. The biofortified crops could be composited with underutilised nutrient-dense indigenous crops, such as bambara groundnut, to further fortify the dishes with essential nutrients and protein. The present study indicated that replacing white maize with PVA-biofortified maize in all three composite dishes studied, resulted in an improved PVA carotenoid content. Although the PVA-biofortified *phutu* and curried chicken was the ideal composite dish for improving the PVA carotenoid content and protein quality, the composite dish containing PVA-biofortified *phutu* and curried bambara groundnut would be a more affordable alternative. It also has a high PVA carotenoid content and would have both high protein quality and content, due to the complementary protein concept. There was no significant difference in the iron and zinc concentration of all three composite dishes containing PVA-biofortified *phutu*. The results further indicated that bambara groundnut would be a suitable alternative food source for compositing with PVA-biofortified maize, to improve the nutritional value of the traditional dishes that normally contain white maize as the main ingredient. However, further studies need to be conducted using different varieties of PVA-biofortified maize in order to determine the usual portion sizes of composite dishes that would meet the EAR for vitamin A for children under five years of age. Furthermore, consumer acceptability of the composite dishes containing bambara groundnut should be investigated further, as the legume is not familiar to most South Africans.

The OFSP had high PVA carotenoid, fibre and iron concentration and a lower protein concentration, compared to the CFSP. The usual portion size of OFSP met approximately three times the EAR for vitamin A in both age groups. It is evident that OFSP has the potential to improve the vitamin A status of VAD-vulnerable population groups in SA if consumed with another food item, especially protein-rich food. Such a composite dish could contribute to combating both VAD and malnutrition.

Overall, the findings of the current study have indicated that PVA-biofortified *phutu*, when combined with other foods, such as curried cabbage, chicken or bambara groundnut as well as OFSP, have the potential to improve nutrient intake and dietary diversity of rural population groups in KZN and other rural areas of SA. The proposed composite foods (PVA-biofortified *phutu* with either curried cabbage, chicken or bambara groundnut) would be new to the target population groups as the target population do not usually consume PVA-biofortified maize dishes. Furthermore, PVA-biofortified maize together with bambara groundnut would also be a new composite food to the target population groups as South Africans are unaccustomed to bambara groundnut. As such it is not known whether they would be acceptable to the consumers. Therefore, future studies should investigate the consumer acceptability and perceptions of combining PVA-biofortified *phutu* with either curried cabbage, chicken and bambara groundnut and OFSP in traditional dishes.

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CHAPTER 6

CONSUMER PERCEPTIONS AND ACCEPTABILITY OF TRADITIONAL COMPOSITE DISHES MADE WITH PROVITAMIN A-BIOFORTIFIED MAIZE AND ORANGE-FLESHED SWEET POTATO IN KWAZULU-NATAL, SOUTH AFRICA[36]

Abstract

Vitamin A deficiency is prevalent in South Africa (SA), particularly among predominantly economically disadvantaged rural communities despite several strategies employed by the South African government to address vitamin A deficiency (VAD). The prevalence of VAD is particularly high among the communities living in rural areas of SA, especially among those that are poor and food insecure. Biofortification is an emerging strategy that has the potential to improve micronutrient deficiencies that are particularly prevalent among economically disadvantaged rural communities in sub-Saharan Africa (SSA). Provitamin A (PVA)-biofortified crops have the potential to address VAD where supplementation, conventional fortification or dietary diversity are limited or problematic to implement. White maize (*Zea mays*) and cream-fleshed sweet potato (CFSP) (*Ipomoea batatas*) are popular food items consumed in SA and would be ideal for biofortification with PVA carotenoids. Many South Africans are accustomed to consuming white maize and CFSP and would thus be more likely to consume biofortified maize and sweet potato. When consumers are familiar with a food item, they are more likely to consume that food item. However, PVA-biofortified crops, especially maize (*Zea mays*), have been found less acceptable in some studies compared to their non-PVA-biofortified counterparts, mainly due to the unfamiliar sensory properties attributed to carotenoid pigments. This study aimed to investigate the effect of replacing white maize and CFSP with PVA-biofortified maize and orange-fleshed sweet potato (OFSP), respectively, on consumer perceptions and acceptance of traditional dishes in KwaZulu-Natal (KZN), SA. A survey was conducted to identify the food items that are commonly consumed together with white *phutu* (a leading maize food product in KZN). Based on the survey results, *phutu* served with curried[37] cabbage and *phutu* served with curried chicken were selected for this study.

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[36] Publication based on this research chapter:
Govender L, Pillay K, Siwela M, Modi AT, Mabhaudhi T (2019). Consumer perceptions and acceptability of traditional dishes prepared with provitamin A-biofortified maize and sweet potato. **Nutrients** 11: 1577; doi: 10.3390/nu11071577.

[37] Curried was selected as the preparation method as it was reported by study participants as the most common way in which the food items were prepared.

Bambara groundnut was also included in this study, as it is an affordable, good source of several nutrients, including protein, but is underutilised. African adults (n=120) were recruited from two rural communities in the KZN province of SA to form two consumer panels for sensory evaluation and 56 adults were then randomly selected from the consumer panel to participate in focus group discussions (FGDs). The food dishes prepared for evaluation by the consumers were: boiled CFSP (control) and OFSP; white maize *phutu* served with either curried chicken, cabbage or bambara groundnut (control) and PVA maize *phutu* served with either curried chicken, cabbage or bambara groundnut. Each panellist received ±75 ml of *phutu*, ±75 ml curry (chicken, cabbage and bambara groundnut) and ±25 g of both boiled CFSP and OFSP in a 250 ml polystyrene tub, separately. The panellists rated the acceptability of key sensory attributes of the six cooked *phutu* composite samples and two boiled sweet potato samples using a five-point facial hedonic scale (1= very bad; 5= very good). A five-point facial hedonic scale was used so that participants who could not read and/or write would be able to participate. A paired preference test was also used. The following pairs were evaluated; white *phutu* and curried chicken compared to PVA-biofortified *phutu* and curried chicken; white *phutu* and curried cabbage compared to PVA-biofortified *phutu* and curried cabbage, white *phutu* and curried bambara groundnut compared to PVA-biofortified *phutu* and curried bambara groundnut and CFSP compared to OFSP. Two trained isiZulu speaking research assistants conducted five FGDs to determine the consumer perceptions of the composite dishes. A digital voice recorder was used to record the discussions, which were then translated into English by the facilitators. The translated recordings were cross-checked by an isiZulu speaking person against the English translation for accuracy in translation. Data from the sensory evaluation was analysed using the Statistical Package for Social Sciences (SPSS) version 25 and the responses from the FGDs were subjected to thematic content analysis.

The majority of the participants rated the composite dishes containing PVA-biofortified *phutu* as "4 = good" and the acceptability of the composite dishes varied significantly ($p<0.05$). Compared to other age groups, the 50-59 year age group showed a higher preference for the white *phutu* and curried chicken composite dish, whereas the 30-39 year age group showed a higher preference for the PVA-biofortified *phutu* and curried chicken composite dish. The acceptability of OFSP and CFSP was similar. The FGDs indicated that participants had positive perceptions of the PVA-biofortified *phutu* when served with either curried chicken or cabbage. However, they had mixed perceptions when served with curried bambara groundnut. The older

FGD participants perceived that composite dishes containing *phutu* and bambara groundnut would not be acceptable to the younger generation as they were not accustomed to bambara groundnut. There were positive responses to the proposal to replace the CFSP with OFSP. Most of the FGDs participants perceived the OFSP to be butternut due to its orange colour, sweet taste and visual appeal. The FGD participants expressed a willingness to grow and purchase the PVA-biofortified maize and PVA-biofortified OFSP, if planting materials were made available or if the two types of biofortified crops were available as food in the market. Although PVA-biofortified foods have been frequently found to be less acceptable, foods investigated in the study were positively perceived by most of the participants. Therefore, the study findings suggest that PVA-biofortified maize and OFSP can replace white maize and CFSP, respectively, in selected traditional composite dishes of the rural communities studied, to alleviate VAD.

6.1 Introduction

Worldwide, VAD is a serious health problem affecting children and pregnant women [World Health Organization (WHO) 2019] and is particularly prevalent among countries (including SA) in developing regions, especially SSA (Bain, Awah, Geraldine, Kindong, Sigal, Bernard & Tanjeko 2013; Smuts, Dhansay, Faber, Van Stuijvenberg, Swanevelder, Gross & Benadé 2005; Ramakrishnan 2002). In SA, national studies showed that between 1994 and 2005, the VAD situation among children had worsened. The prevalence increased from 33.3% in 1994 to 63.6% in 2005 (Labadarios, Swart, Maunder, Kruger, Gericke, Kuzwayo, Ntsie, Steyn, Schloss, Dhansay, Jooste, Dannhauser, Nel, Molefe & Kotze 2008; Labadarios & Van Middelkoop 1995). Additionally, the 2005 National Food Consumption Survey-Fortification baseline (NFCS-FB) study reported that two in three women had VAD in SA and six in ten women living in KZN had VAD. Overall, KZN had the second highest prevalence of VAD (Labadarios *et al* 2008; Labadarios, Steyn, Maunder, Macintyre, Swart, Gericke, Huskisson, Dannhauser, Vorster & Nesamvuni 2000; Labadarios & Van Middelkoop 1995).

The more recent 2012 South African National Health and Nutrition Examination Survey (SANHANES-1) study found that VAD in children was still significantly high (43.6%) (Shisana, Labadarios, Rehle, Simbayi, Zuma, Dhansay, Reddy, Parker, Hoosain, Naidoo, Hongoro, Mchiza, Steyn, Dwane, Makoae, Maluleke, Ramlagan, Zungu, Evans, Jacobs, Faber & SANHANES-1 Team 2013). The 2012 SANHANES-1 study further reported that 45.5% of rural South Africans had VAD, and individuals with the lowest education levels were the most affected by VAD (Shisana *et al* 2013). It is important to try to improve the vitamin A status of South Africans, especially children and vulnerable groups such as pregnant women, as vitamin A is an essential micronutrient that has several physiological roles including immunity, vision and protein synthesis (Webb & Whitney 2017, pp244-245). Vitamin A deficiency can result in an increased risk of mortality due to infections, thus emphasising the need to improve the vitamin A status of vulnerable groups (UNICEF 2019).

One of the leading factors contributing to VAD is household food and nutrition insecurity (Pinstrup-Andersen 2009). In comparison to other regions in the world, Africa has the highest level of moderate (30%) and severe food insecurity (20%) (Development Initiatives 2017). Poor access to food, an element of food insecurity, is a common problem in SA, where 21.3% of households have severely inadequate or inadequate food access [Statistics South Africa (Stats SA) 2018; Stats SA 2017a]. Although the general household survey (GHS) conducted in SA in 2017 showed a 1% decrease in the number of individuals with inadequate or severely inadequate access to food in comparison to the 2016 GHS (Stats SA 2018; Stats SA 2017a), micronutrient malnutrition still remains a challenge. Suboptimal utilisation of available and accessible food is another dominant element of food insecurity in Africa. In SA, access to and utilisation of nutritious foods are a major problem, especially among economically disadvantaged individuals (Stats SA 2018; Altman, Hart & Jacobs 2009). The consumption of nutritious foods promotes human development and enables an individual to perform the basic tasks needed for survival (Kolahdooz, Spearing & Sangita 2013). The South African government has implemented several strategies to reduce micronutrient deficiencies. These strategies include supplementation, food fortification and dietary diversity (DoH 2018; Swart, Sanders & McLachlan 2008; DoH & UNICEF 2007; Labadarios *et al* 2000). Despite the implementation of these strategies, there has been no significant improvement in the vitamin A status of the South African population (DoH 2018; Swart, Sanders & McLachlan 2008; DoH & UNICEF 2007; Labadarios *et al* 2000). This emphasises the need for a complementary strategy such as biofortification to address VAD (Bouis & Saltzman 2017).

White maize and CFSP are two commonly grown and consumed crops in SA [Department of Agriculture, Forestry and Fisheries (DAFF) 2017; Low, Mwanga, Andrade, Carey & Ball 2017), and are therefore ideal for PVA-biofortification (DAFF 2017; Low *et al* 2017; Mitra 2012). Three crops have been identified for PVA-biofortification in Africa by HarvestPlus, namely cassava (*Manihot esculenta),* maize (*Zea mays*) and sweet potato (*Ipomoea batatas*)

(HarvestPlus 2018). However, many studies conducted in Zambia, SA, Kenya and Ghana found that there were challenges with consumer acceptability of biofortified crops (Nuss, Arscott, Bresnahan, Pixley, Rocheford, Hotz, Siamusantu, Chileshe & Tanumihardjo 2012; Pillay, Derera, Siwela & Veldman 2011; De Groote, Kimenju & Morawetz 2011; De Groote, Tomlins, Haleegoah, Awool, Frimpong, Banerji, Chowdury & Meenakshi 2010; De Groote & Kimenju 2008). The poor acceptability of PVA-biofortified crops found in some studies may be attributed to the yellow/orange colour exhibited by carotenoid pigments found in the crops and the strong aroma and flavour of the biofortified crops, also attributed to the carotenoid pigments (Chapman 2012; Nuss & Tanumihardjo 2010). In addition, several studies have found that a stigma attached to the consumption of PVA-biofortified maize has negatively affected consumer acceptance of the biofortified maize crops (Nuss *et al* 2012; De Groote *et al* 2011; De Groote *et al* 2010; De Groote & Kimenju 2008). There are a number of factors that impact on the consumer acceptability of PVA-biofortified crops, such as gender, income, education, ethnicity, geographical location and background (Khumalo, Schönfeldt & Vermeulen 2011). Additionally, Pillay *et al* (2011), found that the acceptability of PVA-biofortified maize varied with food type, which suggested that the acceptability of the biofortified maize could be improved by processing it into suitable food types (Pillay *et al* 2011).

Combining PVA-biofortified crops with other commonly consumed plant and animal food sources, could mask any undesirable sensory properties associated with biofortified crops and thereby increase their acceptability. For example, a study conducted by Amod, Pillay, Siwela & Kolanisi (2016), found that when PVA-biofortified *phutu* was combined with chicken stew, its acceptability increased (Amod *et al* 2016). Additionally, PVA-biofortified composite dishes could improve the nutritional intake of vulnerable individuals (Govender, Pillay, Siwela, Modi & Mabhaudhi 2019). A major problem in SA is poverty; it is a leading cause of food and nutrition insecurity (Govender, Pillay, Siwela, Modi & Mabhaudhi 2016). Currently, in 2019, a basic food basket in SA costs about R883.16/month which is a 3% increase from 2018 [National Agricultural Marketing Council (NAMC) 2019]. This rise in food prices makes animal food sources unaffordable to VAD-vulnerable population groups, who are predominantly of low socioeconomic status. Thus, suitable food items should be sought from among the more affordable plant products for combining with PVA-biofortified foods to improve their acceptability.

Plant products have also risen in price, but are generally cheaper than animal products (NAMC 2018). The most commonly consumed plant-based foods in SA are maize (milled into maize meal) and green leafy vegetables (Lewu & Mavengahama 2011; Modi, Modi & Hendriks 2006). In the KZN province, maize (cooked maize meal) and legumes are leading (Faber, Laubscher & Laurie 2013; Labadarios *et al* 2000). Legumes could be suitable for combining with PVA-biofortified maize because they are rich in several nutrients, including protein (Huma, Anjum, Sehar, Khan & Hussain 2008). Starch-based cereal crops such as maize have limited amounts of lysine and tryptophan (Serna-Saldivar 2010, p98). Lysine and tryptophan are also essential amino acids. Lysine is required for the synthesis of peptide-hormones, antibodies, enzymes and muscle mass, whereas tryptophan is needed as it is a precursor for niacin, nicotinamide and serotonin (Serna-Saldivar 2010, p94). Legumes generally contain higher amounts of lysine and tryptophan and have a lower content of sulfur-containing amino acids, especially methionine (Serna-Saldivar 2010, p580). Thus, the consumption of a starch-based food such as maize together with a legume such as bambara groundnut would result in a balanced amino acid profile (Lichtfouse 2016, p376; Mwale, Azam-Ali & Massawe 2007; Linnemann & Azam-Ali 1993, pp13-58).

Bambara groundnut is an indigenous crop in Africa. It is well-adapted to and thrives in the agronomical marginal regions (Chibarabada, Modi & Mabhaudhi 2017), where a significant proportion of vulnerable population groups live in SSA countries, including SA (Bain *et al* 2013; Shisana *et al* 2013; Labadarios, Moodie & Van Rensburg 2007; Labadarios *et al* 2000). Unlike other legumes, bambara groundnut contains the essential amino acid methionine (Stone, Massey, Theobald, Styslinger, Kane, Kandy, Tung, Adekoya, Madan & Davert 2011, p8; Mwale *et al* 2008). Furthermore, bambara groundnut has been found to have high levels of essential fatty acids, vitamins and minerals (Adeleke, Adiamo & Fawale 2018). Unfortunately, even though bambara groundnut is nutrient-dense, it is generally underutilised as a food source in SSA due to several factors (Bogart, Tickle-Degnen & Joffe 2012). Bambara groundnut has hard-to-cook and hard-to-mill properties and exhibits antinutritional properties, a bitter taste and a strong beany flavour, which contribute to its limited utilisation as a food source (Ndidi, Ndidi, Aimola, Bassa, Mankilik & Adamu 2014; Boye, Zare & Pletch 2010; Uvere, Uwaegbute & Adedeji 1999). In SA, another factor limiting the acceptability of bambara groundnut is the fact that South Africans are generally not accustomed to it (Oyeyinka, Pillay & Siwela 2017). Although underutilised, a few studies have shown that bambara groundnut when prepared in some food types, was positively accepted by consumers (Oyeyinka, Tijani, Oyeyinka, Arise, Balogun, Kolawole, Obalowu & Joseph 2018; Oyeyinka *et al* 2017; Okafor, Okafor, Leelavathi, Bhagya & Elemo 2015). Further, heat processing methods such as roasting have been found to improve the taste and protein quality of bambara groundnut (Okafor *et al* 2015).

Unlike biofortified maize, for which mixed responses in consumer acceptability have been found, OFSP seems acceptable to consumers in SA, although data on its acceptability to different population groups are limited (Pillay, Khanyile & Siwela 2018; Laurie & Van Heerden 2012; Chowdhury, Meenakshi, Tomlins & Owori 2011; Khumalo *et al* 2011; Low & Van Jaarsveld 2008; Tomlins, Ndunguru, Stambul, Joshua, Ngendello, Rwiza, Amour, Ramadhani, Kapande & Westby 2007). With regard to specific rural population groups in the KZN province of SA, only one study has been conducted to assess consumer acceptance of PVA-biofortified maize foods served with other commonly consumed food items (Amod *et al* 2016). Similarly, there are limited reports of consumer acceptability of OFSP in KZN. Thus, phase 2 of the study aimed to investigate the effect of replacing white maize and CFSP with PVA-biofortified maize and OFSP, respectively, on consumer acceptability and perceptions of traditional dishes of selected rural communities in KZN, SA.

6.2 Study design

The study design used in phase 2 of the study was a cross-sectional study using multiple methods (quantitative and qualitative). The conceptual framework of the study flow is illustrated in Figure 6.1.

6.3 Study population and sample selection

The study population and sample selection of phase 1 of the study are presented in chapter 4, section 4.2. From each of the households, one person was selected to answer the survey questions. This person was either the head of the household or the person responsible for purchasing the groceries. Pilot study participants were excluded from the study (this is discussed further in section 6.4.4.1).

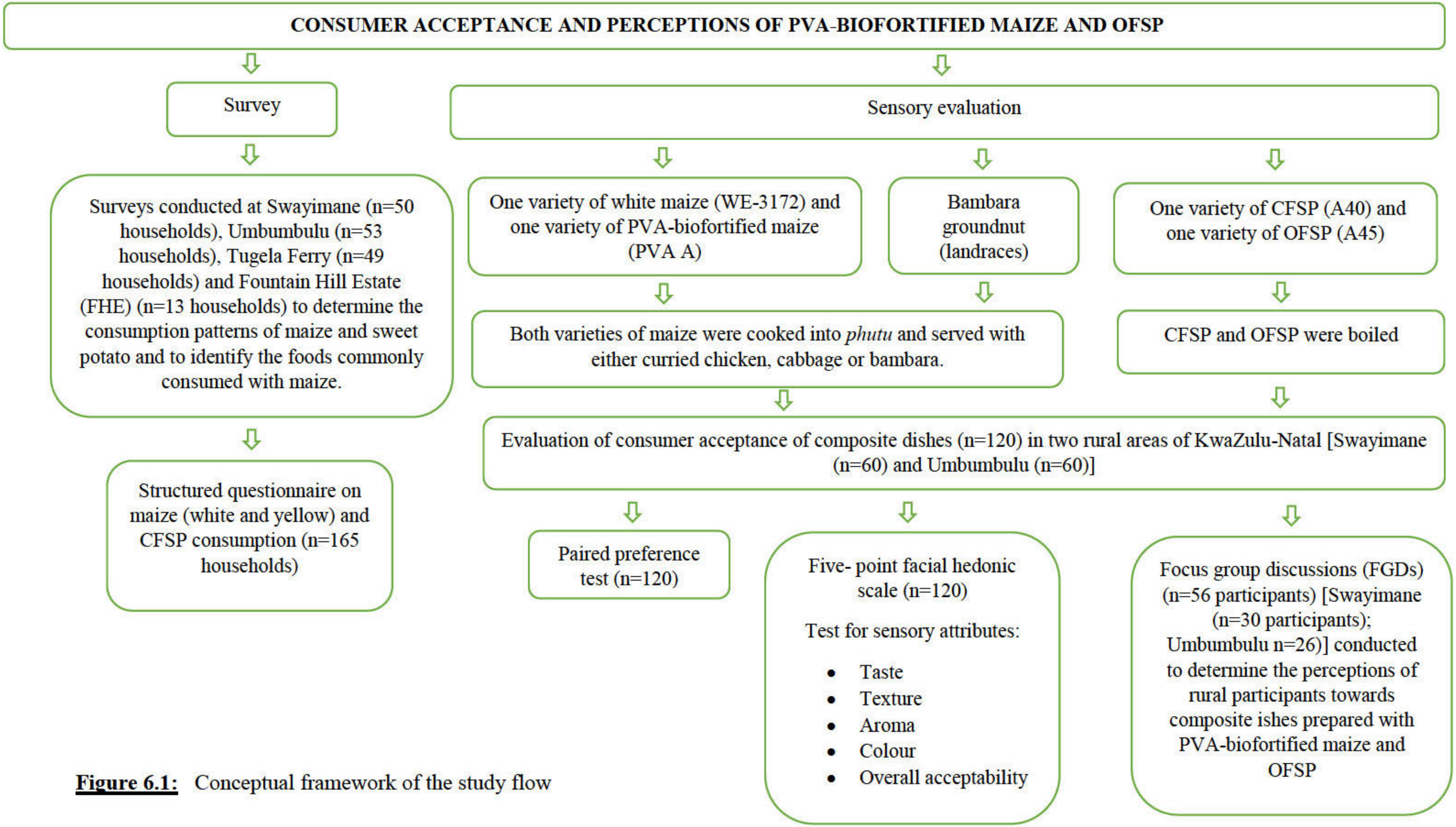

Figure 6.1: Conceptual framework of the study flow

Phase 2 of the study was only conducted at two (Gcumisa tribal hall in Swayimane and at Ezimiwini community hall in Umbumbulu) of the four study sites. This was done as there were no cooking facilities at the study sites and all food dishes needed to be prepared fresh on the morning of the study. The two study sites selected were close to the University of KwaZulu-Natal (UKZN), where the food samples were prepared. A return trip to Tugela Ferry from UKZN would have taken approximately 5 hours, thus it was not selected for phase 2. Fountain Hill Estate farmworkers were not used for this phase of the study as this phase specifically focused on rural communities. Therefore, one hundred and twenty African adult participants living in two selected rural areas (60 participants each from Swayimane and Umbumbulu) were recruited for the study. Children were not used in the study, as their responses are unlikely to be accurate and reliable. A child may be able to relate to the face in the five-point facial hedonic scale but not able to relate the sensory attribute of the food tasted to the face. Secondly, the primary caregiver is responsible for providing the child with food. The caregiver decides which types of food are suitable for the child. However, this can be seen as a study limitation and future studies should include children in sensory evaluation studies. Households from the two selected sites from phase 1 of the study were invited to participate in phase 2 of the study, as they are a population group at high risk for malnutrition [National Department of Health (nDoH), Stats SA, South African Medical Research Council (SAMRC) & ICF 2017; Shisana *et al* 2013). It is noteworthy that some members of the household that were not at home during phase 1 of the study, were allowed to participate in phase 2 of the study. Furthermore, 120 participants were selected as this number falls between 75-150 participants, which is the total recommended size to obtain a significant result for a sensory evaluation (Stone 2018; Lawless & Heymann 2010, p7).

Focus group participants were recruited voluntarily from the sensory evaluation panel. A total of 56 participants from both research sites were randomly selected from the sensory evaluation participants. Each participant had a participant number which was put into a box when they volunteered to participate in the FGD. More than 30 participants from Swayimane volunteered to participate in the FGD, therefore, 30 participants were selected by randomly drawing 30 numbers from a box. This procedure was only followed for Swayimane. All volunteers (n=26) from Umbumbulu participated in the FGDs as there were only 26 sensory evaluation participants that volunteered to participate in the FGDs.

6.4 Study materials and methods

6.4.1 Survey on the consumption of white maize[38]

Survey questions were formulated in English (Appendix P) to determine the consumption patterns of white and PVA-biofortified maize and CFSP. The questions that were formulated were based on the information that the researcher needed to collect. The questions were structured and simple. This survey was translated into isiZulu (Appendix Q) by one research assistant (Appendix Q) and thereafter translated back into English by another research assistant, to check accuracy in translation. Both research assistants were fluent in isiZulu. The survey took the form of an interview survey, and only one survey was completed for each household, by a research assistant. Questions 1-5 in the survey focused on the consumption and production of white maize, question 6 focused on yellow maize consumption and question 7 focused on the consumption and production of CFSP. A sample of 18 households was used for the survey pilot study to test the appropriateness of the questionnaires. This also allowed changes to be made before the main study was conducted. However, no changes were made to the survey questions as all the questions were understood by individuals representing each of the households. The survey was collected at two selected sites (Swayimane and Tugela Ferry). The households were purposively selected, thus the research assistants did not go back to the same households during the main data collection.

For the survey in the main study, participants were asked to provide the research assistants with a list of foods that were commonly consumed with the cooked white maize meal, as well as the corresponding recipes. The participants preferred to consume cooked white maize with a few food items (Table 6.1). The participants provided the research assistant with recipes that were used to cook the maize dishes and the composite food dishes.

Table 6.1: Preferred food items consumed with cooked maize meal

Food item	n (%)*
Beef	85 (51.5)
Chicken	69 (41.8)
Green leafy vegetables	58 (35.2)
Cabbage	51(30.9)
Potatoes	28 (17.0)

*Percentage of households (n=165 households)

[38] Survey results were presented under study methods and materials to explain why maize, sweet potato, cabbage, bambara groundnut and chicken were selected for the study.

Recipes were collected from all 165 households. *Phutu*, sweet potato and curried cabbage were prepared the same in all recipes collected. Curried beef and chicken were prepared the same in most of the recipes collected. The only variations that were noted were with the flavour of stock cubes used, the addition of beans to either curry or the addition of mixed vegetables. The curried bean was cooked similarly by all households, however, a few households added raw tomato. The recipes that were finally used in the study were those that were prepared by the majority of the study participants. After the recipes were selected, they were standardised (Appendices K, L, M and O). Popular food combinations were identified from the answers to the survey questions and the relevant recipes were obtained. Participants (n=57 households) selected the food combinations they preferred. Figure 6.2 and Figure 6.3 indicate the food items that study participants consumed with either *phutu* or pap (a stiff porridge made from maize meal). The least preferred meat composite dish was stiff pap and cooked fish in tomato chutney.[39] The most preferred meat composite dishes were *phutu* with curried beef and stiff pap with curried beef. However, standardised recipes were not formulated for these combinations as beef was not regularly consumed according to the food frequency questionnaire. The mean frequency score for the chicken was 2.11 (n=158) and the mean frequency score for beef was 1.58 (n=161) (page 111). A possible reason for this is that beef is more expensive than chicken and is unaffordable to economically disadvantaged individuals (Delport, Louw, Davids, Verumeulen & Meyer 2017). Therefore, chicken was selected for this study. The most preferred vegetarian options were *phutu* with curried cabbage and stiff pap with curried cabbage. This concurs with the results found in the food frequency which indicated that the mean frequency score for cabbage was 1.68 (n=161) and 1.17 (n=23) for indigenous green leafy vegetable (*imifino*).

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[39] Tomato chutney is cooked following a traditional recipe with oil, onions, tomatoes, water, salt and Raja curry powder spice. It is eaten alone or with another food item such as cooked fish.

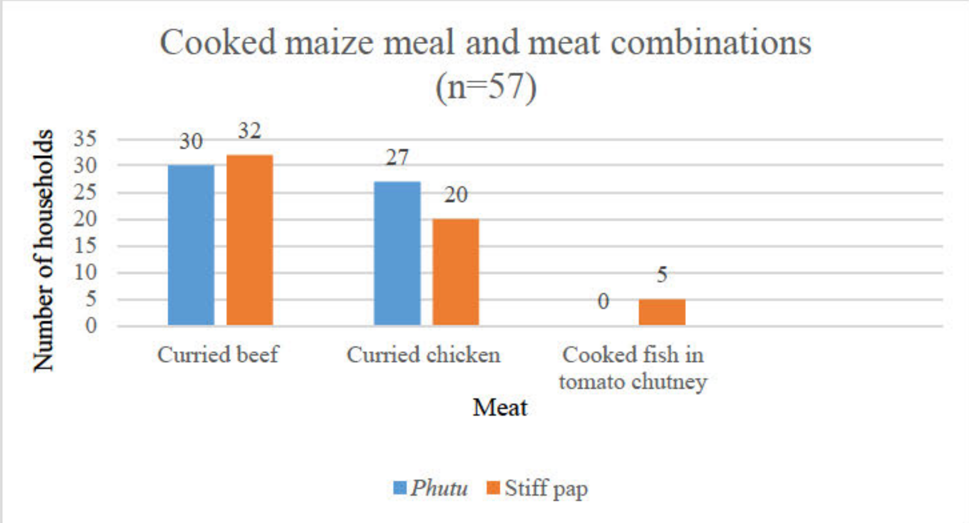


Figure 6.2: Participants preference for cooked white maize meal dishes and meat composite dishes

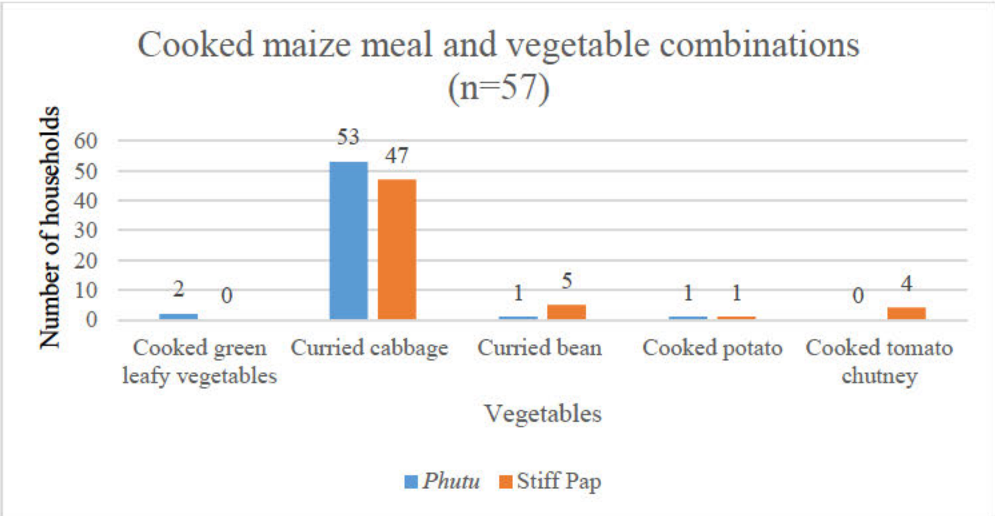


Figure 6.3: Participants preference for cooked white maize meal dishes and vegetable composite dishes

For the purpose of this study, *phutu* was selected as the cooked maize meal dish. Curried cabbage was selected as the vegetarian dish, while curried chicken was the selected meat dish. Curried chicken was selected for this study, as it is a cheaper alternative to beef (Delport *et al* 2017). Although the study participants preferred curried beef, they did not consume it frequently, as it is expensive. Many rural individuals rely solely on government grants (child support grant, old age grant, disability grant and care dependency grant) to purchase food items and cannot always afford animal sources of protein (NAMC 2018; South African Social Security Agency 2018; Stats SA 2017b). Bambara groundnut was also selected for this study as it is an indigenous legume that can be used as an alternative to animal protein. Not only is it a good source of protein, but also contains carbohydrates, minerals and vitamins (Huma *et al* 2008). Although bambara groundnut is grown in certain areas of KZN, it is underutilised (Agriculture, Forestry & Fisheries 2016; Chivenge, Mabhaudhi, Modi & Mafongoya 2015). Thus, bambara groundnut could provide a nutritious alternative to animal protein, if deemed acceptable to economically disadvantaged communities in rural KZN.

6.4.2 Plant materials

A PVA-biofortified maize type (PVA A) and a white maize variety (control) (WE-3172) were selected for the study. The provitamin A-biofortified maize coded PVA A is an experimental type; it has not been commercialised and hence does not have a variety name. The maize grain was produced by plant breeders from UKZN and milled into maize for this study, using methods described in chapter 5 (section 5.2.2). Two varieties of sweet potato were selected for this study, OFSP (A45) and CFSP (A40). The bambara groundnut landrace was purchased from Umvoti beans in Moolla industrial township Stanger and cabbage were purchased from a local (Pietermaritzburg) supermarket for the study.

6.4.3 Animal materials

Frozen mixed portions of chicken (thigh, breast and drumstick) were purchased from a local (Pietermaritzburg) supermarket for the study. All pieces were cooked and used for the sensory evaluation.

6.4.4 Sensory evaluation and focus group discussions

6.4.4.1 Panellists

A total of 120 African adults comprising of males and females were randomly selected from Swayimane and Umbumbulu rural areas of KZN to participate in sensory evaluation of the study food samples. One hundred and twenty participants were recruited as this number falls between 75-150 participants, which is the total recommended size to obtain a significant result for a sensory evaluation (Stone 2018; Lawless & Heymann 2010, p7). Research assistants went to households that participated in phase 1 of the study from Swayimane and Umbumbulu to recruit participants. Participation was voluntary and panellists were allowed to leave the study at any point if they so wished. Ten research assistants fluent in isiZulu were recruited from UKZN and trained before data collection. The research assistants were postgraduate students and were trained on how to complete the consent forms, sensory evaluation and paired preference test data collection sheets. They were also trained on the procedure to be followed during data collection. An English version of the consent form was available but was not used by any of the participants (Appendix H). A research assistant explained the isiZulu version of the consent form (Appendix I) to each participant in isiZulu so that it could be better understood and issued a participant number to each participant. IsiZulu was the selected language as it is the local language spoken by the study participants. The participant number was given to maintain anonymity and for the research assistants to issue the correct sensory evaluation sheet to each participant. Research assistants asked the volunteers if anyone had participated in the pilot study the previous week and if they had, they were excluded from the study. It was assumed that everyone answered the question honestly. Additionally, a local member of the community was also present at the main study to identify participants that had participated in the pilot study. If any pilot study participants were identified, they were excluded from the study.

6.4.4.2 Preparation of food samples

All food dishes were prepared each morning during the sensory evaluation data collection in the Food Processing Laboratory in the Human Nutrition and Dietetics Department at UKZN, Pietermaritzburg. An African woman (Figure 6.4) was recruited from a rural area in the UMgungundlovu District, KZN with appropriate cooking experience to cook *phutu*, curried cabbage, curried chicken, curried bambara groundnut and the sweet potato using the standardised recipes (Appendices K, L, M, N & O). This ensured that the food items prepared were culturally acceptable to participants as it was prepared by someone residing in one of the study sites with experience in cooking traditional dishes.

<u>Figure 6.4:</u> Cooking of food dishes by an experienced cook (permission was granted by the cook to use this photograph, Appendix P)

Prior to this study, surveys (Appendix Q) were conducted to determine the commonly consumed food combinations and recipes were collected (section 6.4.1). Foods were prepared over two trial sessions a week prior to the pilot study to ensure that the recipes were accurate and culturally acceptable. Food safety was maintained during the preparation of the food samples thus adhering to the R992 regulation governing general hygiene requirements for food premises and transport of food (South African Department of Health 2012) and the South African National Standard (South African Bureau of Standards 2019). These recipes were standardised for *phutu* (Appendix K), curried cabbage (Appendix L), curried chicken (Appendix M), curried bambara groundnut (Appendix N) and sweet potato (Appendix O). The curried bambara groundnut was cooked in the same manner as the curried bean; however, extra water was added during the cooking process, and more time was needed to cook the curried bambara groundnut. This was due to the hard-to-cook properties of bambara groundnut (Mubaiwa, Fogliano, Chidewe & Linnemann 2017). The food dishes were tasted by four African males and seven African females working at UKZN, who had a similar sociodemographic profile to the study participants, to test for cultural acceptability. The UKZN workers gave their consent to taste the dishes (Appendix H). The tasting was conducted during the trial cooking. The UKZN workers perceived the dishes as culturally acceptable. The pilot study was conducted after the trial cooking session and is discussed in section 6.4.4.4. Although the UKZN workers were from similar areas as used in the main study, they would have been at work during data collection, thus preventing them from participating in the pilot and main studies. For the main study, the food samples were not made at the research sites (Gcumisa tribal hall in Swayimane and at Ezimiwini community hall in Umbumbulu), as there were no cooking facilities available As mentioned, food samples were prepared in the Food Processing Laboratory in the Human Nutrition and Dietetics Department at UKZN. The cooked food samples were transported in insulating plastic containers closed with tight-fitting lids. Table 6.2 gives a summary of the preparation methods of food items used in the current study.

Table 6.2: Description of food items used in the study

Food item	Description
White maize *phutu* (control)	A popular crumbly maize porridge and traditional maize food product consumed in KZN. A standardised recipe can be found in Appendix K.
PVA maize *phutu* (test sample)	Crumbly maize porridge made with PVA maize in place of white maize. A standardised recipe can be found in Appendix K.
CFSP (control)	The traditional, popular CFSP was boiled until soft as is commonly done by the studied communities (Appendix O).
OFSP (test sample)	The traditional, popular CFSP was replaced by the OFSP, which was boiled in the same manner as the CFSP (Appendix O).
Curried cabbage	Cooked following a traditional recipe (Appendix L) obtained from study participants, with oil, Raja curry powder (It is a spice comprising of coriander, turmeric, garlic, Bengal gram, chilli, yellow mustard, fenugreek, bay leaves, cassia, fennel and salt and cumin), onions, shredded cabbage, water, salt and a stock cube.
Curried chicken	Cooked following a traditional recipe (Appendix M) obtained from study participants with oil, Raja curry powder, onions, cut chicken pieces, water, salt and two stock cubes. Mixed portions of chicken (thigh, breast and drumstick) were used to prepare the curried chicken.
Curried bambara groundnut	Cooked following a modified traditional recipe (Appendix N) obtained from study participants for curried dry bean, which was prepared with oil, Raja curry powder, onions, bambara groundnut (soaked overnight), water, salt, bicarbonate of soda and a stock cube.

PVA: provitamin A; CFSP: creamed-fleshed sweet potato; OFSP: orange-fleshed sweet potato.

6.4.4.3 Sample coding and serving order

Each of the food combinations was assigned a unique three-digit code obtained from a Table of Random Numbers (Heymann 1995). The three-digit codes were known to the researcher, but not to the panellists, to prevent bias. The serving order of the food samples was determined by a Table of Random Permutations of Nine (Heymann 1995). Each sample was carefully dished out so there was uniformity with portion size and appearance. Lawless & Heymann (2010, pp63-64) reported that there are different variables to consider when deciding on a suitable food sample size. The researcher should consider the number of samples tested, what the mouthful of the specific product is, and what the study is trying to evaluate (Lawless & Heymann 2010, pp63-64). The quantities selected for the samples were based on the fact that taste and texture were the only attributes that required analysing in order to rate it. The other attributes relied on other senses such as sight and smell. Each participant received ±75 ml of white and PVA *phutu*, separately with ±75 ml of curried cabbage, ±75 ml of white and PVA *phutu,* separately with ±75 ml curried chicken and ±75 ml of white and PVA *phutu*, separately with ±75 ml of curried bambara groundnut. Participants were also given a quarter piece (±25g) of sweet potato in a 250 ml polystyrene tub, separately.

6.4.4.4 Pilot study for the sensory evaluation and FGDs (phase 2)

The objectives of the pilot study were as follows:

1. To determine if the standardised recipes that were developed after the first phase of the study were culturally acceptable.
2. To determine if the sensory evaluation questionnaires in isiZulu were user-friendly and understood by participants.
3. To finalise the methodology used for the sensory evaluation and the FGDs.
4. To determine if the research assistants were able to collect data efficiently and if they understood the process to be followed.

A pilot study of sensory evaluation and FGDs was conducted at the Gcumisa tribal hall in Swayimane, KZN, prior to the main study. This was one of the selected research sites for the main study. Ten African participants comprising of four males and six females were randomly recruited from the Swayimane area, to participate in the pilot study. Ten participants were selected for the pilot study, as this is the lowest recommended number of participants that can be used in a sensory evaluation study, to obtain a statistically significant result (Stone 2018).

The participants from the pilot study were not allowed to participate in the main study. To ensure this, the researcher randomly selected one participant from different areas of Swayimane. An English version of the consent form was available for participants if needed (Appendix H). All participants signed consent forms in isiZulu (Appendix I), before commencing with the study. Participants, who could not read due to low literacy levels or did not understand the data collection sheets, received a detailed explanation from the research assistants. Each participant was allocated a number from 1-10 to assist with identification and issuing of sensory evaluation sheets. This was done to ensure confidentiality.

Focus group discussions were conducted after the sensory evaluation using the sensory evaluation panellists. Four focus group discussion questions were developed in English (Appendix S) and translated into isiZulu (Appendix T). All 10 participants were invited to participate in the FGDs and included both males and females. Only one focus group session was conducted and was facilitated by a male assistant with experience in conducting focus group discussions.

The outcomes of the pilot study were as follows:

1. The recipe used to cook the curried bambara groundnut was modified to ensure that it was acceptable to the study participants. The bambara groundnut took a longer period to cook and soften. Bambara groundnut was soaked overnight to reduce cooking time and 1 ml of bicarbonate of soda was added during cooking to reduce the hard-to-cook phenomenon and allow the bambara groundnut to soften. The addition of one teaspoon of bicarbonate of soda has been shown to soften legumes that have hard-to-cook properties (Polak, Phillips & Campbell 2015). In this study, 1 ml of bicarbonate of soda was used to cook the bambara groundnut as no studies have been conducted on the maximum amount of bicarbonate of soda that can be added during cooking to soften it, without affecting the taste. The addition of 1 ml of bicarbonate of soda did not affect the taste of the cooked bambara groundnut. This was determined as the participants did not report any changes in taste. Although the addition of bicarbonate of soda softens the bambara groundnut, it destroys the B vitamin, thiamine (Garden-Robinson & McNeal 2013). This was a study limitation as the effect of the bicarbonate of soda on the thiamine concentration was not determined. Future studies should explore this.

2. The quantity of the samples issued for sensory evaluation (five-point facial hedonic scale and paired preference test) was increased from 30 ml to 75 ml, as it was found that 30 ml each of food sample was insufficient for the sensory evaluation. During the pilot, study participants requested more of the sample to taste so that they could rate the sample. Thus, it was determined that 75 ml of each sample would be adequate to use for the sensory evaluation.

3. The food samples were warmed for ten seconds in a microwave prior to being served to ensure that it was warm before being served to each participant. The ideal temperature was determined during the pilot study. This was done to ensure that the samples were not cold, as cold samples could negatively affect the outcome of the sensory evaluation (Bajec, Pickering & DeCourville 2012).

4. The research assistants needed to be trained after the pilot study to ensure that the correct procedures were followed and there was no confusion regarding the tasks that needed to be

conducted by each research assistant. During the pilot study, the research assistants tried to assist each other with tasks and it became confusing. Each research assistant was allocated one specific task for the duration of the main study.

5. For the pilot study, a FGD was conducted by a male research assistant with experience in conducting FGDs. The group consisted of both males and females of varying age. Elderly female participants were not comfortable with expressing their views in the presence of male participants. The change made for the main study was that two research assistants (one male and one female) with experience with conducting FGDs, were used. The female research assistant conducted FGDs with female participants and the male research assistant conducted FGDs with the male participants.

6. Some female participants did not understand the contents of the consent form when it was explained to them as a group. For the main study, the consent form was explained in detail by the same research assistant to all participants individually, so that any queries could be addressed immediately.

6.4.4.5 Main study for the sensory evaluation (phase 2)

Panellists were recruited from research sites[40] and given a consent form in isiZulu (Appendix I) to sign after the contents were explained. Thereafter, the panellists were escorted to their sensory evaluation station by the research assistant. Panellists were told not to communicate with one another during the sensory evaluation. A separating board divided the panellists (Figure 6.5) so that they could not communicate with each other during the sensory evaluation session.

[40] Research assitants recruited participants randomly from different areas within Swayimane and Umbumbulu areas. There was no set pattern used for the recruitment process.

Figure 6.5: Sensory evaluation set-up at the Gcumisa tribal hall in Swayimane

Each panellist was provided with a pen, a cup of water to rinse the palate between samples and sensory evaluation questionnaires [five-point hedonic facial scale (Appendix U) and paired preference test (Appendix V)] in isiZulu. The English versions of the sensory evaluation questionnaires [five-point hedonic facial scale (Appendix W) and a paired preference test (Appendix X)] were available for participants if needed. However, it was not needed for the main study. The five-point hedonic facial scale tested the sensory attributes (taste, texture, aroma, colour and overall acceptability) of six maize combination food samples (white *phutu* and curried cabbage; PVA-biofortified *phutu* and curried cabbage; white *phutu* and curried chicken; PVA-biofortified *phutu* and curried chicken; white *phutu* and curried bambara groundnut; PVA-biofortified *phutu* and curried bambara groundnut). The same scale was used to test the sensory attributes of two sweet potato samples (boiled CFSP and boiled OFSP).

The maximum number of samples that should be tested at one point in time is six for a full description of sensory analysis. However, if a researcher is testing less than 10 sensory attributes, a maximum of 10 samples may be tasted (Kemp, Hort & Hollowood 2018, pp57-58). For the purpose of the study, the six maize combination samples were tasted first and thereafter the two sweet potato dishes. One sample was given to the participant at a time.

Participants were required to put a cross over the face that they felt best described the attributes of the sample that was tasted. The research assistant explained each sensory attribute to the participant before the samples were evaluated so that the participant knew what was meant by each of the five attributes. Figure 6.6 illustrates an example of the five-point hedonic facial scale for the sensory attribute aroma that was used in this study.

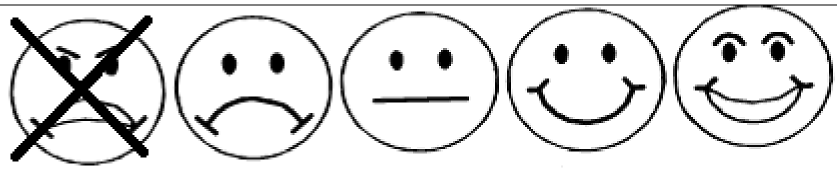
Aroma	 Very bad Bad Average Good Very good

Figure 6.6: Example of the five-point hedonic scale for the sensory attribute aroma

The hedonic scale is a popular sensory evaluation tool that indicates the degree of likes and dislikes (Lim 2011). The hedonic scale is best used when there are elderly participants or participants that have difficulty reading (Lawless & Heymann 2010, p332). It is simple and does not involve any mathematical equations, thus it was selected for this study. Each panellist completed the paired preference test after tasting all eight-food samples. Samples of white *phutu* combinations were compared to PVA *phutu* combinations and CFSP was compared to OFSP.

The paired preference test helps to validate the results from the sensory evaluation using a five-point hedonic facial scale, which was done in this study (Lawless & Heymann 2010, pp305-306, 332). The paired preference test is used to investigate the preference after tasting two products and adapted versions are simple to use for semi-literate/illiterate participants (Lawless & Heymann 2010, pp305-306). The same three-digit code that was allocated to the two samples during the initial sensory evaluation using the five-point facial hedonic scale, was used in the paired preference test. The participant was requested to put a circle around the three-digit number on the questionnaire that corresponded to the three-digit number on the container of the sample that they preferred. The paired preference test conducted alone does not give a true reflection on whether or not a sample is liked, as both samples may be disliked, and one may be more preferred (Lawless & Heymann 2010, p305).

6.4.4.6 Focus group discussions

The FGD questions were developed in advance from the themes that were identified. The FGD questions were first formulated in English by the researcher (Appendix S) and then translated into isiZulu (Appendix T) and back to English by two isiZulu speaking individuals. Two research assistants were involved in the translation to ensure that the FGD questions were translated accurately. The FGD questions were checked by an individual with experience in working with FGDs. The FGD questions were tested on the four African males and seven African females working at UKZN that also tasted the samples for appropriateness. The UKZN workers gave consent before participating. The UKZN workers clearly understood the questions and were able to give feedback on the composite dishes and OFSP that they tasted. They perceived all food samples as culturally acceptable. The PVA-biofortified *phutu* and bambara groundnut composite dish was new to some of the UKZN workers however, they enjoyed the taste. The most preferred composite dish was the PVA-biofortified *phutu* and curried chicken. The UKZN workers preferred the OFSP over the CFSP. No changes were made to the FGD questions prior to the pilot study and after the pilot study as all participants understood the questions.

Fifty-six African adults comprising of males and females from Swayimane and Umbumbulu were randomly selected from the sensory evaluation panel to participate in the FGDs. On completion of the sensory evaluation survey, FGD participants were recruited voluntarily. The participants were then randomly selected in order to reduce bias that could be created when a participant is personally recruited (Krueger & Casey 2009, p66). Each participant had a participant number which was put into a box when they volunteered. Thirty numbers were randomly selected from the box and those participants were selected to participate in the FGDs. This procedure was followed for Swayimane. All volunteers (n=26) from Umbumbulu participated in the FGDs. A total of 56 participants from both areas agreed to participate in the FGDs. The participants were divided into five groups of between 7 and 10 participants each. This was decided as the ideal size for a focus group discussion is between 6 and 10 participants (Silverman 2017, p297; Tolley, Ulin, Mack, Robinson & Succop 2016, p116; Bogart *et al* 2012. However, FGDs can have as little as four participants and as many as 12 participants (Krueger & Casey 2009, p6). The FGDs were facilitated by two trained research assistants (one male and one female), who were fluent in isiZulu and had experience with conducting FGDs. The research assistants alternated facilitating the FGDs. A digital voice recorder was used to record the FGDs after all participants consented to the use of the voice recorder. The recordings were later translated into English by both focus group discussion facilitators. The translated recordings were cross-checked by an isiZulu speaking person against the English translation, for accuracy.

6.4.5 Data quality control

Research assistants were responsible for inspecting all completed sensory evaluation and paired preference sheets to ensure that all the samples were tasted and rated. Data from the sensory evaluation and paired preference sheets were captured on a Microsoft Excel spreadsheet by research assistants. The data entry was cross-checked for accuracy by another research assistant.

6.4.6 Reduction of bias

During the preparation for the sensory evaluation, various steps were taken to reduce bias. All ingredients to be cooked were weighed using a calibrated scale. The same brands of ingredients were used to cook the composite dishes and the same measuring cup, measuring jug and measuring spoons were used to measure the ingredients. Insulated airtight containers were used for the transportation of food products. All participants were served the same amount of each sample using measuring spoons in a 250 ml polystyrene tub. All food products were warmed before testing in a microwave for ten seconds. This was done as cold samples could negatively affect the rating of the samples during the sensory evaluation (Bajec *et al* 2012). All samples were clearly labelled using a permanent marker on one side of the 250 ml polystyrene tub. The serving order was randomised using a Table of Random Permutations of Nine (Heymann 1995). For the FGDs, the same questions were asked to the FGD participants in the same order and participants were randomly selected from those that volunteered to participate in the FGDs.

6.4.7 Statistical analysis

Data from the sensory evaluation questionnaires were analysed using the Statistical Package for Social Sciences (SPSS) (version 25.0 SPSS Inc, Chicago, IL, USA) at the 5% level of significance. The Friedman's test, a nonparametric statistical test was used to test for significant differences in sensory attributes across the *phutu* combinations. The specific differences were then analysed using the Wilcoxon test for the *phutu* combinations and two varieties of sweet potato. The independent samples t-test was used to determine significant differences across gender for the average sensory attributes of the food samples. Analysis of variance (ANOVA) was used to determine significant differences between different age groups for the sensory attributes for all food samples. The Welch test was used when conditions of the ANOVA test were not met. The paired preference results were analysed using a Pearson chi-square test. The responses from the FGDs were subjected to thematic content analysis. Thematic analysis is a method used to identify patterns or themes that are related to the research question (Barbour 2018, p124, 125). This process does not just entail summarising the main points but interpreting the content into a meaningful output (Barbour 2018, p125). Verbatim comments from the FGDs were extracted from the voice recorder and translated from isiZulu into English. Data from the FGDs and the notes were coded. Similar coded ideas were then arranged into appropriate themes. Thereafter, a discussion was written for each theme from the FGDs.

6.4.8 Ethical considerations

Ethical approval was obtained from the UKZN, Humanities and Social Science Ethics Committee (HSS/0256/016D) (Appendix A). Gatekeeper's permission was obtained to conduct the study at the Swayimane (Appendix B), Tugela Ferry (Appendix C), Umbumbulu (Appendix D) and Fountain Hill Estate (Appendix E). Each panellist was required to sign a consent form (Appendix I) before participating in the sensory evaluation. The consent form was available in English (Appendix H) and isiZulu (Appendix I). The consent form was read to the participants in isiZulu so that all participants understood the contents of the consent form. All participants were able to sign the consent form. The participants were shown where to sign or initial on the consent form if they understood what was explained. If they did not understand something, it was re-explained and they signed once they understood. The consent form also allowed participants to grant permission to be photographed and audio and video recorded. Permission for use of photographs in the thesis was granted by the relevant participants.

6.5 Results

6.5.1 Survey

Results from the survey indicated that all 165 households consumed meals made with cooked white maize meal. Sixty-one percent of the participants (n=100) reported that they had consumed cooked maize meal in different forms, several times a week. The maize meal was both bought and homemade. Table 6.3 indicates the different forms of food prepared using white maize meal. White maize meal was most commonly prepared as *phutu* (84.8%; n=140) by the study participants.

Table 6.3: Various forms of cooked white maize meal (n=165 households)

Name of dish	Description	n (%)
Amaheu	Fermented porridge made from maize meal (cold)	27 (16.4%)
Incwancwa	Fermented soft porridge made from maize meal (liquid)	4 (2.4%)
Isicukwane	Maize meal cooked into a soft porridge with lemon juice added	4 (2.4%)
Isigwamba	Spinach and maize meal cooked together	4 (2.4%)
Isigwaqane	Beans and maize meal cooked together	38 (23.0%)
Isijingi	Butternut and maize meal cooked together to form a soft porridge	37 (22.4%)
Mealie meal porridge	Soft porridge made with maize meal	107 (64.8%)
Phutu	Maize meal cooked into a crumbly porridge	140 (84.8%)
Steamed bread	A type of bread made with maize meal and prepared by steaming	7 (4.2%)
Stiff pap	Maize meal cooked into a stiff porridge	70 (42.4%)

Seventy-five (66.4%), thirty-nine (34.5%), thirty-two (28.3%) and six (5.3%) of the study participants reported that they produced white maize meal for use as food, for an animal feed, for selling and from remnant seeds, respectively. The majority of the participants purchased their seeds from McDonalds seeds[41] (23.9%; n=26) and Madiba store[41] (21.1%; n=23) (Table 6.4).

Table 6.4: Source of white maize seeds (n=109 households)

Source	n (%)
Checkers	2 (1.8)
Dalton seed company	2 (1.8)
Donation	5 (4.6)
KaMfundisi Esphingo	2 (1.8)
Khwezi	2 (1.8)
Ladysmith	3 (2.8)
Local grocery store	7 (6.4)
Madiba	23 (21.1)
McDonalds	26 (23.9)
Mike Hardware	12 (11.0)
Remnant seeds	10 (9.2)
Tugela Ferry	11 (10.1)
Wartburg	4 (3.7)

Moreover, from the 52 participants not growing their own white maize, 38% (n=16) indicated it was due to a shortage of space. Maize meal was purchased from supermarkets with the most popular brand purchased being White Star (39.4%; n=13) and the least popular brand being Blue bird (3.0%; n=1) (Table 6.5).

[41] These are stores were seeds are purchased for agricultural purposes.

Table 6.5: Different brands of white maize meal purchased (n=33 households)

Maize meal brand	n (%)
ACE	5 (15.2)
Blue bird	1 (3.0)
Meliver King	2 (6.1)
Nyala	4 (12.1)
Sharp sharp	3 (9.1)
Spar brand	5 (15.2)
White star	13 (39.4)

Participants were asked further questions related to yellow maize meal. Eighty-three households (50.3%) reported that they had used yellow maize meal before. However, 82 households (49.7%) reported that they had never used yellow maize. The households that reported using yellow maize meal, used it for human consumption (42.2%; n=35), animal feed (55.4%; n=46) and both human consumption and animal feed (2.4%; n=2). Participants that consumed yellow maize meal, identified food items that they consumed together with yellow maize. In contrast to the cooked white maize meal, cooked yellow maize meal was consumed mostly with cabbage (38.6%; n=32). A small percentage of participants consumed yellow maize with dry beans (10%; n=8). The main reason why yellow maize was not consumed by households was that the participants had not seen it before (29.5%; n=18) (Table 6.6).

Table 6.6: Reasons why yellow maize was not consumed (n=61 households)

Reason why yellow maize was not consumed	n (%)
Participants did not like it	13 (21.3)
Participants have not seen yellow maize before	18 (29.5)
Yellow maize seeds are not accessible	3 (4.9)
Unfamiliar	12 (19.7)
Used during times of drought	6 (9.8)

Eighty-seven households (52.7%) reported that they consumed CFSP and 78 households (47.3%) reported that they did not. From the 87 households that consumed sweet potato, it was consumed daily (17.2%; n=15), bi-weekly (23%; n=20), weekly (23%; n=20), monthly (24.1%; n=21), several times a week (9.2%; n=8) and seasonally (3.4%; n=3). Sixty-eight households that consumed sweet potato prepared the sweet potato by boiling it in water with the skin on, until soft and served as a snack or a side dish with a meal.

6.5.2 Consumer acceptance and perceptions of PVA-biofortified maize and OFSP

6.5.2.1 Sample characteristics

The majority of participants that participated in the sensory evaluation and FGDs were female. (Tables 6.7 and 6.8). Although most of the sensory evaluation participants were above 60 years of age (n=29; 24.2%), the majority of the FGDs comprised of participants aged 40-49 years (n=16; 28.6%). Table 6.7 presents the total number of African rural participants of both genders within specific age groups that participated in the sensory evaluation. Most of the participants were ≥ 60 years (n=29; 24.2%) and the least number of participants were from the 20-29 age group (n=14; 11.7%). Table 6.8 indicates the total number of participants of both genders within specific age groups that participated in the FGDs.

Table 6.7: Characteristics of sensory evaluation participants (n=120)

Characteristics	n (%)*
Gender	
Males	34 (28.3)
Females	86 (71.7)
Age group (years)	
20-29	14 (11.7)
30-39	24 (20.0)
40-49	28 (23.3)
50-59	25 (20.8)
≥ 60	29 (24.2)

* Percentage of sample calculated using total sample (n=120).

Table 6.8: Characteristics of the focus group discussion participants (n=56)

Characteristics	n (%)*
Gender	
Males	16 (28.6)
Females	40 (71.4)
Age group (years)	
20-29	4 (7.1)
30-39	12 (21.4)
40-49	16 (28.6)
50-59	15 (26.8)
≥ 60	9 (16.1)

* Percentage of sample calculated using total sample (n=56).

6.5.3 Sensory evaluation

The panellists rated the sensory attributes (taste, texture, aroma, colour and overall acceptability) of all eight dishes as 'good'. Tables 6.9 and 6.10 indicates the percentages of panellists who gave different ratings for the sensory attributes and composite dishes evaluated.

Table 6.9: Number and percentages of panellists who gave the different ratings for the sensory attributes evaluated for the composite dishes (n=120)

Composite dishes	Rating	Taste	Texture	Aroma	Colour	Overall acceptability
White *phutu* and curried chicken	Very bad	1[a] (0.8)[b]	2 (1.7)	0 (0.0)	0 (0.0)	0 (0.0)
	Bad	11 (9.2)	12 (10.0)	4 (3.3)	4 (3.3)	1 (0.8)
	Average	15 (12.5)	13 (10.8)	14 (11.7)	20 (16.7)	12 (10.0)
	Good	65 (54.2)	65 (54.2)	74 (61.7)	78 (65.0)	83 (69.2)
	Very good	28 (23.3)	28 (23.3)	28 (23.3)	18 (15.0)	24 (20.0)
PVA *phutu* and curried chicken	Very bad	1 (0.8)	2 (1.7)	1 (0.8)	0 (0.0)	0 (0.0)
	Bad	8 (6.7)	13 (10.8)	4 (3.3)	10 (8.3)	6 (5.0)
	Average	11 (9.2)	8 (6.7)	12 (10.0)	10 (8.3)	6 (5.0)
	Good	72 (60.0)	75 (62.5)	81 (67.5)	67 (55.8)	78 (65.0)
	Very good	28 (23.3)	22 (18.3)	22 (18.3)	33 (27.5)	30 (25.0)
White *phutu* and curried cabbage	Very bad	2 (1.7)	2 (1.7)	0 (0.0)	0 (0.0)	0 (0.0)
	Bad	11 (9.2)	13 (10.8)	10 (8.3)	9 (7.5)	7 (5.8)
	Average	15 (12.5)	29 (24.2)	22 (18.3)	30 (25.0)	15 (12.5)
	Good	65 (54.2)	53 (44.2)	66 (55.0)	62 (51.7)	77 (64.2)
	Very good	27 (22.5)	23 (19.2)	22 (18.3)	19 (15.8)	21 (17.5)
PVA *phutu* and curried cabbage	Very bad	0 (0.0)	1 (0.8)	0 (0.0)	0 (0.0)	0 (0.0)
	Bad	9 (7.5)	12 (10.0)	8 (6.7)	9 (7.5)	8 (6.7)
	Average	24 (20.0)	26 (21.7)	24 (20.0)	16 (13.3)	14 (11.7)
	Good	62 (51.7)	57 (47.5)	64 (53.3)	69 (57.5)	60 (50.0)
	Very good	25 (20.8)	24 (20.0)	24 (20.0)	26 (21.7)	38 (31.7)
White *phutu* and curried bambara groundnut	Very bad	12 (10.0)	10 (8.3)	2 (1.7)	1 (0.8)	6 (5.0)
	Bad	18 (15.0)	22 (18.3)	18 (15.0)	12 (10.0)	13 (10.8)
	Average	10 (8.3)	13 (10.8)	22 (18.3)	23 (19.2)	11 (9.2)
	Good	62 (51.7)	62 (51.7)	68 (56.7)	71 (59.2)	70 (58.3)
	Very good	18 (15.0)	13 (10.8)	10 (8.3)	13 (10.8)	20 (16.7)
PVA *phutu* and curried bambara groundnut	Very bad	13 (10.8)	11 (9.2)	6 (5.0)	3 (2.5)	4 (3.3)
	Bad	20 (16.7)	20 (16.7)	14 (11.7)	16 (13.3)	17 (14.2)
	Average	20 (16.7)	16 (13.3)	26 (21.7)	22 (18.3)	11 (9.2)
	Good	60 (50.0)	55 (45.8)	62 (51.7)	65 (54.2)	73 (60.8)
	Very good	7 (5.8)	18 (15.0)	12 (10.0)	14 (11.7)	15 (12.5)

[a] Number of subjects; [b] Percentage of total number of participants; PVA = Provitamin A; Acceptability rating 1–5: 1 = very bad; 5 = very good.

Table 6.10: Number and percentages of panellists who gave the different ratings for the sensory attributes evaluated for two types of sweet potato (n=120)

Sweet potato	Rating	Taste	Texture	Aroma	Colour	Overall acceptability
CFSP	Very bad	1[a] (0.8) [b]	0 (0.0)	0 (0.0)	2 (1.7)	2 (1.7)
	Bad	9 (7.5)	8 (6.7)	6 (5.0)	6 (5.0)	2 (1.7)
	Average	3 (2.5)	16 (13.3)	24 (20.0)	20 (16.7)	10 (8.3)
	Good	61 (50.8)	50 (41.7)	63 (52.5)	67 (55.8)	70 (58.3)
	Very good	46 (38.3)	46 (38.3)	27 (22.5)	25 (20.8)	36 (30.0)
OFSP	Very bad	2 (1.7)	2 (1.7)	1 (0.8)	4 (3.3)	3 (2.5)
	Bad	7 (5.8)	11 (9.2)	12 (10.0)	7 (5.8)	4 (3.3)
	Average	6 (5.0)	8 (6.7)	26 (21.7)	13 (10.8)	9 (7.5)
	Good	62 (51.7)	60 (50.0)	58 (48.3)	67 (55.8)	62 (51.7)
	Very good	43 (35.8)	39 (32.5)	23 (19.2)	29 (24.2)	42 (35.0)

[a] Number of subjects; [b] Percentage of total number of participants; CFSP = Cream-fleshed sweet potato; OFSP = Orange-fleshed sweet potato; Acceptability rating 1–5: 1 = very bad; 5 = very good.

Most of the study participants rated the taste, texture and aroma of PVA *phutu* and curried chicken as “good” compared with white *phutu* and curried chicken (control). The texture and colour of PVA *phutu* and curried cabbage were rated “good” by more study participants in comparison to white *phutu* and curried cabbage (control). A higher percentage of participants rated the combination of PVA *phutu* and curried bambara groundnut (60.8%) as “good” in comparison to the white *phutu* and curried bambara groundnut (control) combination (58.3%). When comparing the composite dishes made with PVA *phutu*, the PVA *phutu* and curried chicken composite dish was rated “good” by most study participants for all five sensory attributes. Although the PVA *phutu* and curried cabbage composite dish and PVA *phutu* and curried bambara groundnut composite dish was rated as “good” by most participants, the taste, texture, aroma and colour of the PVA *phutu* and curried cabbage composite dish was rated “good” by more participants in comparison to PVA *phutu* and curried bambara groundnut. The OFSP was rated “good” by most participants for taste and texture in comparison to CFSP, however, the same number of participants rated OFSP and CFSP as “good”.

The mean scores for the sensory evaluation of the composite dishes and sweet potato are presented in Table 6.11. Results from the Friedman test showed that there was a significant difference in taste, texture, aroma, colour and overall acceptability across the dishes that included *phutu* ($p<0.05$).

Table 6.11: Mean scores for the sensory evaluation of PVA-biofortified maize and OFSP dishes compared with the white maize (control) and CFSP dishes (n=120)

Sensory attributes	Taste	Texture	Aroma	Colour	Overall acceptability
Composite dishes					
White *phutu* and curried chicken	3.9[a] (0.9)[b]	3.9 (0.9)	4.1 (0.7)	3.9 (0.7)	4.1 (0.6)
PVA *phutu* and curried chicken	4.0 (0.8)	3.9 (0.9)	4.0 (0.7)	4.0 (0.8)	4.1 (0.7)
White *phutu* and curried cabbage	3.9 (0.9)	3.7 (1.0)	3.8 (0.8)	3.8 (0.8)	3.9 (0.7)
PVA *phutu* and curried cabbage	3.9 (0.8)	3.8 (0.9)	3.9 (0.8)	3.9 (0.8)	4.1 (0.8)
White *phutu* and curried bambara groundnut	3.5 (1.2)	3.4 (1.2)	3.6 (0.9)	3.7 (0.8)	3.7 (1.1)
PVA *phutu* and curried bambara groundnut	3.2 (1.1)	3.4 (1.2)	3.5 (1.0)	3.6 (0.9)	3.7 (1.0)
p-value [c]	<0.05	<0.05	<0.05	<0.05	<0.05
Sweet potato					
CFSP	4.2 (0.9)	4.1 (0.9)	3.9 (0.8)	3.9 (0.9)	4.1 (0.8)
OFSP	4.1 (0.9)	4.0 (1.0)	3.8 (0.9)	3.9 (0.9)	4.1 (0.9)
p-value [d]	ns	ns	ns	ns	ns

[a] Mean; [b] Standard deviation; [c] Friedman's test; [d] The Wilcoxon test; PVA= Provitamin A; CFSP =Cream-fleshed sweet potato; OFSP = Orange-fleshed sweet potato; ns = not significant.

In order to determine the specific significant differences between the composite dishes for each of the sensory attributes, the Wilcoxon test was applied. Results are summarised in Tables 6.12 and 6.13.

Table 6.12: Significant differences between composite dishes and the sensory attributes of taste, texture and aroma

Composite dish A is preferred over composite dish B	Composite dish A	Composite dish B	p-value[a]
Taste	White *phutu* and curried chicken	White *phutu* and curried bambara groundnut	p=0.001
		PVA *phutu* and curried bambara groundnut	p<0.05
	PVA *phutu* and curried chicken	White *phutu* and curried bambara groundnut	p<0.05
		PVA *phutu* and curried bambara groundnut	p<0.05
	White *phutu* and curried cabbage	White *phutu* and curried bambara groundnut	p=0.003
		PVA *phutu* and curried bambara groundnut	p<0.05
	PVA *phutu* and curried cabbage	White *phutu* and curried bambara groundnut	p=0.005
		PVA *phutu* and curried bambara groundnut	p<0.05
	White *phutu* and curried bambara groundnut	PVA *phutu* and curried bambara groundnut	p=0.010
Texture	White *phutu* and curried chicken	White *phutu* and curried bambara groundnut	p<0.05
		PVA *phutu* and curried bambara groundnut	p=0.001
	PVA *phutu* and curried chicken	White *phutu* and curried bambara groundnut	p<0.05
		PVA *phutu* and curried bambara groundnut	p=0.001
	White *phutu* and curried cabbage	White *phutu* and curried bambara groundnut	p=0.031
		PVA *phutu* and curried bambara groundnut	p=0.024
	PVA *phutu* and curried cabbage	White *phutu* and curried bambara groundnut	p=0.003
		PVA *phutu* and curried bambara groundnut	p=0.019
Aroma	White *phutu* and curried cabbage	White *phutu* and curried cabbage	p=0.017
		PVA *phutu* and curried cabbage	p=0.025
		White *phutu* and curried bambara groundnut	p<0.05
		PVA *phutu* and curried bambara groundnut	p<0.05
	PVA *phutu* and curried bambara groundnut	White *phutu* and curried bambara groundnut	p<0.05
		PVA *phutu* and curried bambara groundnut	p<0.05
	White *phutu* and curried cabbage	White *phutu* and curried bambara groundnut	p=0.005
		PVA *phutu* and curried bambara groundnut	p=0.005
	PVA *phutu* and curried cabbage	White *phutu* and curried bambara groundnut	p=0.005
		PVA *phutu* and curried bambara groundnut	p=0.002

Composite dish A is preferred over composite dish B for the respective sensory attribute; [a] Wilcoxon Test.

Table 6.13: Specific significant differences between composite dishes and the sensory attributes of colour and overall acceptability

Composite dish A is preferred over composite Dish B	Composite dish A	Composite dish B	p-value[a]
Colour	White *phutu* and curried chicken	White *phutu* and curried bambara groundnut	p=0.019
		PVA *phutu* and curried bambara groundnut	p=0.005
	PVA *phutu* and curried chicken	White *phutu* and curried cabbage	p=0.014
		White *phutu* and curried bambara groundnut	p=0.002
		PVA *phutu* and curried bambara groundnut	p<0.05
	PVA *phutu* and curried cabbage	White *phutu* and curried bambara groundnut	p=0.017
		PVA *phutu* and curried bambara groundnut	p=0.001
Overall acceptability	White *phutu* and curried chicken	White *phutu* and curried bambara groundnut	p=0.001
		PVA *phutu* and curried bambara groundnut	p<0.05
	PVA *phutu* and curried chicken	White *phutu* and curried cabbage	p=0.029
		White *phutu* and curried bambara groundnut	p<0.05
		PVA *phutu* and curried bambara groundnut	p<0.05
	White *phutu* and curried cabbage	White *phutu* and curried bambara groundnut	p=0.032
		PVA *phutu* and curried bambara groundnut	p=0.015
	PVA *phutu* and curried cabbage	White *phutu* and curried bambara groundnut	p<0.05
		PVA *phutu* and curried bambara groundnut	p<0.05

Composite dish A is on average significantly better than composite dish B for the respective sensory attribute; [a]Wilcoxon Test.

The sensory attributes, taste, texture, aroma, colour and overall acceptability of PVA *phutu* combined with curried chicken were rated similarly by participants in comparison to white *phutu* served with curried chicken ($p>0.05$). Provitamin A-biofortified *phutu* and curried cabbage combination had a similar rating for all five sensory attributes in comparison to white *phutu* and curried cabbage ($p>0.05$). The PVA *phutu* and curried bambara groundnut had a significantly lower rating for taste in comparison to white *phutu* and curried bambara groundnut (control) ($p<0.05$); however, both composite dishes were rated similarly for the other sensory attributes ($p>0.05$). When comparing the PVA composite dishes, it was found that when PVA *phutu* was combined with either curried cabbage or chicken, the taste, texture and overall acceptability was rated better than that of PVA *phutu* and curried bambara groundnut ($p<0.05$). Although the PVA *phutu* and curried chicken had a significantly better rating for colour in comparison to PVA *phutu* and curried cabbage, the PVA *phutu* and cabbage combination was rated higher for colour in comparison to PVA *phutu* and curried bambara groundnut ($p<0.05$). The Wilcoxon test found that the two varieties of sweet potato were rated similarly for taste, texture, aroma, colour and overall acceptability ($p>0.05$) (Table 6.10).

Results from the independent samples t-test found that there were no significant differences across gender for the average sensory attributes of all eight dishes ($p>0.05$) (Table 6.14). In terms of the *phutu* composite dishes, the male participants rated the taste of white *phutu* and curried cabbage the highest, whereas females rated the taste of PVA *phutu* and curried chicken the highest. Both males and females least liked the taste of the PVA *phutu* and bambara groundnut combination. The male participates liked the texture of the composite dishes that contained curried chicken, whereas female participants preferred the texture of the white *phutu* and curried chicken composite dish. Female participants preferred the aroma and colour of PVA *phutu* and curried chicken, while the male participants preferred the aroma and colour of white *phutu* and curried chicken. The overall acceptability of white *phutu* and curried chicken and PVA *phutu* and curried chicken was rated the same by males, however, female participants preferred the PVA *phutu* and curried chicken composite dish. The taste and texture of CFSP were liked by both males and females in comparison to OFSP. Female participants preferred the aroma of CFSP to OFSP, while the male participants rated the aroma of both types of sweet potato the same. Conversely, females preferred the colour of OFSP to CFSP, while the male participants rated the colour of OFSP and CFSP the same. The overall acceptability of OFSP was rated higher by males and lower by females in comparison to CFSP.

Table 6.14: Mean scores for the sensory evaluation of PVA-biofortified maize and OFSP dishes compared with the white maize (control) and CFSP dishes by gender (n=120)

Sensory attributes	Taste		Texture		Aroma		Colour		Overall acceptability	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Composite dishes										
White *phutu* and curried chicken	3.79[a] (1.00)[b]	3.94 (0.85)	3.97 (0.87)	3.84 (0.97)	4.12 (0.64)	4.02 (0.72)	3.97 (0.63)	3.90 (0.69)	4.09 (0.51)	4.08 (0.60)
PVA *phutu* and curried chicken	3.94 (0.69)	4.00 (0.87)	3.97 (0.76)	3.80 (0.96)	3.88 (0.69)	4.03 (0.71)	3.91 (0.90)	4.07 (0.81)	4.09 (0.75)	4.10 (0.69)
White *phutu* and curried cabbage	4.06 (0.85)	3.79 (0.95)	3.88 (0.91)	3.60 (0.97)	3.97 (0.83)	3.78 (0.82)	3.76 (0.78)	3.76 (0.83)	4.03 (0.67)	3.90 (0.75)
PVA *phutu* and curried cabbage	3.76 (0.89)	3.90 (0.81)	3.71 (1.03)	3.78 (0.87)	3.97 (0.76)	3.83 (0.83)	3.74 (0.93)	4.01 (0.74)	3.91 (0.93)	4.13 (0.79)
White *phutu* and curried bambara groundnut	3.53 (1.16)	3.44 (1.23)	3.24 (1.18)	3.44 (1.14)	3.65 (1.07)	3.51 (0.84)	3.76 (0.86)	3.66 (0.82)	3.82 (1.03)	3.66 (1.04)
PVA *phutu* and curried bambara groundnut	3.09 (1.22)	3.29 (1.11)	3.38 (1.30)	3.42 (1.16)	3.47 (1.02)	3.51 (0.99)	3.62 (1.05)	3.58 (0.91)	3.68 (1.09)	3.64 (0.94)
p-value[c]	ns[d]		ns		ns		ns		ns	
Sweet potato										
CFSP	4.15 (0.86)	4.20 (0.88)	4.03 (0.94)	4.15 (0.86)	3.74 (0.86)	4.00 (0.75)	3.79 (0.85)	3.93 (0.85)	3.97 (0.80)	4.20 (0.75)
OFSP	4.09 (1.08)	4.16 (0.80)	3.97 (1.17)	4.05 (0.87)	3.74 (1.14)	3.76 (0.81)	3.79 (1.12)	3.97 (0.86)	4.09 (1.00)	4.15 (0.83)
p-value [c]	ns		ns		ns		ns		ns	

[a] Mean; [b] Standard deviation; [c] Independent t test; [d] ns = not significant; PVA= Provitamin A; CFSP =Cream-fleshed sweet potato; OFSP = Orange-fleshed sweet potato.

Results from applying ANOVA indicated a significant difference in the average sensory attribute taste for white *phutu* and curried cabbage and white *phutu* and curried bambara groundnut, across certain age categories (p>0.05) (Table 6.15).

<u>Table 6.15:</u> Significant differences in the acceptability ratings of composite dishes across age groups

Composite dishes	**Sensory attribute**	**p-value[a]**	**Specific difference across age[b]**
White *phutu* and curried cabbage	Taste	<0.05 [c]	>60 (A) rated higher than 50-59 (B)
White *phutu* and curried bambara groundnut	Taste	<0.05 [c]	>60 (A) rated higher than 20-29 (B)
White *phutu* and curried bambara groundnut	Aroma	<0.05 [d]	>60 (A) rated higher than 50-59 (B)
White *phutu* and curried bambara groundnut	OA	<0.05 [d]	>60 (A) rated higher than 20-29 (B)

[a] Result from testing for differences across all age groups regarding the specific product and sensory attribute; [b]Indicates the age category (years) (A) that gave a statistically higher rating for the respective composite dish and sensory attribute than age category (years) (B); [c]ANOVA test; [d] Welch test; OA= Overall acceptability.

The Welch test indicated that there was a significant difference between certain age categories and the sensory properties of aroma and overall acceptability for white *phutu* and curried bambara groundnut (p<0.05) (Table 6.15). There was no significant difference in the acceptability ratings of PVA-biofortified composite dishes across age groups (p>0.05). The taste of the PVA *phutu* and curried chicken and the PVA *phutu* and curried cabbage was preferred by participants aged 30-39 years and 40-49 years, respectively. The 40-49 age group preferred the texture and aroma of the PVA *phutu* and curried chicken and PVA *phutu* and curried cabbage in comparison to the other age groups. The colour was preferred by both the 30-39 and 50-59 year age groups. Participants older than 60 years of age preferred the colour and overall acceptability of the PVA *phutu* and cabbage composite dish more, in comparison to the other age groups. The taste, texture, aroma, colour and overall acceptability of PVA *phutu* and curried bambara groundnut were rated higher by those older than 60 years of age, in comparison to other age groups. The 20-29 year old participants preferred the taste, texture, aroma, colour and overall acceptability of OFSP, in comparison to the other age groups. The paired preference results are presented in Tables 6.16 and 6.17.

Table 6.16: Variation in paired preference with gender (n=120)

Gender	n	***Phutu* and curried chicken**		***Phutu* and curried cabbage**		***Phutu* and curried bambara groundnut**		**Sweet potato**	
		White *phutu* and curried chicken	**PVA *phutu* and curried chicken**	**White *phutu* and curried cabbage**	**PVA *phutu* and curried cabbage**	**White *phutu* and curried bambara groundnut**	**PVA *phutu* and curried bambara groundnut**	**CFSP**	**OFSP**
Males	34	19[a] (56) [b]	15 (44)	17 (50)	17 (50)	19 (56)	15 (44)	14 (41)	20 (59)
Females	86	40 (46)	46 (54)	44 (51)	42 (49)	47 (55)	39 (45)	41 (48)	45 (52)
Total no. of participants	120	59 (49)[c]	61 (51)	61 (51)	59 (49)	66 (55)	54 (45)	55 (46)	65 (54)

[a] Number of participants; [b] Percentage (%) of the sample within a gender group; [c] Percentage (%) of the total number of participants; PVA = Provitamin A; CFSP = Cream-fleshed sweet potato; OFSP = Orange-fleshed sweet potato.

There was no statistical significance noted for the preference of PVA-biofortified and non-PVA-biofortified food combinations between males and females (p>0.05). Although not statistically significant, males from this sample preferred the white *phutu* and curried chicken (n=19; 56%), white *phutu* and curried bambara groundnut (n=19; 56%) and OFSP (n=20; 59%). The female participants preferred the provitamin A-biofortified *phutu* and curried chicken (n=46; 54%), white *phutu* and curried cabbage (n=44; 51%), white *phutu* and curried bambara groundnut (n=47; 55%) and OFSP (n=65; 54%).

Table 6.17: Preference ratings across age groups (n=120)

Age group (years)	n	***Phutu* and curried chicken**		***Phutu* and curried cabbage**		***Phutu* and curried bambara groundnut**		**Sweet potato**	
		White *phutu* and curried chicken	**PVA *phutu* and curried chicken**	**White *phutu* and curried cabbage**	**PVA *phutu* and curried cabbage**	**White *phutu* and curried bambara groundnut**	**PVA *phutu* and curried bambara groundnut**	**CFSP**	**OFSP**
20-29	14	7[a] (50)[b]	7 (50)	9 (64)	5 (36)	9 (64)	5 (36)	5 (36)	9 (64)
30-39	24	7 (29)	17 (71)[c]	11 (46)	13 (54)	13 (54)	11 (46)	10 (42)	14 (58)
40-49	28	11 (39)	17 (61)	12 (43)	16 (57)	16 (57)	12 (43)	14 (50)	14 (50)
50-59	25	17 (68)	8 (32)	11 (44)	14 (56)	13 (52)	12 (48)	10 (40)	15 (60)
>60	29	17 (59)	12 (41)	18 (62)	11 (38)	15 (52)	14 (48)	16 (55)	13 (45)
Total no. of participants	120	59 (49)	61 (51)	61 (51)	59 (49)	66 (55)	54 (45)	55 (46)	65 (54)

[a] Number of participants; [b] Percentage (%); [c] Bold values within the same column are significantly different at p<0.05 (Pearson chi-square); PVA = Provitamin A; CFSP = Cream-fleshed sweet potato; OFSP = Orange-fleshed sweet potato.

Significantly more participants aged 30-39 years preferred provitamin A-biofortified *phutu* and chicken (n=17; 71%) than the other age groups (p<0.05). Moreover, participants aged 50-59 years who preferred white *phutu* and chicken (n=17; 68%), was statistically significantly higher than participants from the other age groups. There was a tendency for all age groups to prefer white *phutu* with cabbage, white *phutu* with bambara groundnut and OFSP, although this was not statistically significant (p>0.05).

6.5.4 Focus group discussions

Sensory evaluation participants, participated in the FGDs after they completed the sensory evaluation (five-point facial hedonic scale and paired preference test). Focus group discussions revealed both positive and negative responses to the PVA-biofortified *phutu* and bambara groundnut composite dish However, overall the participants had positive perceptions about the sensory properties of the PVA-biofortified composite dishes and OFSP. The participants offered suggestions as to how the meals could be prepared to increase the acceptability. Although the participants were not asked how to improve the meals, they did offer suggestions during the discussions. The participants expressed a willingness to purchase PVA-biofortified maize and sweet potato if it was available at local stores. The participants were also keen to grow their own biofortified produce if seeds were accessible. The results are presented in Table 6.18.

Table 6.18: Participants' perceptions towards the consumption of OFSP and PVA-biofortified *phutu* with curried chicken, cabbage and bambara groundnut

Themes	Concepts	Quotes	Discussion
Consumer perceptions about PVA-biofortified composite dishes and OFSP	Preference of combinations: *Phutu* and chicken *Phutu* and cabbage *Phutu* and bambara groundnut OFSP	*'Yellow phutu and chicken was nice.'* *'Cabbage and yellow phutu went good together.'* *'I did not like these beans.'* *'This type of beans was different from what I am used to. I love it.'* *'Orange sweet potato taste nice.'* *'These beans must be mixed with dry mealies to make iznkobe. It will taste better.'*	The FGDs indicated that participants had positive perceptions of the PVA *phutu* when served with curried chicken or curried cabbage. However, they had mixed perceptions when served with curried bambara groundnut. The older FGDs participants perceived that some of the combinations such as *phutu* and bambara would not be acceptable to younger consumers, as they were not accustomed to bambara.
	Food preparation methods	*'Yellow maize could have been cooked for longer.'* *'Too much water in the orange sweet potato.'* *'Beans should be cooked with the maize for more flavour.'* *'Beans could be cooked for longer.'* *'Chicken would of tasted better with stiff pap.'* *'Food cooked like I cook at home.'*	Participants suggested names of other dishes made with PVA-biofortified maize that could be better accepted. Stiff pap was one of the suggestions given by FGD participants. Although there were mixed responses concerning bambara, participants offered a few suggestions to improve the acceptability. Participants would have preferred the bambara to be cooked for a longer period or cooked together with the maize meal.
Cultural acceptance of PVA-biofortified composite dishes and OFSP	Expectations of sensory qualities: • Smell • Appearance • Taste • Texture	*'Foods were made like I eat at home.'* *'Our kids may not accept the preparation of the food as it has less oil and spice.'* *'Thought the orange sweet potato was butternut.'*	The majority of the FGD participants perceived the foods as culturally acceptable, however, they felt that some foods would not be as acceptable to their children and grandchildren. Foods that the younger generation like are prepared with more oil, salt and spices. Most of the FGD participants perceived the OFSP as butternut due to its orange colour, sweet taste and visual appeal and enjoyed the taste.

Table 6.18: Participants' perceptions towards the consumption of OFSP and PVA-biofortified *phutu* with curried chicken, cabbage and bambara groundnut continued

Themes	Concepts	Quotes	Discussion
Comparison with white maize food combinations and CFSP	Expectations of sensory qualities: • Smell • Appearance • Taste • Texture	*'Preferred the white sweet potato as too much water in the orange one.'* *'The orange sweet potato was nicer as it had an orange colour and taste sweet.'* *'The chicken and yellow maize and beans and yellow maize looked nice.'* *'First time I had this yellow phutu and it was very nice with the cabbage and meat. I won't eat it alone.'* *'I did not like the smell of yellow maize.'*	Participants would have preferred if OFSP contained less water in comparison to CFSP. However, they found the sweet taste and orange colour of the OFSP very appealing and preferred it to the CFSP. The smell of PVA-biofortified *phutu* and curried bambara groundnut and PVA-biofortified *phutu* on its own were disliked by some of the participants. On the contrary, PVA-biofortified maize was well accepted with the curried cabbage and curried chicken.
Willingness to use yellow maize and OFSP for human consumption	• Affordability • Availability • Accessibility	*'Not accessible, if it was I would buy yellow maize and OFSP.'* *'We use yellow maize in drought times.'* *'It is fed to animals.'* *'People are not familiar with yellow maize but will buy if educated on it.'* *'I would plant if I get seeds.'*	Some participants reported that PVA-biofortified maize was used to feed animals and eaten during times of drought, however, they expressed a willingness to grow and purchase the PVA-biofortified maize and OFSP if planting materials were made available or if the two types of biofortified crops were available as food in the market. The acceptance of PVA-biofortified maize could be improved by educating people on the nutritional benefits of PVA-biofortified crops and preparation methods that could be used to cook these crops.

6.6 Discussion

Malnutrition is the leading contributor to the global disease burden (UNICEF, WHO & World Bank Group 2019; UNICEF 2016; Faber & Wenhold 2007). South Africa is faced with the double burden of malnutrition (Shisana *et al* 2013). Many interventions focus on under and over-nutrition in vulnerable population groups; however, micronutrient deficiencies are still prevalent. Although the fortification of maize meal and wheat flour was legislated in SA in October 2003, the accessibility of these commercially fortified foods to rural households remains questionable (DoH & UNICEF 2007). Although PVA-biofortified crops improve the nutrient content of foods, their acceptability to target consumers should be improved through research. Thus, this study aimed to investigate the effect of replacing white maize and CFSP with PVA-biofortified maize and OFSP, respectively, on consumer acceptability and perceptions of traditional dishes of selected rural communities in KZN, SA.

The study results are encouraging as the sensory attributes taste, texture, aroma, colour and overall acceptability were rated as good by most study participants for all of the PVA *phutu* composite dishes. Over a millennium ago, in rural South African communities, indigenous and traditional crops were the main source of food. However, with urbanisation, there has been a shift from traditional foods to more western foods with less consumption of indigenous and traditional foods (Van der Hoeven, Osei, Greeff, Kruger, Faber & Smuts 2013). The older generation has displayed some knowledge of bambara groundnut (Oyeyinka *et al* 2017), which was also found in the current study during the FGDs. The older generation (above 60 years) rated the overall acceptability of *phutu* and curried bambara groundnut better than the younger generation (20-29 years). Chowdhury *et al* (2011), reported that introducing an unfamiliar product could negatively affect consumer acceptance. This could have been the case in the current study with the younger generation, specifically with regards to the *phutu* and curried bambara groundnut composite dish which was least preferred in comparison to the other composite dishes.

Although bambara groundnut is an unfamiliar food crop, it was introduced and investigated in this study as it could be a cheaper alternative to animal protein. Crops like bambara groundnut could be included in the meals used in school feeding programmes. Bambara groundnut is sold dry; thus, it is available all year round. However, the cost and accessibility need to be further explored so that this crop can be used in school feeding programmes. The introduction of bambara groundnut would not only improve the nutritional intake of these children but also result in earlier exposure to this food item. Early and frequent exposure to a food item improves the acceptance of the food item (Appleton, Hemingway, Rajska & Hartwell 2018). Another suggestion would be to prepare bambara groundnut into different food types using preparation methods that have been shown to improve acceptance, such as roasting. A study conducted by Oyeyinka *et al* (2017) found that bambara groundnut made into a pureed infant complementary food was acceptable to caregivers. Another study conducted in Nigeria using a snack made from bambara groundnut flour found that the aroma, colour, crunchiness and overall acceptability were higher than those of the control made with cowpea (Oyeyinka *et al* 2018). Additionally, Okafor *et al* (2015) found that substituting roasted bambara groundnut at different substitution levels for wheat flour in biscuits, had a higher sensory rating for the attributes investigated. However, the flavour of the biscuits was similar to that of the control for up to 70% substitution (Okafor *et al* 2015). These studies further confirm that how a food item is prepared and the geographic location of consumers influence its acceptability (Oyeyinka *et al* 2018; Oyeyinka *et al* 2017; Okafor *et al* 2015).

As alluded to earlier, poverty is a problem and, in some cases, economically disadvantaged individuals rely on social grants as their sole source of income for purchasing food (Jacobs, Baiphethi, Ngcobo & Hart 2010). Hence, there is a lack of dietary diversity and a high reliance on starch-based foods, such as maize meal as they are cheaper (Battersby & Peyton 2014; Temple & Steyn 2009). Thus, it is important to introduce economically disadvantaged individuals to affordable nutritious food alternatives such as bambara groundnut that can be consumed together with cooked maize meal. It is important to note that an individual's background, traditions, socioeconomic standing and geographical location are important factors that influence the types of foods consumed and the preparation methods used (Emily, Huggins, Huggins, McCaffrey, Palermo & Bonham 2017; Kamphuis, de Bekker-Grob & Van Lenthe 2015; Wenhold, Annandale, Faber & Hart 2012; Kearney 2010).

Most participants from the present study were unfamiliar with bambara groundnut and the younger generation lacked basic knowledge about this crop. This emphasises the need for education on the nutritional benefits of bambara groundnut and methods of preparation, to improve exposure and acceptance of this underutilised crop. It is noteworthy that this study did not educate participants about the composite dishes prior to the sensory evaluation and FGDs. Future studies could investigate the impact of nutritional education on consumer acceptability.

The acceptance of PVA-biofortified maize has been previously investigated by several authors (Awobusyi, Siwela, Kolanisi & Amonsou 2016; Govender, Pillay, Derera & Siwela 2014; Khumalo *et al* 2011; Pillay *et al* 2011; De Groote *et al* 2010; Stevens & Winter-Nelson 2008). Provitamin A-biofortified maize has been found to have an undesirable colour. The grain colour changes from white to either yellow or orange due to the carotenoid pigments (Muzhingi, Langyintuo, Malaba & Banziger 2008; Stevens & Winter-Nelson 2008), thus contributing to poor acceptability (De Groote *et al* 2010). However, the change did not hinder colour acceptability of the PVA-biofortified *phutu* and OFSP in this study. A number of studies have investigated the preference of PVA-biofortified maize to white maize and found mixed responses (Awobusuyi *et al* 2016; Govender *et al* 2014; Nuss *et al* 2012; Muzhingi *et al* 2008; Stevens & Winter-Nelson 2008). However, there is a paucity of information regarding the preference of PVA-biofortified *phutu* composite dishes compared to corresponding white maize composite dishes. The PVA *phutu* and curried chicken combinations were well accepted in the current study. This result was similar to the results obtained by Amod *et al* (2016), who investigated the sensory acceptability of PVA-biofortified *phutu* consumed together with chicken stew. The authors found that the combination of PVA-biofortified *phutu* and chicken was well accepted by caregivers attending the paediatric outpatient department at Edendale Hospital in KZN (Amod *et al* 2016). The participants of the study conducted by Amod *et al* (2016) were similar to the current study participants, as Edendale Hospital mainly services individuals living in surrounding rural areas (DoH 2019). In the current study, it was reported that the aroma and colour of the chicken and yellow *phutu* were well-accepted. These findings suggest that the combination of curried chicken and PVA-biofortified *phutu* was well-accepted by study participants and could help improve the vitamin A intake in vulnerable groups. However, as mentioned earlier, animal food sources are not affordable. Thus, bambara groundnut should be considered not only as a nutritious alternative, but also a viable production option in these areas.

Several studies conducted on OFSP have shown positive responses from participants, despite the orange colour (Pillay *et al* 2018; Laurie, Faber, Calitz, Moelich, Muller & Labuschagne 2013; Tomlins, Owori, Bechoff, Menya & Westby 2012; Chowdhury *et al* 2011; Tomlins *et al* 2007). A study conducted by Pillay *et al* (2018) on infant caregivers found that a complementary food made with OFSP was well accepted by the caregivers (Pillay *et al* 2018). Additionally, another study that investigated the acceptance of OFSP by caregivers, reported that the OFSP was preferred to the pale-fleshed sweet potato for all sensory attributes investigated (Low & Van Jaarsveld 2008). Moreover, a study conducted in Uganda found that the deep orange coloured sweet potato was preferred over yellow or white sweet potato (Chowdhury *et al* 2011). Although not statistically significant, numerically, OFSP was preferred to CFSP in the current study. This could be due to the sweet taste and colour of OFSP. The results from this study are encouraging as they suggest that there is a potential to use OFSP in some rural areas of KZN similar to the study sites, to improve the vitamin A status of vulnerable individuals.

Consumption of biofortified crops such as maize and OFSP and the consumption of an indigenous crop like bambara groundnut could potentially increase the dietary diversity of economically disadvantaged individuals and improve their nutritional status (Mavengahama, McLachlan & De Clercq (2013). However, bambara groundnut should be introduced in a different cooked form rather than curried to improve acceptability. For this study, bambara groundnut was cooked similarly to curried bean to investigate the acceptance. The younger generation was unaccustomed to bambara groundnut and the older generation that were familiar with it enjoyed the taste. Acceptance of bambara groundnut could be improved if it is cooked together with *phutu* or mealie meal or milled into a flour and used to prepare other products. There is a need to further investigate the sensory acceptability of combining other cooked PVA-biofortified maize foods such as stiff pap, mealie meal porridge, *amaheu, isigwaqane* or *isijingi*, with commonly consumed food items in rural KZN, and the other provinces within SA. Furthermore, future studies could explore the impact of education on the nutritional benefits of these crops and the acceptance, perception and consumption of these crops.

The FGD results correlate with the results obtained from the sensory evaluation as the FGD participants had positive perceptions of the composite dishes made from PVA-biofortified *phutu* and chicken and cabbage. However, there were mixed responses about PVA-biofortified *phutu* and curried bambara groundnut. This result was not surprising, as bambara groundnut is an indigenous nutritious crop; however, it is not usually consumed in rural areas of KZN (Chivenge *et al* 2015). The older generation of participants perceived the *phutu* and bambara groundnut combination as something the younger generation would not like, as they are not accustomed to it. A study conducted by Oyeyinka *et al* (2017) found that the older generation was familiar with the preparation of bambara groundnut. This study further identified that a lack of knowledge may be a reason for the underutilisation of this crop (Oyeyinka *et al* 2017). It is important to educate the younger generation on the nutritional benefits of consuming this crop, as well as good agricultural practices to produce this crop. Knowing the nutritional value of a particular food item could improve the acceptance of that specific item (Meenakshi, Banerji, Manyong, Tomlins, Mittal & Hamukwala 2012). Furthermore, indigenous crops such as bambara groundnut should be promoted to local farmers to improve the production and access to these crops. These crops could become cash crops and further provide not only nutrients but income for the local farmers.

Participants from the FGDs perceived the foods to be culturally acceptable and familiar; however, they made suggestions as to what should be changed to improve the combinations. A few male participants from the FGDs suggested that PVA-biofortified maize should be cooked into stiff pap and served with curried chicken instead of *phutu*. A survey conducted at the start of this study, found that 84.4% of the study participants consumed *phutu*, whereas only 42.4% consumed stiff pap. From the combinations investigated, more participants preferred *phutu* and curried chicken (n=27), rather than stiff pap and curried chicken (n=20). Although, it was suggested that the PVA-biofortified maize should be cooked into stiff pap and served with curried chicken, the *phutu* combination was still well perceived. Future studies should investigate consumer perceptions of cooking PVA-biofortified maize into food forms other than *phutu*, and served with commonly consumed foods. This would offer a variety of more acceptable foods that individuals could consume to improve their nutritional status, particularly vitamin A.

The OFSP prepared for the sensory evaluation in this study seemed to retain water. Some of the participants mentioned that they would have enjoyed it more if it were boiled for longer in less water. The same amount of water and time taken for straining was used to cook the CFSP. A possible reason for excess water content could be attributed to a relatively lower dry matter content of the OFSP (Kathabwalika, Chilembwe & Mwale 2016). The genotypes found in the different varieties of OFSP influence the dry matter content and affect consumer acceptability (Kathabwalika *et al* 2016). Some participants suggested that the curried bambara groundnut needed to be cooked for a longer period and that less water should be used when cooking OFSP. Further studies could investigate the acceptance of OFSP when prepared with different amounts of water and cooking times to improve acceptability. If OFSP is well accepted and consumed in areas where VAD is a significant problem, it has the potential to improve the vitamin A status of these individuals.

Many study participants perceived the OFSP to be butternut due to the orange colour, sweet taste and visual appeal, which was similar to the findings of a study conducted by Pillay *et al* (2018) on the acceptance of OFSP (Pillay *et al* 2018). Moreover, other studies have also reported that OFSP has been compared to pumpkin (Laurie *et al* 2013; Tomlins *et al* 2007). Although OFSP may be unfamiliar to some individuals, it resembles other familiar food items. Participants can, therefore, relate to it and are more likely to consume it. Generally, individuals are more inclined to consume foods that are familiar to them (Chowdhury *et al* 2011). The participants mentioned that they would not have enjoyed PVA-biofortified *phutu* on its own. This was possibly due to the undesirable sensory properties of biofortified foods and some participants being unfamiliar with it (Chapman 2012; Nuss & Tanumihardjo 2010). This further suggests that if yellow maize is consumed with another food item, it may mask the undesirable sensory changes noted with biofortified foods, thus increasing its acceptance. Participants' also indicated that the PVA-biofortified *phutu* was appealing when served with curried chicken or curried bambara groundnut. These results were consistent with the study conducted by Amod *et al* (2016).

Many participants expressed that yellow maize was used as an animal feed or during drought. This was similarly expressed in other studies (Amod *et al* 2016; Govender *et al* 2014; Nuss *et al* 2012; Muzhingi *et al* 2008). However, study participants expressed a willingness to grow and purchase PVA-biofortified maize and OFSP if seeds were made available or if they could be found in shops. At the time of the study, the crops used in this study were experimental and not available on the market. Although PVA-biofortified foods have been found to be less acceptable by some studies, foods investigated in the study were positively perceived by most of the FGD participants. Therefore, PVA-biofortified maize and OFSP could replace or partially replace white maize and CFSP, respectively, as these foods are rich in vitamin A and could contribute to addressing VAD, which is prevalent in rural areas of SA. However, there is a need to provide education on the health benefits of these crops especially to the younger generation, who are not accustomed to these crops, to improve their acceptance.

6.7 Conclusions

Provitamin A-biofortified foods served on their own have been well-accepted in some studies, while other studies have found a poor acceptance due to several factors. The results of this study were encouraging as foods investigated in this study were positively perceived by the majority of the study participants. This study indicates that the undesirable properties of PVA-biofortified foods that were found in other studies could be masked by serving it with another commonly consumed food item, thus improving its acceptance. Although *phutu* and curried bambara groundnut were not as preferred in comparison to the other composite dishes investigated, it was rated as 'good' for all the sensory attributes. This indicated that although it was least preferred in comparison to the other composite dishes if served on its own it would be acceptable to consumers. *Phutu* and curried chicken was the most preferred composite dish, however, it contains animal protein which is less affordable to economically disadvantaged individuals. Bambara groundnut can be used as an alternative affordable plant-based protein source; however, the acceptance needs to be further investigated in other food products, such as incorporating the bambara groundnut and *phutu* during cooking, the addition of bambara groundnut to maize meal to make a traditional drink or serving it with another form of cooked maize meal. Overall, it appears that PVA-biofortified maize combined with curried cabbage, chicken, bambara groundnut and boiled OFSP have the potential to be used as healthy alternatives to white maize combined with curried cabbage chicken, bambara groundnut and boiled CFSP. However, more studies need to be conducted on trying to improve the exposure to and acceptance of PVA-biofortified maize and bambara groundnut together, especially to the younger generation. The bambara groundnut and PVA *phutu* combination could be used in school feeding programmes as a cheaper alternative to animal protein. Not only will it improve the nutritional intake of young children, but provide exposure to these crops to consumers at a young age. Additionally, more education needs to be conducted on the nutritional benefits of PVA-biofortified crops and bambara groundnut, especially for the younger generation as many of them are not familiar with these crops. Moreover, PVA-biofortified crops (maize and sweet potato) and bambara groundnut should be promoted to local farmers. Local farmers should be educated on the production of these crops and possibly be given or sold seeds at a reduced cost. This would result in an increased production of these crops by farmers, which could lead to improved consumption. This study suggests that PVA-biofortified maize and OFSP could be incorporated into the diets of the rural communities studied to contribute to combating VAD, which is a major problem in SA and SSA.

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CHAPTER 7

OVERALL DISCUSSION

Malnutrition is prevalent in developing countries, such as South Africa (SA) [United Nations Children's Fund (UNICEF), World Health Organization (WHO) & World Bank Group 2017; UNICEF 2016; Faber & Wenhold 2007]. The economically disadvantaged communities, including rural population groups, are particularly affected by several forms of malnutrition, including micronutrient malnutrition, particularly vitamin A [National Department of Health (nDoH), Statistics South Africa (Stats SA), South African Medical Research Council (SAMRC) & ICF 2017; Napier & Oldewage-Theron 2015; Duncan, Howe, Manukusa & Purdy 2014; Devanathan, Esterhuizen & Govender 2013; Grobbelaar, Napier & Oldewage-Theron 2013; Shisana, Labadarios, Rehle, Simbayi, Zuma, Dhansay, Reddy, Parker, Hoosain, Naidoo, Hongoro, Mchiza, Steyn, Dwane, Makoae, Maluleke, Ramlagan, Zungu, Evans, Jacobs, Faber & Sanhanes-1 Team 2013; Zhou, Lurie, Bärnighausen, McGarvey, Newell & Tanser 2012; Smuts, Faber, Schoeman, Laubscher, Oelofse, Benadé & Dhansay 2008; Jinabhai, Taylor & Sullivan 2003; Labadarios, Steyn, Maunder, Macintyre, Swart, Gericke, Huskisson, Dannhauser, Vorster & Nesamvuni 2000]. The major contributing factors to malnutrition are poverty, food and nutrition insecurity as well as the shift from traditional diets to more westernised diets (Bain, Awah, Geraldine, Kindong, Sigal, Bernard & Tanjeko 2013; Van der Hoeven, Osei, Greeff, Kruger, Faber & Smuts 2013; Kimani-Murage, Kahn, Pettifor, Tollman, Dunger, Gómez-Olivé & Norris 2010; Chopra, Daviaud, Pattinson, Fonn & Lawn 2009; Manary & Sandige 2008; Smuts, Faber, Schoeman, Laubscher, Oelofse, Benadé & Dhansay 2008). The general hypothesis of this study was that the challenge of malnutrition among economically disadvantaged communities in SA, particularly rural population groups such as the rural communities of KwaZulu-Natal (KZN) province, could be addressed through a food-based approach that promotes the utilisation of affordable and locally adaptive, nutrient-rich crops. It was proposed that bambara groundnut, provitamin A (PVA)-biofortified maize and orange-fleshed sweet potato (OFSP) have the potential to be used in a food-based approach. To test the hypothesis, the following investigations were conducted.

(1) The nutritional value of the OFSP and composite dishes containing either bambara groundnut or PVA-biofortified maize was determined;

(2) Consumer acceptance of the OFSP and composite dishes containing either bambara groundnut or PVA-biofortified maize was assessed.

This study was conducted in two phases. The objective of phase 1 of the study was to assess, by a survey, the nutritional status using selected anthropometric indices and dietary intake methods of four rural communities in KZN, SA. No published nutritional studies have been conducted at the sites selected for this study and there was no baseline nutritional data available on the target population. Therefore, it was necessary to determine the nutritional status and dietary patterns of these communities so that appropriate food-based nutrition approaches to address malnutrition could be investigated.

The survey results showed both under- and over-nutrition were prevalent among children in the rural communities investigated. Stunting and obesity were prevalent in children under five years. Furthermore, the prevalence of obesity was high in African female adults, especially females aged 16-35 years. The results for malnutrition (both under- and over-nutrition) found in this study are consistent with other studies (nDoH *et al* 2017; Shisana *et al* 2013). Dietary intake plays an important role in determining nutritional status. The dietary intake patterns of the communities investigated indicated that the diets were low in diversity and therefore sub-optimal. The diets were high in carbohydrate and low in micronutrients and fibre. More than 50% of the sample of children and adults had inadequate vitamin A intake for all of the age groups of the study participants. From these results, it is clear that it was necessary to develop a food-based approach to address the malnutrition affecting these communities. Bambara groundnut and PVA-biofortified maize and OFSP were thought to have the potential for use in the food-based approach and therefore their potential was evaluated in the two investigations (objectives 1 and 2 of phase 2 of the overall study) described and their main findings are discussed below.

In the two investigations, PVA-biofortified composite dishes and the boiled OFSP (alone) were evaluated for their suitability as the food forms in which to incorporate PVA-biofortified maize and the OFSP in the diets of the target communities. Phase 1 of the overall study included a survey to establish food items that were commonly consumed with *phutu* so that they could be included in the investigations. The composite dishes that were selected for this study were *phutu* served with either curried cabbage, chicken or bambara groundnut. Bambara groundnut was not consumed by the target population and was introduced in this study as a plant-based protein alternative and to promote the use of this underutilised crop. The novelty of this study lies in a food-based nutritional approach incorporating PVA-biofortified *phutu* served together with other commonly consumed food items and the development of a composite dish using bambara groundnut. It was established from the survey that the form in which sweet potato was commonly consumed, was just as a boiled tuber. Thus, the OFSP was included in the investigations in its boiled form.

Combining different food items with either PVA-biofortified maize or bambara groundnut to form modified traditional composite dishes could improve the nutritional composition of the composite dishes and was investigated. Similarly, due to genetic manipulation, the nutritional composition, including PVA content, of the OFSP is likely to be significantly superior to that of the traditional cream-fleshed sweet potato (CFSP). Thus, the first objective of phase 2 of the overall study was to determine the effect of replacing white maize and CFSP with PVA-biofortified maize and OFSP, respectively, on the nutritional composition of traditional and indigenous dishes of KZN communities.

The results of this study are encouraging, as they confirm that PVA-biofortified maize contains a much higher PVA carotenoid concentration compared to white maize (control), which was expected as this was similar to a previous study (Pillay, Siwela, Derera & Veldman 2014). Moreover, the study findings indicate that all three PVA-biofortified *phutu* composite dishes were nutritionally superior to the non-biofortified composite dishes. However, it appears that there is a paucity of information on the nutritional composition of composite dishes containing PVA-biofortified maize food products like *phutu*. Nevertheless, when either curried cabbage, chicken, or bambara groundnut were combined with PVA maize *phutu*, the PVA carotenoid concentration of the composite dishes was higher than that of the corresponding composite dishes containing white maize (controls). The PVA *phutu* and curried chicken composite dish not only contained a higher PVA carotenoid content, but an improved protein content in comparison to the white *phutu* and curried chicken composite dish.

As alluded to earlier, animal protein foods are expensive and unaffordable (NAMC 2019, Stats SA 2017; Argent, Leibbrandt & Woolard 2009), thus the PVA *phutu* and bambara groundnut composite dish could be a suitable, affordable protein alternative. The boiled OFSP had a nutritionally superior PVA carotenoid and fibre content compared to the CFSP. Therefore, the hypothesis that composite dishes made with PVA-biofortified maize and boiled OFSP would have a superior nutritional composition compared to composite foods made from white maize and CFSP, is accepted. Even though the study found that all three PVA-biofortified composite dishes contained a higher vitamin A content, these composite dishes did not meet the EAR for vitamin A for the 1-3 and 4-5 year age groups. However, the OFSP met more than three times the EAR for vitamin A for the 1-3 and 4-5 year age groups.

The findings of this study suggest that PVA-biofortified *phutu* composite dishes and OFSP could improve nutritional intake, thus contributing to reducing malnutrition including VAD and PEM. However, the proposed foods are new to the target population, particularly PVA-biofortified maize and OFSP. Furthermore, the communities selected for this study were not accustomed to bambara groundnut. Provitamin A-biofortified maize composite dishes and OFSP are being proposed for addressing VAD, but it is not known if they would be acceptable to the target community, therefore, this needed to be investigated.

The second objective in phase 2 of the study was to determine the effect of replacing white maize and CFSP with PVA-biofortified maize and OFSP, respectively, on the sensory properties and consumer acceptance of traditional and indigenous dishes of KZN, SA. The study findings indicated that the PVA-biofortified composite dishes investigated in this study were positively perceived by the majority of the study participants. There are no other published studies that compare the consumer acceptability of PVA-biofortified *phutu* served with either curried cabbage or bambara groundnut. Orange-fleshed sweet potato was as acceptable as CFSP, which was similar to other consumer acceptability studies (Pillay, Khanyile & Siwela 2018; Laurie, Faber, Calitz, Moelich, Muller & Labuschagne 2013; Tomlins, Owori, Bechoff, Menya & Westby 2012; Chowdhury, Meenakshi, Tomlins, Owori 2011; Tomlins, Ndunguru, Stambul, Joshua, Ngendello, Rwiza, Amour, Ramadhani, Kapande & Westby 2007). Therefore, the study hypothesis that the consumer acceptance of composite foods made with PVA-biofortified maize and boiled OFSP would be low due to the unacceptable sensory properties exhibited by PVA-biofortified foods, is rejected. It appears that PVA-biofortified *phutu* combined with curried chicken, cabbage or bambara groundnut and boiled OFSP have the potential to be used as a food-based nutrition approach to reduce micronutrient deficiencies such as VAD in the communities investigated. However, more studies should be conducted to improve the exposure to and acceptance of PVA-biofortified maize and bambara groundnut together, especially among the younger generation. Overall, it appears that PVA-biofortified maize, sweet potato, and bambara groundnut have the potential to improve the nutritional status of rural communities in KZN, SA. Specifically, the PVA-biofortified crops have the potential to improve vitamin A intake and reduce VAD, whilst underutilised crops such as bambara groundnut has the potential to improve the protein quality of the diet.

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CHAPTER 8

OVERALL CONCLUSIONS AND RECOMMENDATIONS

This chapter concludes the main findings of the study and makes recommendations. This study aimed to investigate the potential of provitamin A (PVA)-biofortified maize and sweet potato, and bambara groundnut for improving the nutritional status of rural communities in KwaZulu-Natal (KZN), South Africa (SA). The objectives were; (i) to assess the nutritional status using selected anthropometric indices and dietary intake methods of four rural communities in KZN, SA. Because this study involved a food-based approach to address nutrition problems, baseline nutritional data of the targeted community was required; (ii) To determine the effect of replacing white maize and CFSP with PVA-biofortified maize and OFSP, respectively, on the nutritional composition of traditional and indigenous dishes of KZN, SA and (iii) to determine the effect of replacing white maize and CFSP with PVA-biofortified maize and OFSP, respectively, on the sensory properties and consumer acceptance of traditional and indigenous dishes of KZN, SA. Provitamin A-biofortified maize composite dishes and OFSP is being proposed for addressing VAD, but it is not known if they would be acceptable to the target community, therefore, this needs to be investigated.

8.1 General conclusions

The current study found that under- and over-nutrition were prevalent in children under five years and obesity was prevalent in African female adults, especially those aged 16-35 years. The dietary patterns indicated that there was a low intake of several nutrients, including dietary fibre and several micronutrients including vitamin A, indicating that the diets consumed by the target population lacked dietary diversity. Phase 1 of the study emphasised the need for agricultural and nutritional approaches to help reduce the double burden of malnutrition in the study population. It is noteworthy that there were no published data on the nutritional status and dietary patterns of the target communities prior to this study. Provitamin A-biofortified composite dishes and OFSP were the proposed foods investigated in this study. The nutritional analysis conducted in phase 2 of the study indicated that all three PVA-biofortified *phutu* composite dishes were nutritionally superior to the non-biofortified composite dishes. The PVA carotenoid concentration of the composite dishes was higher than that of the corresponding composite dishes containing white maize (controls). The boiled OFSP had a nutritionally superior PVA carotenoid and fibre content than CFSP. Notably, this was the first study to investigate improving the nutritional value of popular traditional composite dishes of defined, food and nutrition insecure communities by either replacing white maize with PVA-biofortified maize or including bambara groundnut in the composite dishes. The nutritional analysis of the innovative composite dishes indicated that they were nutritionally superior and could therefore be used as a food-based approach to address malnutrition in the target communities. However, before the current study, the consumer acceptability of the innovative composite dishes, especially containing bambara groundnut was not known. Furthermore, consumer acceptability of OFSP had not been investigated in the targeted study population. The sensory evaluation and FGD results found in phase 2 of the study are encouraging as it revealed that PVA-biofortified composite dishes investigated in this study were positively perceived by the majority of the study participants. Thus, the study was the first to report on the consumer acceptance of specific nutritive composite dishes processed by modifying the popular and traditional dishes of target communities affected by malnutrition. Furthermore, OFSP was as acceptable as CFSP to the target communities. Overall, it appears that PVA-biofortified maize and OFSP can replace or partially replace white maize and CFSP, respectively, in selected traditional dishes of the rural communities studied, to improve nutritional status. The PVA-biofortified crops have the potential to reduce VAD, whilst including underutilised crops such as bambara groundnut has the potential to improve the protein quality of the diet.

8.2 Study limitations

- Dietary intake was only recorded and assessed over two non-consecutive days. If done for a longer period, it could give a better pattern of the foods consumed by individuals living in a specific area.
- Seasonal data was not collected. Food patterns change depending on what is available during different times of the year. Collecting dietary intake during all seasons would ensure that the consumption patterns are collected for a long period, taking into consideration environmental and climate changes. This would assist in better determining the nutritional status of a specific community.
- This study only made use of one variety of PVA-biofortified maize to prepare the composite dishes and it was only prepared as *phutu*. One serving of either of the three PVA-biofortified *phutu* composite dishes did not meet the EAR for vitamin A in the 1-5 year age group. If different varieties of PVA-biofortified maize containing a higher PVA carotenoid content was used, the EAR for vitamin A could have been met. Furthermore, there would be a better chance of meeting the EAR for vitamin A if larger portions of

cooked PVA-biofortified maize combined with other food items were used in the day. For example, serving a PVA maize soft porridge for breakfast, PVA-biofortified *phutu* or pap with other food items for lunch and supper.

- The study only investigated maize cooked into *phutu*. However, in KZN, stiff pap (porridge made from cooked maize meal) is also commonly consumed.
- This study only investigated the nutritional composition and sensory acceptability of OFSP. It did not investigate the nutritional composition and sensory acceptability when served together with other commonly consumed food items. The OFSP used in this study had a high PVA carotenoid, fibre and iron concentration and was well accepted by participants. It would be beneficial to combine OFSP with other commonly consumed traditional food items to enhance the nutritional composition.
- The sensory evaluation component of the study was not conducted on children as caregivers are responsible for deciding which foods should be given to their children and for preparing them. Food choice is usually governed by traditions, experience, age, financial situation and preference. However, the exclusion of children in this study can be seen as a study limitation as children should also be involved in sensory evaluation studies, using an age-appropriate sensory evaluation test. Their preference could influence their caregiver's decision to utilise the foods investigated. If a child likes a food item that is known to exhibit a health benefit, this would increase the chances of the caregiver giving it to their child. This should be explored in future studies.
- The individuals residing in the study sites investigated did not consume bambara groundnut. Although this was known to the researcher, bambara groundnut should have been included in the FFQ. Even though it was not commonly consumed, it is possible that a small percentage of the target population may have used it and may have had indigenous recipes to prepare bambara groundnut.
- The effect of the shelf life of bambara groundnut on its nutritional content was not determined. Older stock could affect cooking time and the nutritional content of cooked bambara groundnut.

8.3 Implications of findings and recommendations

- Similar studies should be conducted in other provinces to identify traditional recipes using maize. Geographical location plays a major role in the way foods are processed and utilised. By conducting a study of this nature, one would be able to improve the nutritional content of traditional meals by substituting/partially substituting non-biofortified food items for PVA-biofortified food items in traditional recipes for a particular province.

- There is a need to further investigate the sensory acceptability of combining other cooked PVA-biofortified maize foods such as stiff pap, mealie meal porridge, *amaheu, isigwaqane* or *isijingi*, with other commonly consumed foods in KZN, and other provinces in SA.
- More education needs to be conducted on the nutritional benefits of PVA-biofortified crops and bambara groundnut, especially for the younger generation as many of the younger generation are not familiar with these crops. Future studies could investigate the impact of nutrition education on food choices and whether it influences an individual's perception of the food item investigated.
- PVA-biofortified crops (maize and sweet potato) and bambara groundnut should be promoted to local farmers as these farmers are involved in subsistence farming. Local farmers should be educated on the production of these crops and possibly given or sold seeds at a reduced cost. This could result in an increased production of these crops by farmers, which could lead to improved consumption.
- The government could consider starting food garden initiative programmes in rural areas with the main focus being mothers and children. Mothers from the community could be a part of this programme, where they are taught how to plant biofortified crops such as PVA-biofortified maize and sweet potato and educated on how to prepare these crops so that their children receive optimal nutrition.
- It is recommended that PVA-biofortified foods and OFSP should be made available for purchase in local shops or supermarkets. This would increase exposure and accessibility. Study participants expressed a willingness to use biofortified foods if it was available to them. However, more studies need to be conducted to determine if there will be a sustainable production in SA to meet the demands of the communities. Currently, biofortified foods are produced for experimental purposes and not for sale. Further studies should also explore the cost implications of these products, specifically for SA.
- Only a few stores sell OFSP and bambara groundnut. More shops especially the local shops should be encouraged to sell these crops. Not only would it be more widely available but would be sold at a more affordable price. When a few stores sell a food item it tends to be a speciality item and can be costly. However, if it is sold by other smaller shops these items can be more affordable.

APPENDIX A: ETHICS APPROVAL FROM THE HUMANITIES AND SOCIAL SCIENCE ETHICS COMMITTEE, UNIVERSITY OF KWAZULU-NATAL

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

2 June 2016

Ms Laurencia Govender 206511208
School of Agricultural, Earth and Environmental Sciences
Pietermaritzburg Campus

Dear Ms Govender

Protocol reference number: HSS/0256/016D
Project Title: Impact of combining provitamin A-biofortified maize with pumpkin and orange sweet potato on consumer acceptance and nutritional value of selected traditional maize based foods consumer in KwaZulu-Natal, South Africa

Full Approval – Expedited Application

In response to your application received 14 March 2016, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL**.

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

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

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

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

Yours faithfully

[redacted]

....

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

/pm

Cc Supervisor: Dr K Pillay & Dr M Siwela
Cc. Academic Leader: Professor Onisimo Mutanga
Cc School Administrator: Ms Marsha Manjoo

Humanities & Social Sciences Research Ethics Committee
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APPENDIX B: LETTER OF APPROVAL TO CONDUCT RESEARCH AT SWAYIMANE

UKZN Ethics Committee

Pietermaritzburg Campus

RE: Permission to enter Ward 8 of Swayimani and conduct a research study

This letter serves to confirm that I Mrs Ndlovu in my capacity as councillor for Ward 8 of Swayimani do hereby consent to giving permission to Ms Laurencia Govender (206511208) to come and conduct a research study within Ward 8 of Swayimani. The purpose of the research study has been explained to myself in detail as follows:

1. To assess the dietary intake and eating patterns of the Swayimani community.
2. To identify methods of preparing and processing maize, pumpkin and orange sweet potato into food products.
3. To identify recipes that combine maize, pumpkin and orange sweet potato.
4. To determine the effect of replacing white maize with provitamin A-biofortified maize on consumer perceptions and sensory properties of the food products.
5. To identify sources of water used for crop production and food processing preparation.

This permission does not, however, oblige households to participate. Individual informed consent should still be obtained from individual households for the surveys.

Regards,

Community Swayimane
Name: Mrs Ndlovu
Title of Authorized Official: Councillor
Date: 4/02/2016
Signature of community representative

Authorized Official: [redacted]

Certification by UKZN
Print Name: TAFADZWANASHE MABHAUDHI
Print Title of Authorized Official: RESEARCH FELLOW
Date: 4/02/2016
Signature of UKZN representative

Authorized Official: [redacted]

APPENDIX C: LETTER OF APPROVAL TO CONDUCT RESEARCH AT TUGELA FERRY

UKZN Ethics Committee

Pietermaritzburg Campus

RE: Permission to enter Tugela Ferry and conduct a research study

This letter serves to confirm that I Busisiwe Zulu in my capacity as gate keeper of Tugela Ferry do hereby consent to giving permission to Ms Laurencia Govender (206511208) to come and conduct a research study within Tugela Ferry. The purpose of the research study has been explained to myself in detail as follows:

1. To assess the dietary intake and eating patterns of the Tugela Ferry community.
2. To identify methods of preparing and processing maize and orange sweet potato into food products.
3. To identify recipes that combine maize and orange sweet potato.
4. To determine the effect of replacing white maize with provitamin A-biofortified maize on consumer perceptions and sensory properties of the food products.
5. To identify sources of water used for crop production and food processing preparation.

This permission does not, however, oblige households to participate. Individual informed consent should still be obtained from individual households for the surveys.

Regards,

Community Tugela Ferry
Name: Busisiwe Zulu
Title of Authorized Official: DEPUTY CHAIR
Date: 08/02/2016
Signature of community representative

Authorized Official: [redacted]

Certification by UKZN
Print Name: Laurencia Govender
Print Title of Authorized Official: PHD candidate
Date: 08/02/2016
Signature of UKZN representative

Authorized Official: [redacted]

APPENDIX D: LETTER OF APPROVAL TO CONDUCT RESEARCH AT UMBUMBULU

UKZN Ethics Committee

Pietermaritzburg Campus

RE: Permission to enter Umbumbulu and conduct a research study

This letter serves to confirm that I N. P. WHNAH in my capacity as INDUNA of Umbumbulu do hereby consent to giving permission to Ms Laurencia Govender (206511208) to come and conduct a research study within Umbumbulu. The purpose of the research study has been explained to myself in detail as follows:

1. To assess the dietary intake and eating patterns of the Umbumbulu community.
2. To identify methods of preparing and processing maize, pumpkin and orange sweet potato into food products.
3. To identify recipes that combine maize, pumpkin and orange sweet potato.
4. To determine the effect of replacing white maize with provitamin A-biofortified maize on consumer perceptions and sensory properties of the food products.
5. To identify sources of water used for crop production and food processing preparation.

This permission does not, however, oblige households to participate. Individual informed consent should still be obtained from individual households for the surveys.

Regards,

Community Umbumbulu
Name:
Title of Authorized Official:
Date:
Signature of community representative

Authorized Official: [redacted]

Certification by UKZN
Print Name: TAFADZWA MABHAUDHI
Print Title of Authorized Official: RESEARCHER
Date: 02/03/2016
Signature of UKZN representative

Authorized Official: [redacted]

APPENDIX E: LETTER OF APPROVAL TO CONDUCT RESEARCH AT FOUNTAIN HILL ESTATE

UKZN Ethics Committee

Pietermaritzburg Campus

Fountain Hill Estate

RE: Permission to enter ~~Ward 8 of Swayimani~~ and conduct a research study [redacted]

This letter serves to confirm that I Edwin Harold Geevers in my capacity as General Manager of Fountain Hill Estate do hereby consent to giving permission to Ms Laurencia Govender (206511208) to come and conduct a research study within Fountain Hill Estate. The purpose of the research study has been explained to myself in detail as follows:

1. To assess the dietary intake and eating patterns of the ~~Swayimani~~ Fountain Hill Estate community. [redacted]
2. To identify methods of preparing and processing maize, pumpkin and orange sweet potato into food products.
3. To identify recipes that combine maize, pumpkin and orange sweet potato.
4. To determine the effect of replacing white maize with provitamin A-biofortified maize on consumer perceptions and sensory properties of the food products.
5. To identify sources of water used for crop production and food processing preparation.

This permission does not, however, oblige households to participate. Individual informed consent should still be obtained from individual households for the surveys.

Regards,

Community: Fountain Hill Estate
Name: Edwin Harold Geevers
Title of Authorized Official:
Date: 10/02/16
Signature of community representative

Authorized Official: [redacted]

Certification by UKZN
Print Name: Laurencia Govender
Print Title of Authorized Official:
Date: 10/02/16
Signature of UKZN representative

Authorized Official: [redacted]

APPENDIX F: PARTICIPANT CONSENT FORM IN ENGLISH FOR INTERVIEWS

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

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

Dear Participant

INFORMED CONSENT LETTER

My name is Laurencia Govender. I am a PhD (Dietetics) student registered at the University of KwaZulu-Natal, Pietermaritzburg campus.
The aim of my research is to investigate the impact of combining provitamin A-biofortified maize with pumpkin and orange-fleshed sweet potato on consumer acceptance and nutritional value of selected traditional maize-based foods consumed in KwaZulu-Natal, South Africa.
Participants will be required to answer a few questions on food production and processing of foods using certain food items (maize, pumpkin and orange sweet potato).

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.
- 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
Audio equipment		
Photographic equipment		
Video equipment		

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

I can be contacted at:
Email: govender.laurencia@gmail.com
Phone number: 033 395 4993.

My supervisor is Dr Kirthee Pillay who is located at Dietetics and Human Nutrition in the School of Agricultural, Earth and Environmental Sciences, Pietermaritzburg campus of the University of KwaZulu-Natal.
Contact details: email: pillayk@ukzn.ac.za Phone number: 033 260 5674.

My Co-supervisor is Dr Muthulisi Siwela who is located at Dietetics and Human Nutrition in the School of Agricultural, Earth and Environmental Sciences, Pietermaritzburg campus of the University of KwaZulu-Natal
Contact details: email: siwelam@ukzn.ac.za Phone number: 033 260 5459.

You may also contact the Research Office through:
P. Mohun
HSSREC Research Office,
Contact details: email: mohunp@ukzn.ac.za Phone number: 031 260 4557.

Thank you for your contribution to this research.

UNIVERSITY OF KWAZULU-NATAL™
INYUVESI YAKWAZULU-NATALI

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**

………………………………………… ……………………………………

School of Agricultural, Earth and Environmental Sciences
iSikole seSayensi yeZolimo, eZomhlaba kanye Nemvelo
Postal Address: University of KwaZulu-Natal, Pietermaritzburg Campus, Life Sciences Campus, Carbis Road, Scottsville, 3209, South Africa
Telephone: +27 (0)33 260 5515 **Facsimile:** +27 (0)33 261 6094 **Email:** saees@ukzn.ac.za **Website:** www.ukzn.ac.za

APPENDIX G: PARTICIPANT CONSENT FORM IN ISIZULU FOR INTERVIEWS

UNIVERSITY OF KWAZULU-NATAL™
INYUVESI YAKWAZULU-NATALI

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

Kozibandakanyayo

INCWADI YESIVUMELWANO

Igama lami ngingu Laurencia Govender. Ngingumfundi owenza iziqu zobudokotela ezifundweni ezimayelana nokudla (PhD Dietetics) eNyuvesi yaKwaZulu-Natal, eMgungundlovu.
Inhlosongqangi yalolu cwaningo ukubheka umthelela wokuhlanganisa umbila onezinga eliphezulu lika vitamin A (provitamin A–biofortified maize) nethanga nobhatata o–olintshi ngebala kumsoco nasekwamukeleni kwezidlo zasemakhaya ezikhethiwe ezihambisana nombila ezidliwa KwaZulu Natal, eNingizimu Afrika.
Abavuma ukuzibandakanya bacelwa ukuba baphendule imibuzo embalwa emayelana nokukhiqiza ukudla kanye nokulungisa izidlo usebenziza izitshalo ezikhetiwe (okuwu mbila, amathanga, kanye no bhatata o–olintshi ngebala).

Okulandelayo kubalulekile ukuthi ukwazi:

- Imininingwane yakho izogcinwa iyimfihlo, nolwazi olunikezayo aluzobekwa njengolwakho siqu sakho kepha njengelungu lomphakathi noma iqoqo elizibandakanya kucwaningo.
- Noma yiluphi ulwazi olunikezayo ngeke lusetshenziswe ukwenza okubi kuwe, kepha luzosetshenziselwa izinhloso zalolu cwaningo kuphela.
- Akukho ukuphatheka kabi noma ingozi yokulimala ezohambisana nabavuma ukuzibandakanya nalolu cwaningo.
- Ulwazi esiluthatha lapha luzogcinwa endaweni ephephile, bese luyasulwa emva kweminyaka emihlanu.
- Unelungelo lokukhetha ukuzibandakanya, elokungavumi ukuzibandakanya, nelokuma ukuzibandakanya noma usuqalile ukuzibandakanya. Akukho okubi okuzokwehlela ngenxa yanoma yisiphi isinqumo osithathayo kulezi ezibekiwe.
- Inhloso yokuzibandakanya kwakho eyocwaningo nemfundo kuphela, akukho nzuzo yezezimali ebhekekile.
- Uma uvuma ukuzibandakanya, sicela ukhombise ngokubeka umaka ebhokisini elifanele ukuthi ungathanda yini ilekhodwe inkulumo yakho kusenziswe izinto ezishiwo ngezansi.

	Ngingathanda	Kangithandi
Amazwi engxoxo		
Izithombe		
Umbukiso (ividiyo)		

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

Ngiyatholakala kulemi niningwane elandelyo:
Email: govender.laurencia@gmail.com
Inombolo yocingo: 033 395 4993.

Ongiphethe ngokocwaningo ngu Dokotela Kirthee Pillay, yena otholakala e Dietetics and Human Nutrition in the School of Agricultural, Earth and Environmental Sciences, eNyuvesi yaKwaZulu Natal, eMgungundlovu.
Ungamuthinta kulemininingwane: email: pillayk@ukzn.ac.za Inombolo yocingo: 033 260 5674.

Iphini longiphethe ngokocwaningo ngu Dokotela Kirthee Pillay, yena otholakala e Dietetics and Human Nutrition in the School of Agricultural, Earth and Environmental Sciences, eNyuvesi yaKwaZulu Natal, eMgungundlovu.
Ungamuthinta kulemininingwane: email: siwelam@ukzn.ac.za Inombolo yocingo: 033 260 5459.

Ungathintana futhi nehhovisi locwanigo (Research Office) ngokuthinta u:
P. Mohun
HSSREC Research Office,
Ungamuthinta kulemininingwane: email: mohunp@ukzn.ac.za Inombolo yocingo: 031 260 4557.

Siyabonga ngokunikezela kulolu cwaningo.

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

UKUVUMA

Mina…………………………………………………………………………… (amagama aphelele alowo ozibandakanyayo) ngiyavuma ukuthi ngiyaqonda okubhalwe kulomqulu nendlela lolucwaningo oluzokwenziwa ngayo. Ngiyavuma ukuzibandakanya kulolu cwaningo.

Ngiyaqonda ukuthi ngingakhetha noma yinini ukuma ukuzibandakanya kulolu cwaningo uma kwenzeka ngiba nesifiso.

AKUSAYINE OZIBANDAKANYAYO	**USUKU**
………………………………………	……………………………………

School of Agricultural, Earth and Environmental Sciences
iSikole seSayensi yeZolimo, eZomhlaba kanye Nemvelo
Postal Address: University of KwaZulu-Natal, Pietermaritzburg Campus, Life Sciences Campus, Carbis Road, Scottsville, 3209, South Africa
Telephone: +27 (0)33 260 5515 **Facsimile:** +27 (0)33 261 6094 **Email:** saees@ukzn.ac.za **Website:** www.ukzn.ac.za

APPENDIX H: PARTICIPANT CONSENT FORM IN ENGLISH FOR THE SENSORY EVALUATION AND FOCUS GROUP DISCUSSIONS

UNIVERSITY OF KWAZULU-NATAL™
INYUVESI YAKWAZULU-NATALI

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

Dear Participant

INFORMED CONSENT LETTER

My name is Laurencia Govender. I am a PhD (Dietetics) student registered at the University of KwaZulu-Natal, Pietermaritzburg campus.
The aim of my research is to investigate the impact of provitamin A-biofortified maize and orange sweet potato on consumer acceptance and nutritional value of selected traditional maize based foods consumed in KwaZulu-Natal, South Africa.
Participants will be required to taste samples of food items made with provitamin A-biofortified maize and orange sweet potato and rate the samples using a simple picture scale and a paired preference test. After the sensory evaluation, participants will be required to participate in a focus group discussion.

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.
- 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
Audio equipment		
Photographic equipment		
Video equipment		

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

I can be contacted at:
Email: govender.laurencia@gmail.com
Phone number: 033 395 4993.

My supervisor is Dr Kirthee Pillay who is located at Dietetics and Human Nutrition in the School of Agricultural, Earth and Environmental Sciences, Pietermaritzburg campus of the University of KwaZulu-Natal.
Contact details: email: pillayk@ukzn.ac.za Phone number: 033 260 5674.

My Co-supervisor is Dr Muthulisi Siwela who is located at Dietetics and Human Nutrition in the School of Agricultural, Earth and Environmental Sciences, Pietermaritzburg campus of the University of KwaZulu-Natal
Contact details: email: siwelam@ukzn.ac.za Phone number: 033 260 5459.

You may also contact the Research Office through:
P. Mohun
HSSREC Research Office,
Contact details: email: mohunp@ukzn.ac.za Phone number: 031 260 4557.

Thank you for your contribution to this research.

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

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

……………………………………… ……………………………………

School of Agricultural, Earth and Environmental Sciences
iSikole seSayensi yeZolimo, eZomhlaba kanye Nemvelo
Postal Address: University of KwaZulu-Natal, Pietermaritzburg Campus, Life Sciences Campus, Carbis Road, Scottsville, 3209, South Africa
Telephone: +27 (0)33 260 5515 **Facsimile:** +27 (0)33 261 6094 **Email:** saees@ukzn.ac.za **Website:** www.ukzn.ac.za

APPENDIX I: PARTICIPANT CONSENT FORM IN ISIZULU FOR THE SENSORY EVALUATION AND FOCUS GROUP DISCUSSIONS

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

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

Kozibandakanyayo

INCWADI YESIVUMELWANO

Igama lami ngingu Laurencia Govender. Ngingumfundi owenza iziqu zobudokotela ezifundweni ezimayelana nokudla (PhD Dietetics) eNyuvesi yaKwaZulu-Natal, eMgungundlovu.
Inhlosongqangi yalolu cwaningo ukubheka umthelela wokuhlanganisa umbila onezinga eliphezulu lika vitamin A (provitamin A–biofortified maize) nobhatata o–olintshi ngebala kumsoco nasekwamukeleni kwezidlo zasemakhaya ezikhethiwe ezihambisana nombila ezidliwa KwaZulu Natal, eNingizimu Afrika.
Abazibandakanyayo bazocelwa ukuba bezwe bese behlola ama sampula ezidlo ezikhethekile ezenziwe ngombila onezinga eliphezulu lika vitamin A (provitamin A-biofortified maize) ezihlanganiswe nobhatata o–olintshi ngebala besebenzise isikali sezithombe esinikeziwe.

Okulandelayo kubalulekile ukuthi ukwazi:

- Imininingwane yakho izogcinwa iyimfihlo, nolwazi olunikezayo aluzobekwa njengolwakho siqu sakho kepha njengelungu lomphakathi noma iqoqo elizibandakanya kucwaningo.
- Noma yiluphi ulwazi olunikezayo ngeke lusetshenziswe ukwenza okubi kuwe, kepha luzosetshenziselwa izinhloso zalolu cwaningo kuphela.
- Akukho ukuphatheka kabi noma ingozi yokulimala ezohambisana nabavuma ukuzibandakanya nalolu cwaningo.
- Ulwazi esiluthatha lapha luzogcinwa endaweni ephephile, bese luyasulwa emva kweminyaka emihlanu.
- Unelungelo lokukhetha ukuzibandakanya, elokungavumi ukuzibandakanya, nelokuma ukuzibandakanya noma usuqalile ukuzibandakanya. Akukho okubi okuzokwehlela ngenxa yanoma yisiphi isinqumo osithathayo kulezi ezibekiwe.
- Inhloso yokuzibandakanya kwakho eyocwaningo nemfundo kuphela, akukho nzuzo yezezimali ebhekekile.
- Uma uvuma ukuzibandakanya, sicela ukhombise ngokubeka umaka ebhokisini elifanele ukuthi ungathanda yini ilekhodwe inkulumo yakho kusenziswe izinto ezishiwo ngezansi.

	Ngingathanda	Kangithandi
Amazwi engxoxo		
Izithombe		
Umbukiso (ividiyo)		

School of Agricultural, Earth and Environmental Sciences
iSikole seSayensi yeZolimo, eZomhlaba kanye Nemvelo
Postal Address: University of KwaZulu-Natal, Pietermaritzburg Campus, Life Sciences Campus, Carbis Road, Scottsville, 3209, South Africa
Telephone: +27 (0)33 260 5515 **Facsimile:** +27 (0)33 261 6094 **Email:** saees@ukzn.ac.za **Website:** www.ukzn.ac.za

UNIVERSITY OF KWAZULU-NATAL™
INYUVESI YAKWAZULU-NATALI

Ngiyatholakala kulemi niningwane elandelyo:
Email: govender.laurencia@gmail.com
Inombolo yocingo: 033 395 4993.

Ongiphethe ngokocwaningo ngu Dokotela Kirthee Pillay, yena otholakala e Dietetics and Human Nutrition in the School of Agricultural, Earth and Environmental Sciences, eNyuvesi yaKwaZulu Natal, eMgungundlovu.
Ungamuthinta kulemininingwane: email: pillayk@ukzn.ac.za Inombolo yocingo: 033 260 5674.

Iphini longiphethe ngokocwaningo ngu Dokotela Kirthee Pillay, yena otholakala e Dietetics and Human Nutrition in the School of Agricultural, Earth and Environmental Sciences, eNyuvesi yaKwaZulu Natal, eMgungundlovu.
Ungamuthinta kulemininingwane: email: siwelam@ukzn.ac.za Inombolo yocingo: 033 260 5459.

Ungathintana futhi nehhovisi locwanigo (Research Office) ngokuthinta u:
P. Mohun
HSSREC Research Office,
Ungamuthinta kulemininingwane: email: mohunp@ukzn.ac.za Inombolo yocingo: 031 260 4557.

Siyabonga ngokunikezela kulolu cwaningo.

UKUVUMA

Mina.. (amagama aphelele alowo ozibandakanyayo) ngiyavuma ukuthi ngiyaqonda okubhalwe kulomqulu nendlela lolucwaningo oluzokwenziwa ngayo. Ngiyavuma ukuzibandakanya kulolu cwaningo.

Ngiyaqonda ukuthi ngingakhetha noma yinini ukuma ukuzibandakanya kulolu cwaningo uma kwenzeka ngiba nesifiso.

AKUSAYINE OZIBANDAKANYAYO	**USUKU**
....	....

APPENDIX J: TRAINING MANUAL

Assessment of the nutritional status of three communities in rural KwaZulu-Natal

A training manual for field workers

Laurencia Govender 2016

Contents **Page Number**

Appendices

1. Introduction

The aim of this field data collection is to determine the nutritional status of the members of each community. This process involves:

- Obtaining anthropometric data
- Conducting a 24 hour recall
- Conducting a food frequency questionnaire
- Asking a few structured questions

It is very important that you understand that confidentiality and honesty are two important components needed to be a field worker. If the people we are trying to obtain information from do not trust us, we will not be able to obtain information from them. If we do not get accurate information the researcher will be unable to get an accurate assessment of the nutritional status in that community.

Every participant is required to fill in a consent form before participating in the study. No one should be forced to participate and the participant can chose to exit the study at any time. The consent form for this study is attached as Appendix 1 and Appendix 2.

2. Anthropometry

Anthropometry involves obtaining body measurements from an individual. It will require you to use different types of equipment. Different measurements will be taken in adults and children. All measurements will be taken in triplicate.

2.1 Children

2.1.1 Weight

The weight of a child will be measured using a digital scale and the weight will be recorded in kilograms. A digital scale will be used so that a more accurate reading can be obtained. For this study a baby scale will not be available. The following steps will be taken to weigh the child:

- Make sure that the scale shows zero when it is turned on.
- All clothes including napkins/diapers should be removed in infants under two years of age who are unable to stand.
- In older children, excess clothing such as jackets, shoes and additional shorts should be removed.
- All pockets should be emptied.

- Children who can stand should be asked to step on the scale and the reading will be taken to the nearest 100g.
- For children who cannot stand do the following: The mother will stand on the scale first and the weight recorded, thereafter she will carry the child and that weight will be recorded. The weight of the mother alone will be subtracted from the weight of the mother and child to give the weight of the child.

2.1.2 Height

The height of a child will be measured using a height stick. When measuring height the following method should be followed:

- All hair ornaments should be removed.
- The child should not have shoes on.
- If the child is unable to stand the child should put placed in a lying down position. Get the caregiver to hold the child's head in position. The head should be in a straight position and the legs should be straight. If the legs are not straight, push down on the knees gently. The height should be taken at the soles of the feet.
- Height should be read to the neatest 0.1m.
- Older children will be required to stand in an upright position. Head faced forward. Heels and buttocks against the wall. If the child is unable to understand commands the field worker will push gently on the child's tummy before taking the reading. If the child can understand commands then the child will take a deep breath in whilst the reading is taken. Figure 1 below indicates the correct way to obtain a height measurement in a child.

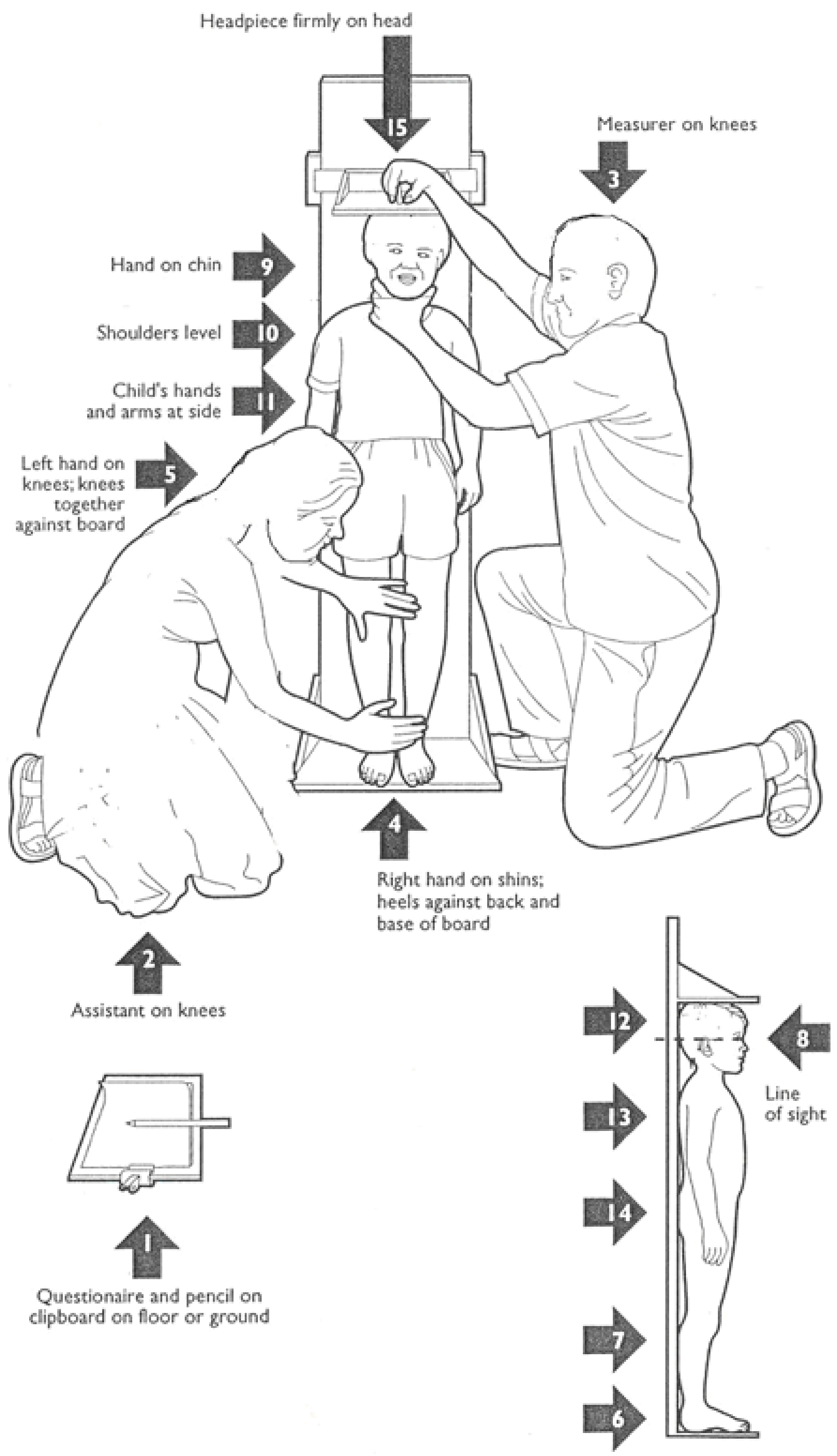

Figure 1: Measuring height in a child

2.1.3 MUAC

This is a measurement that measures the circumference of the mid upper arm. Always use the left hand when taking this measurement. The process is as follows:

- The child's left arm should be at a 90 degree angle.
- Using the tape measure, measure the length from the tip of the shoulder to the tip of the elbow. Divided the measurement by two and make this point on the arm using a pencil.
- Place the tape measure around this mark on the arm and read the measurement.
- Ensure that you do not keep the tape measure too loose or too tight around the arm as you will get an incorrect reading.

Figure 2 indicates the proper technique used to measure the MUAC

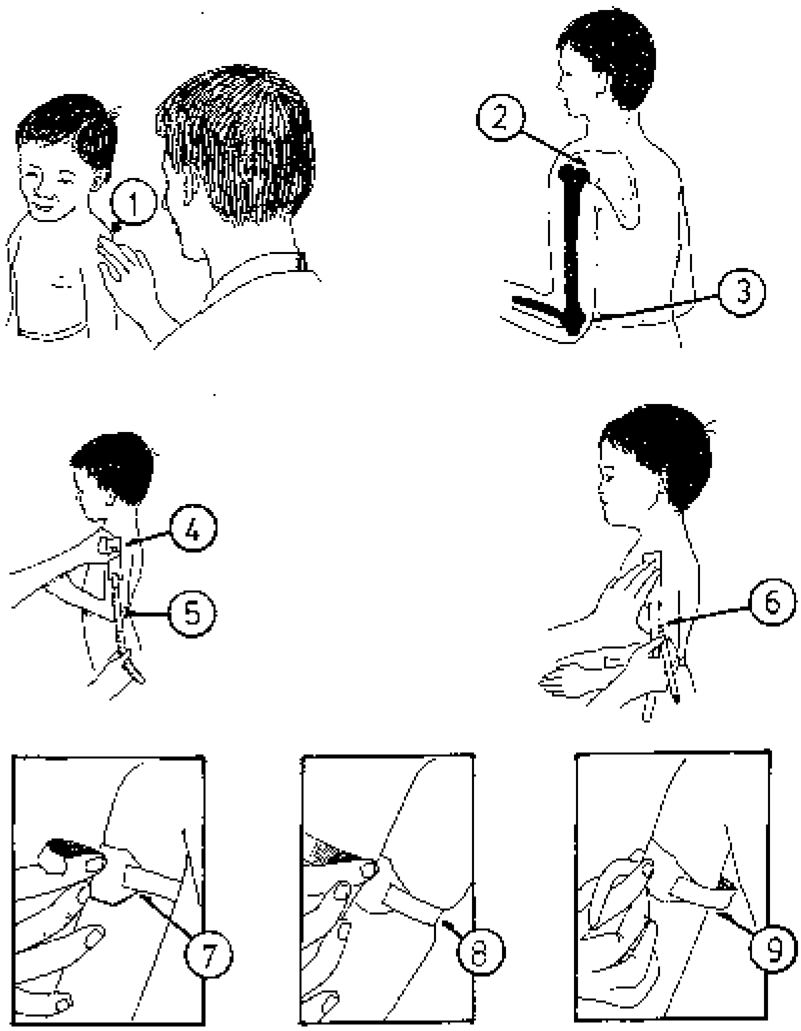

Figure 2: Correct technique used to obtain the MUAC in children

2.2 Adults

2.2.1 Weight

Weight is measured using a digital scale. The procedure followed is the same as for older children. Make sure all heavy objects are removed from the pockets. Shoes and excess clothing should be removed. The scale should be at zero and the weight should be taken to the nearest

100g. Figure 3 indicates the correct way to place an adult's feet on the scale to obtain an accurate weight measurement.

<u>Figure 3:</u> Correcting positioning of feet on the scale

2.2.2 Height

The height is measure using a height stick. This is done using the same procedure as used with the older children. All hair ornaments and shoes need to be removed. The adult will be required to stand in an upright position. Head faced forward. Heels and buttocks must be against the wall. The adult will be required to take a deep breath in whilst the measurement is taken. The measurement is taken to the nearest 0.1m. Figure 4 indicates both the incorrect and correct way to obtain a height measurement.

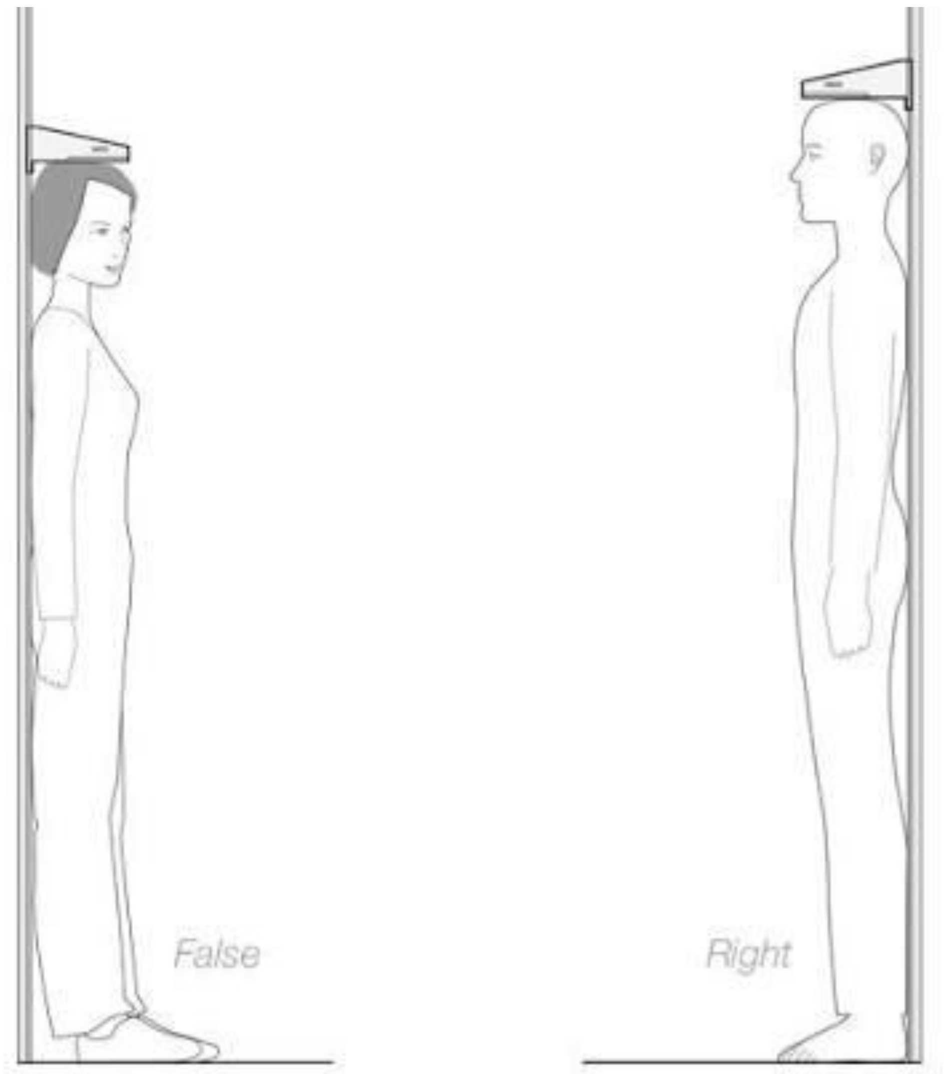

Figure 4: Incorrect and correct position for obtaining the height in adults

2.2.3 Waist and Hip

This measurement is taken using a measuring tape. You will be required to measure the waist and hip of the adult. A waist measurement can be difficult to take in an obese adult therefore one of two sites can be used for this measurement. For an obese adult the measurement is taken by placing the tape measure around the belly button. The tape should not be too tight or too loose.

The common site that is measured is the natural waist. The natural waist is situated midway between the tenth rib and the iliac crest. The tenth rib is located under the breastbone and the iliac crest can be found if you run your fingers down the sides of the rib cage until you reach the first hard spot. This is the hip bone. Place your hands on top with thumbs pointing behind you.

The hip measurement is taken over the widest point over the buttocks. To obtain a more accurate reading the adult is required to wear minimum clothing. Whilst taking the measurement it is important for the individual to be in an upright position and standing with both legs an equal distant apart. Figure 5 below indicates the waist and hip measurements that need to be taken in females and males.

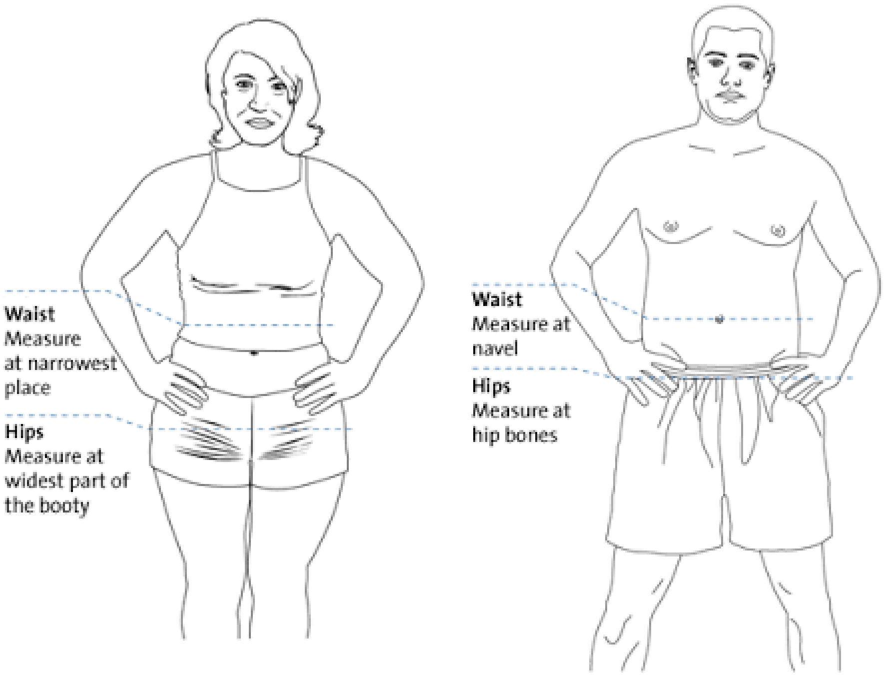

Figure 5: Waist and hip measurements

The data collection tool is attached as Appendix 3.

3. Conducting a 24 hour recall

This is done to determine what a person has eaten in the last 24 hours. You as a fieldworker will need to obtain this information from all people in the household above the age of one year. For children under four years of age, the primary caregiver will be interviewed. Children between the ages of 4-8 years of age will be interviewed together with their primary caregiver. The information obtained from this recall will include; portion sizes, preparation methods, ingredients used and a rough estimate of amounts eaten by each individual in that household.

The fieldworker needs to ask the individual the following questions:

1. When was your first meal of the day?
2. What time was it?
3. What did you eat? (full description)
4. Ask portion sizes?

5. Preparation methods (cooked, baked, fried)
6. Was anything added to the meal (e.g. margarine)
7. Did you have anything to drink?
8. If yes, how much?
9. Did you have a snack after breakfast? (repeat 2-7)
10. What was the next thing that you ate?

Continue with this method of questioning until you reach the last meal for the day

For this study the 24 hour recall will be conducted over two non-consecutive days and should be conducted by the same fieldworker. Tools that are available could be used to determine portion sizes such as; plates, side plates, bowls, measuring cups, measuring spoons, cups, mugs, glasses and rulers.

Before ending the 24 hour recall it is important to ask questions about and vitamin and mineral supplements that may be taken and record it. Record the name of the supplement and how many capsules/pills are taken.

All information collected for this section will be recorded on a data collection sheet (see Appendix 4)

4. <u>Conduct a food frequency</u>

This information helps to determine how often a particular food item is eaten. There is a list of foods in specific categories. You will be required to tick the following below to indicate the frequency of that particular item. If you find other items that are eaten on the 24 hour recall that are not on the list, please add it onto the space below and tick the appropriate frequency.

Example:

Foods and amounts	**Average use last year**								
	Never or less than once/month	**1-3 per month**	**Once a week**	**2-4 per week**	**5-6 per week**	**Once a day**	**2-3per day**	**4 -5 per day**	**6+ per day**
Cereals and Grains									
All bran flakes			✓						

See Appendix 5 for the fill list

5. Asking a few structured questions

The following questions need to be asked and the responses recorded on the blank sheet provided.

Survey Questions

1. Do you eat white maize at home? Yes No
   1.1. If yes, how often do you eat white maize?
   1.2. If no, why do you not eat white maize?
2. What do you eat together with the white maize
3. Can you list the dishes that you cook using white maize
4. Can you give me the recipe for each of the dishes?
   See attached pages
5. Do you grow your own maize at home?
   5.1. If yes;
      5.1.1. Why do you grow your own maize?
      5.1.2. Where do you purchase your seeds from?
      5.1.3. For what purpose do you use the home grown maize?
   5.2. If no;
      5.2.1 Why do you not grow your own maize?
      5.2.2 If purchased at a supermarket, which brand do you buy?
6. Have you ever used yellow maize at home?
   6.1. If yes;
      6.1.1 For what purpose did you use the yellow maize?
      6.1.2 If you do eat it what do you eat yellow maize with?
      6.1.3 Can you explain how you prepare the yellow maize?
   6.2. If no, why have you not used yellow maize?
7. Do you eat sweet potato?
   7.1. If yes;
      7.1.1 How often do you eat sweet potato?
      7.1.2 How do you prepare the sweet potato?
      7.1.3 Do you grow your own sweet potato?

7.2. If no, why do you not eat sweet potato?

<u>Appendix 1</u>: Informed consent English

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

Dear Participant

INFORMED CONSENT LETTER

My name is Laurencia Govender. I am a PhD (Dietetics) student registered at the University of KwaZulu-Natal, Pietermaritzburg campus.
The aim of my research is to investigate the impact of combining provitamin A-biofortified maize with pumpkin and orange-fleshed sweet potato on consumer acceptance and nutritional value of selected traditional maize-based foods consumed in KwaZulu-Natal, South Africa.
Participants will be required to answer a few questions on food production and processing of foods using certain food items (maize, pumpkin and orange sweet potato).

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.
- 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
Audio equipment		
Photographic equipment		
Video equipment		

I can be contacted at:
Email: govender.laurencia@gmail.com
Phone number: 033 395 4993.

My supervisor is Dr Kirthee Pillay who is located at Dietetics and Human Nutrition in the School of Agricultural, Earth and Environmental Sciences, Pietermaritzburg campus of the University of KwaZulu-Natal.
Contact details: email: pillayk@ukzn.ac.za Phone number: 033 260 5674.

My Co-supervisor is Dr Muthulisi Siwela who is located at Dietetics and Human Nutrition in the School of Agricultural, Earth and Environmental Sciences, Pietermaritzburg campus of the University of KwaZulu-Natal
Contact details: email: siwelam@ukzn.ac.za Phone number: 033 260 5459.

You may also contact the Research Office through:
P. Mohun
HSSREC Research Office,
Contact details: email: mohunp@ukzn.ac.za Phone number: 031 260 4557.

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

……………………………………… …………………………………

<u>Appendix 2</u>: Informed consent Zulu

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

Kozibandakanyayo

INCWADI YESIVUMELWANO

Igama lami ngingu Laurencia Govender. Ngingumfundi owenza iziqu zobudokotela ezifundweni ezimayelana nokudla (PhD Dietetics) eNyuvesi yaKwaZulu-Natal, eMgungundlovu.
Inhlosongqangi yalolu cwaningo ukubheka umthelela wokuhlanganisa umbila onezinga eliphezulu lika vitamin A (provitamin A–biofortified maize) nethanga nobhatata o–olintshi ngebala kumsoco nasekwamukeleni kwezidlo zasemakhaya ezikhethiwe ezihambisana nombila ezidliwa KwaZulu Natal, eNingizimu Afrika.
Abavuma ukuzibandakanya bacelwa ukuba baphendule imibuzo embalwa emayelana nokukhiqiza ukudla kanye nokulungisa izidlo usebenziza izitshalo ezikhetiwe (okuwu mbila, amathanga, kanye no bhatata o–olintshi ngebala).

Okulandelayo kubalulekile ukuthi ukwazi:

- Imininingwane yakho izogcinwa iyimfihlo, nolwazi olunikezayo aluzobekwa njengolwakho siqu sakho kepha njengelungu lomphakathi noma iqoqo elizibandakanya kucwaningo.
- Noma yiluphi ulwazi olunikezayo ngeke lusetshenziswe ukwenza okubi kuwe, kepha luzosetshenziselwa izinhloso zalolu cwaningo kuphela.
- Akukho ukuphatheka kabi noma ingozi yokulimala ezohambisana nabavuma ukuzibandakanya nalolu cwaningo.
- Ulwazi esiluthatha lapha luzogcinwa endaweni ephephile, bese luyasulwa emva kweminyaka emihlanu.
- Unelungelo lokukhetha ukuzibandakanya, elokungavumi ukuzibandakanya, nelokuma ukuzibandakanya noma usuqalile ukuzibandakanya. Akukho okubi okuzokwehlela ngenxa yanoma yisiphi isinqumo osithathayo kulezi ezibekiwe.
- Inhloso yokuzibandakanya kwakho eyocwaningo nemfundo kuphela, akukho nzuzo yezezimali ebhekekile.
- Uma uvuma ukuzibandakanya, sicela ukhombise ngokubeka umaka ebhokisini elifanele ukuthi ungathanda yini ilekhodwe inkulumo yakho kusenziswe izinto ezishiwo ngezansi.

	Ngingathanda	Kangithandi
Amazwi engxoxo		
Izithombe		
Umbukiso (ividiyo)		

Ngiyatholakala kulemi niningwane elandelyo:
Email: govender.laurencia@gmail.com
Inombolo yocingo: 033 395 4993.

Ongiphethe ngokocwaningo ngu Dokotela Kirthee Pillay, yena otholakala e Dietetics and Human Nutrition in the School of Agricultural, Earth and Environmental Sciences, eNyuvesi yaKwaZulu Natal, eMgungundlovu.
Ungamuthinta kulemininingwane: email: pillayk@ukzn.ac.za Inombolo yocingo: 033 260 5674.

Iphini longiphethe ngokocwaningo ngu Dokotela Kirthee Pillay, yena otholakala e Dietetics and Human Nutrition in the School of Agricultural, Earth and Environmental Sciences, eNyuvesi yaKwaZulu Natal, eMgungundlovu.
Ungamuthinta kulemininingwane: email: siwelam@ukzn.ac.za Inombolo yocingo: 033 260 5459.

Ungathintana futhi nehhovisi locwanigo (Research Office) ngokuthinta u:
P. Mohun
HSSREC Research Office,
Ungamuthinta kulemininingwane: email: mohunp@ukzn.ac.za Inombolo yocingo: 031 260 4557.

Siyabonga ngokunikezela kulolu cwaningo.

UKUVUMA

Mina……………………………………………………………………………… (amagama aphelele alowo ozibandakanyayo) ngiyavuma ukuthi ngiyaqonda okubhalwe kulomqulu nendlela lolucwaningo oluzokwenziwa ngayo. Ngiyavuma ukuzibandakanya kulolu cwaningo.

Ngiyaqonda ukuthi ngingakhetha noma yinini ukuma ukuzibandakanya kulolu cwaningo uma kwenzeka ngiba nesifiso.

AKUSAYINE OZIBANDAKANYAYO **USUKU**

……………………………………… **…………………………………**

Appendix 3: **Anthropometry data collection tool**

Participant Number: 1

ANTHROPOMETRY DATA COLLECTION TOOL

Date:
Household number:
Participants name:
Gender:
Age:
Area: Swayimane/ Umbumbulu/ Fountain Hill Estate
Fieldworkers name:

CHILDREN (< 15 years)

	Reading 1	Reading 2	Reading 3
HEIGHT			
WEIGHT			
MUAC			

ADULTS (> 15years)

	Reading 1	Reading 2	Reading 3
HEIGHT			
WEIGHT			
WAIST CIRCUMFERENCE			

Appendix 4: **24 hour recall**

Participant Number: 1

24 HOUR RECALL SURVEY

Date:

Household number:

Participants name:

Gender:

Age:

Day of intake: Mon/ Tue /Wed/ Thu/ Fri/ Sat/ Sun

Area: Swayimane/ Umbumbulu/ Fountain Hill Estate

Fieldworkers Name:

General Introduction:

My name is …… I am a research assistant from the University of KwaZulu-Natal. I am here today to ask you about the food that you eat. I would like to find out about the food you ate in the last 24 hours.

Time of day	Place food eaten	Food item	Preparation methods	Amount (Household measures)

Time of day	Place food eaten	Food item	Preparation methods	Amount (Household measures)

Time of day	Place food eaten	Food item	Preparation methods	Amount (Household measures)

Additional questions:

Is this the usual way that you eat? YES NO

If No, in what way is it different?

____

Do you consume any vitamins and/or mineral supplements? YES NO

If yes, what kind?

Appendix 5: **Food frequency questionnaire**

Participant Number:

Food Frequency Questionnaire

Date:

Household number:

Participants name:

Gender:

Age:

Day of intake: Mon/ Tue /Wed/ Thu/ Fri/ Sat/ Sun

Area: Swayimane/ Umbumbulu/ Fountain Hill Estate

Fieldworkers Name:

PLEASE PUT A TICK (   ) ON EVERY LINE

Foods and amounts	**Average use last year**								
	Never or less than once/month	**1-3 x per month**	**Once a week**	**2-4 x per week**	**5-6 x per week**	**7 x per week**	**2-3 x per day**	**4 -5 x per day**	**> 6 x per day**
Cereals and Grains									
Cornflakes									
Future life									
Mageu									
Maize meal, stiff									
Maize meal porridge									
Maltabela									
Oats									
Pasta									
Phutu									
Pronutro									
Rice, brown									
Rice, white									
Samp and beans									
Weetbix									
Bread									
Brown bread/roll									
Ujeqe									
White bread/roll									
Biscuits and Snacks									
Biscuit, filling									
Biscuit									

Foods and amounts	Average use last year								
	Never or less than once/month	**1-3 x per month**	**Once a week**	**2-4 x per week**	**5-6 x per week**	**7 x per week**	**2-3 x per day**	**4 -5 x per day**	**> 6 x per day**
Biscuit, plain									
Cream crackers									
Starchy Vegetables									
Amadumbe									
Mealie/corn (on cob)									
Peas, green									
Potato, mashed, boiled, baked									
Squash, butternut, pumpkin,winter squash									
Sweet potato									
Starchy Foods Prepared with Fats									
Crumpets									
Fried chips									
Instant noodles									
Popcorn with oil									
Scone									
Vetkoek									
Fruit									
Apple, unpeeled, medium									
Banana, small									
Canned fruit									
Fruit juice									
Fruit salad, fresh									
Grapes, small									
Orange									
Pear									
Guava									
Milk and Milk Products									
Custard sweetened full cream									
Custard ultra Mel									
Full cream milk									
Low fat milk									
Maas									
Yogurt flavoured									
Yogurt low fat									
Yogurt plain									
Vegetables									
Beans, green									
Beetroot									
Broccoli									
Cabbage									

Foods and amounts	Average use last year								
	Never or less than once/month	1-3 x per month	Once a week	2-4 x per week	5-6 x per week	7 x per week	2-3 x per day	4 -5 x per day	> 6 x per day
Cauliflower									
Imfino (Indigenous leafy vegetables)									
Lettuce									
Mixed vegetable									
Mushroom									
Peppers									
Onions									
Spinach									
Tomato									
Meat and Meat Substitutes									
Baked beans									
Beans, lentils and peas (cooked/canned)									
Bean salad, no oil									
Beef, cuts									
Beef, mince									
Beef, patty									
Beef sausage									
Cheese, cheddar									
Chicken, cooked									
Chicken, stewed									
Chicken, feet									
Eggs									
Fish, hake									
Fish, tuna									
Lentils									
Organ meat (liver, kidney, heart)									
Peanut butter									
Pilchards, canned									
Polony									
Pork, bacon									
Pork, ham									
Pork, sausage									
Viennas									
Fats									
Avocado, medium									
Holsum									
Margarine, brick									
Margarine, tub									
Mayonnaise									
Oil									

Foods and amounts	**Average use last year**								
	Never or less than once/month	**1-3 x per month**	**Once a week**	**2-4 x per week**	**5-6 x per week**	**7 x per week**	**2-3 x per day**	**4 -5 x per day**	**> 6 x per day**
Other Carbohydrates									
Cake, icing									
Cake, plain									
Chocolate									
Cup cake									
Chips (Simba)									
Sweets									
Other Items that are Not on the List but are Eaten									

If you are unsure about anything do not hesitate to contact me.

Contact details:

Laurencia Govender (Researcher)

Cell: 0820965179

Email: govender.laurencia@gmail.com

If you are unsure about anything do not hesitate to contact me.

Contact details:

Laurencia Govender (Researcher)

Cell: 0820965179

Email: govender.laurencia@gmail.com

APPENDIX K: STANDARDISED RECIPE FOR THE PREPARATION OF *PHUTU*

INGREDIENTS

- 625 ml water
- 1 ml salt
- 536g (4 cups) mealie meal [White maize/ Provitamin A-biofortified maize]

METHOD

1. Bring 625 ml of water to the boil in a heavy-bottom pot on a Defy Thermofan Stove (Model 731 MF) on high heat (plate control setting 6).
2. Add 1 ml of salt to the water.
3. Add 4 cups of mealie meal (536g) to the boiling water and stir as soon as the mixture reaches boiling point.
4. Allow the *phutu* to stand on low heat (plate control setting 1) for approximately 75 minutes, with the pot lid on and occasional stirring until cooked.

APPENDIX L: STANDARDISED RECIPE FOR THE PREPARATION OF CURRIED CABBAGE

INGREDIENTS

- 1 medium shredded cabbage (908g)
- 1 finely chopped medium onion (125g)
- 10 ml (2 tsp) Raja curry spice
- 5 ml (1 tsp) salt
- 90 ml (1 ladle spoon) of sunflower oil
- 1 Knorrox cube (oxtail spice)
- 400 ml water

METHOD

1. Heat 1 ladle spoon (90 ml) sunflower oil in a heavy-bottom pot on a Defy Thermofan Stove (Model 731 MF) on medium heat (plate control setting 4).
2. Add 2 teaspoons (10 ml) Raja curry spice and finely chopped onion to the hot oil. Allow to brown.
3. Once the chopped onion have browned, add the shredded cabbage and 400 ml water and allow the cabbage to cook with the pot lid on and occasional stirring.
4. When the cabbage has softened, add 1 teaspoon (5 ml) salt and break 1 Knorrox cube into the pot.
5. Allow the curried cabbage to continue cooking on low heat (plate control setting 2) for approximately 20 minutes with the pot lid on and occasional stirring until cooked.

APPENDIX M: STANDARDISED RECIPE FOR THE PREPARATION OF CURRIED CHICKEN

INGREDIENTS

- 3kg of cut chicken pieces
- 2 finely chopped medium onions (250g)
- 10 ml (2 tsp) Raja curry spice
- 5 ml (1 tsp) salt
- 90 ml (1 ladle spoon) of sunflower oil
- 2 Knorrox cubes (oxtail spice)
- 250 ml water

METHOD

1. Heat 1 ladle spoon (90 ml) of sunflower oil in a heavy-bottom pot on a Defy Thermofan Stove (Model 731 MF) on medium heat (plate control setting 4).
2. Add 2 teaspoons (10 ml) Raja curry spice and finely chopped onions to the hot oil. Allow to brown.
3. Once the onions have browned, add cut chicken pieces and 250 ml of water and allow the chicken to cook with the pot lid on and occasional stirring.
4. Half an hour later add the 1 teaspoon (5 ml) of salt and 2 knorrox cubes into the pot.
5. Allow the curried chicken to continue cooking on low heat (plate control setting 2) for approximately 30 minutes with the pot lid on and occasional stirring until cooked.

APPENDIX N: STANDARDISED RECIPE FOR THE PREPARATION OF CURRIED BAMBARA GROUNDNUT

INGREDIENTS

- 4 cups (760g) of bambara groundnut (Soaked overnight)
- 4000 ml water
- 2 finely chopped medium onions (250g)
- 5 ml (1 tsp) Raja curry spice
- 5 ml (1 tsp) salt
- 1 ml bicarbonate of soda
- 180 ml (2 ladle spoons) of sunflower oil
- 1 Knorrox cube (oxtail spice)

METHOD

1. Bring 2000 ml of water to the boil in a heavy-bottom pot on a Defy Thermofan Stove (Model 731 MF) on high heat (plate control setting 6) and add bambara groundnut.
2. Half an hour later, add 2 ladle spoons (180 ml) of sunflower oil and 2 finely chopped onions. Allow the bambara groundnut to continue cooking on medium heat (plate control setting 4).
3. When the water starts to reduce, add 1 ml bicarbonate of soda and 1000 ml water. Allow the curried bambara groundnut to continue cooking on medium heat (plate control setting 4).
4. When the bambara groundnut becomes soft, add 1 teaspoon (5 ml) of Raja curry spice, 1 teaspoon (5 ml) of salt and 1 knorrox cube.
5. Add a further 1000 ml of water and allow the curried bambara groundnut to continue cooking on low heat (plate control setting 2) for approximately 40 minutes with the pot lid on and occasional stirring until cooked.

APPENDIX O: STANDARDISED RECIPE FOR THE PREPARATION OF SWEET POTATO

INGREDIENTS

- 5kg sweet potato
- 3000 ml water

METHOD

1. Bring 3000 ml of water to the boil in a heavy-bottom pot on a Defy Thermofan Stove (Model 731 MF) on high heat (plate control setting 6).
2. Add 5kg sweet potato to the boiling water.
3. Allow the sweet potato to continue boiling on medium heat (plate control setting 4) for approximately 45 minutes.

APPENDIX P: SURVEY QUESTIONS IN ENGLISH

Survey Questions

1. Do you eat white maize at home? Yes No
    - 1.1. If yes, how often do you eat white maize?
    - 1.2. If no, why do you not eat white maize?
2. What do you eat together with the white maize?
3. Can you list the dishes that you cook using white maize?
4. Can you give me the recipe for each of the dishes?
5. Do you grow your own maize at home?
    - 5.1. If yes;
        - 5.1.1. Why do you grow your own maize?
        - 5.1.2. Where do you purchase your seeds from?
        - 5.1.3. For what purpose do you use the home grown maize?
    - 5.2. If no;
        - 5.2.1 Why do you not grow your own maize?
        - 5.2.2 If purchased at a supermarket, which brand do you buy?
6. Have you ever used yellow maize at home?
    - 6.1. If yes;
        - 6.1.1 For what purpose did you use the yellow maize?
        - 6.1.2 If you do eat it what do you eat yellow maize with?
        - 6.1.3 Can you explain how you prepare the yellow maize?
    - 6.2. If no, why have you not used yellow maize?
7. Do you eat sweet potato?
    - 7.1. If yes;
        - 7.1.1 How often do you eat sweet potato?
        - 7.1.2 How do you prepare the sweet potato?
        - 7.1.3 Do you grow your own sweet potato?
    - 7.2. If no, why do you not eat sweet potato?

APPENDIX Q: SURVEY QUESTIONS IN ISIZULU

Survey Questions

1. Uyawudla umbila omhlophe ekhaya? Yebo Cha

    1.1. Uma impendulo kungu yebo, uwudla kangaki?

    1.2. Uma impendulo kungu cha, yini indaba ungawudli?

2. Yikuphi ukudla okudla ndawonye nombila omhlophe?

3. Chaza izidlo oziphekayo ngombila omhlophe?

4. Ngicela ungichazele kabanzi ngendlela opheka ngayo isidlo ngasinye?

5. Uyawutshala umbila ekhaya?

    5.1. Uma impendulo kungu yebo;

        5.1.1. Yiziphi izizathu ezenza utshale umbila?

        5.1.2. Uyithenga kuphi imbewu yombila?

        5.1.3. Yiyiphi inhloso yokutshala umbila?

    5.2. Uma impendulo kungu yebo;

        5.2.1 Kungani ungawutshali umbila?

        5.2.2 Uma uwuthenga esitolo, yiyiphi inhlobo oyithengayo? (Ace, White Star, Inyala e.t.c)

6. Usuke wawusebenzisa umbila obomvu ekhaya?

    6.1. Uma impendulo kungu yebo;

        6.1.1 Wawwusebenzisa ukwenzani umbila obomvu?

        6.1.2 Uma kungukuthi uyawudla, uwudla nani?

        6.1.3 Chaza ukuthi usilingisa kanjani isidlo sombila omhlophe?

    6.2. Uma impendulo kungu yebo, kungani ungakaze uwusebenzise umbila obomvu?

7. Uyalidla ithanga nobhatata?

    7.1. Uma impendulo kungu yebo;

        7.1.1. Yiziphi izizathu ezenza utshale umbila?

        7.1.2. Uyithenga kuphi imbewu yombila?

        7.1.3. Yiyiphi inhloso yokutshala umbila?

    7.2. Uma impendulo kungu yebo;

APPENDIX R: INFORMED CONSENT TO USE PHOTOGRAPHS

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

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

INFORMED CONSENT TO USE PHOTOGRAPHS

I Winnet Dladla (full name and surname) hereby confirm that I have granted Ms Laurencia Govender (206511208), permission to use my photographs taken during data collection for her PhD thesis. I fully understand I will not receive any money or other compensation for the use of my photographs.

SIGNATURE OF PARTICIPANT **DATE**

[redacted] ...16.11.26.............

School of Agricultural, Earth and Environmental Sciences
iSikole seSayensi yeZolimo, eZomhlaba kanye Nemvelo
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1910 - 2010
100 YEARS OF ACADEMIC EXCELLENCE

Founding Campuses: Edgewood Howard College Medical School Pietermaritzburg Westville

INSPIRING GREATNESS

APPENDIX S: FOCUS GROUP DISCUSSION GUIDE QUESTIONS IN ENGLISH

Focus Group Discussion

The focus group facilitator introduces him/herself to the group of participants and explains to them that he/she has a few questions for them to discuss based on the food samples that they consumed during the sensory evaluation. The facilitator checks if the participants are happy to continue with the FGDs, reminds them that they are free to leave at any time if they wish and that the FGD will be recorded. Participants are issued with numbers that are used when communicating with them during the FGDs so that the participants' anonymity is maintained. The facilitator reassures participants that there are no correct or incorrect answers and leads the discussion based on the following questions:

1. Do you like the combination food that you tasted?
2. Was the taste of the meal culturally acceptable to you?
3. Could you taste the difference between the meal prepared with white maize and cream fleshed sweet potato in comparison to yellow maize and orange-fleshed sweet potato?
4. Would you use yellow maize and orange-fleshed sweet potato at home for human consumption? If yes why and if no why?

The following rules were used during the FGDs:

- The facilitator will not express his/her feelings to the group and will keep a neutral response throughout the FGD.
- Be aware of the group interaction. Do not allow a few members of the group to dominate the discussion. Encourage all members to participate by creating a comfortable environment.
- If participants go off the topic bring them back to the question. Ensure that you build a rapport and gain their trust so that you can probe them for deeper answers.
- Be aware of time. Do not rush the participants but subtly control the time.
- Do not be assertive and be aware of your tone of voice.

To conclude, the facilitator needs to tell the participants that the FGD is about to end. Give the participants the opportunity to give their last comments. Thank the participants for their valuable contribution.

APPENDIX T: FOCUS GROUP DISCUSSION GUIDE QUESTIONS IN ISIZULU

Izingxoxo zamaqoqo

1. Uyithandile inhlanganisela yokudla obukade ukuzwa?
2. Ukunambitheka kokudla engabe bekwamukelekile ngokwesiko?
3. Ukwazile ukuzwa umehluko phakathi kokudla okuphekwe ngombila omhlophe nokuphekwe ngombila obomvu?
4. Ungakuvumela ukudla umbila obomvu ekhaya?

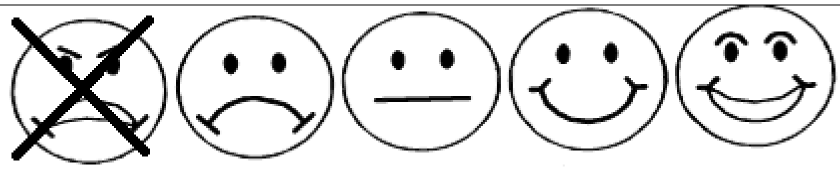
APPENDIX U: SENSORY EVALUATION IN ISIZULU

<u>Umthelela wokuhlanganisa umbila onezinga eliphezulu lika vitamin A (provitamin A–biofortified maize) nethanga nobhatata o–olintshi ngebala ekwamukeleni kwezidlo zasemakhaya ezikhethiwe ezihambisana nombila ezidliwa KwaZulu Natal, eNingizimu Afrika</u>

<u>Imilayelo:</u>

- Hlambulula umlomo ngamanzi ngaphambi kokuthi uqale.
- Hlambulula umlomo ngamanzi ngemuva kokuzwa isampula lesidlo.
- Yizwa izidlo ngendlela ezibekwe ngayo, usuka ngasesandleni sokudla uya kwesobunxele.
- Kala ukunambitheka, ukuzwakala, iphunga, ibala nokwamukelela kwesampula ngokufaka iziphambano esithombeni esichaza indlela ozwa ngayo.
- Ungaphinda usizwe futhi isidlo uma ufisa.

Isibonelo :

Iphunga	 Libi kakhulu · Libi · Alinankinga · Limnandi · Limnandi kakhulu

Inombolo yozibamdakanyayo:

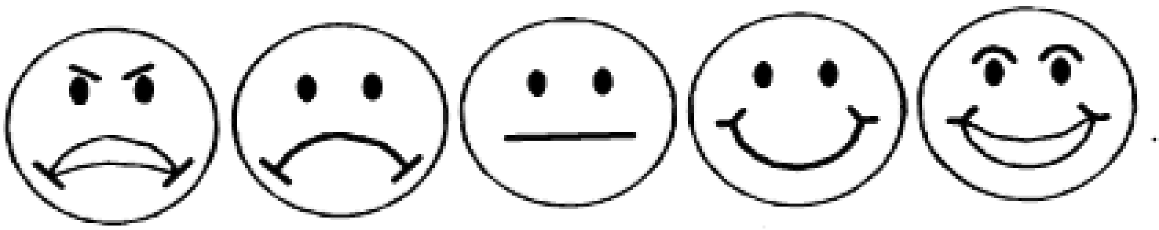
Inombolo yesampula:

Ukuhlowa kukudla ngezinzwa

Usuku lokuzalwa (usuku/inyanga/unyaka): ____________________

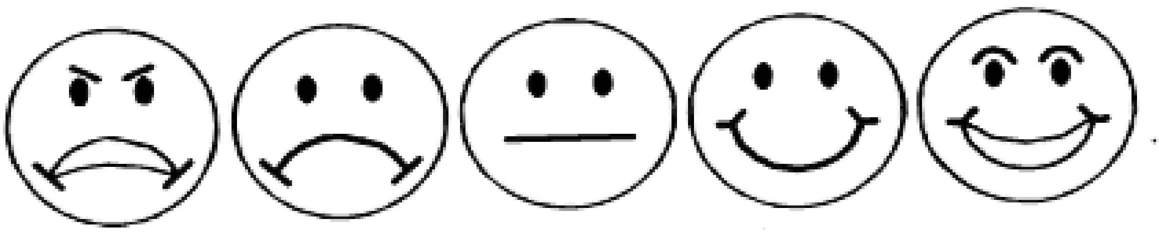
____

Ukunambitheka



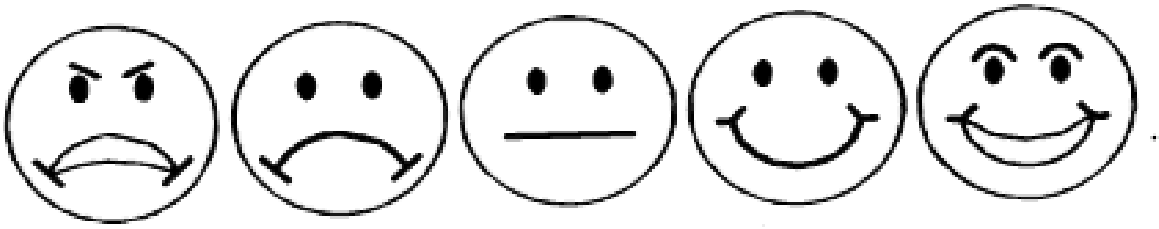
Kubi kakhulu Kubi Akunankinga Kumnandi Kumnandi kakhulu

Ukuzwakala



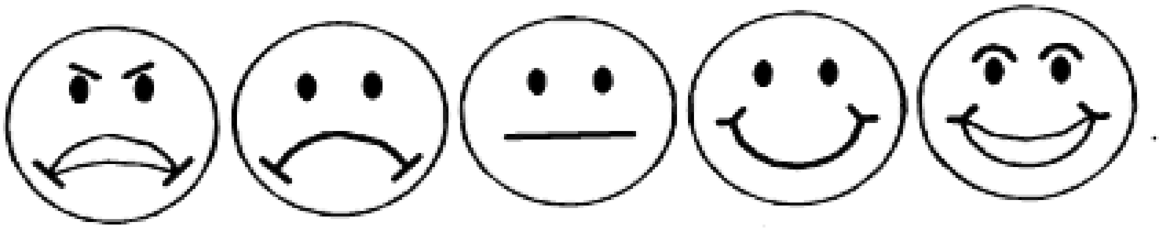
Kubi kakhulu Kubi Akunankinga Kumnandi Kumnandi kakhulu

<u>Iphunga</u>



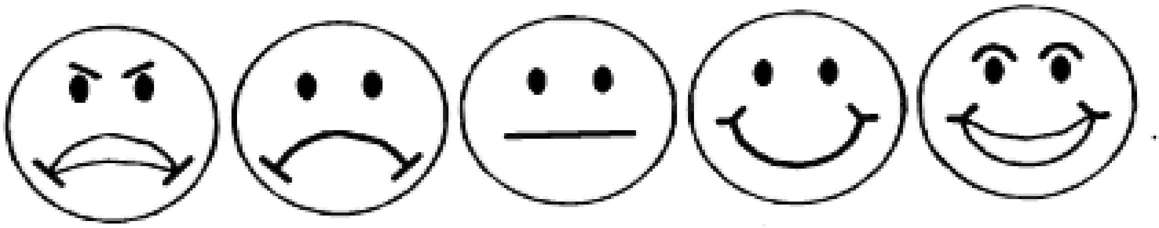
Libi kakhulu | Libi | Alinankinga | Limnandi | Limnandi kakhulu

<u>Umbala</u>



Mubi kakhulu | Mubi | Awunankinga | Muhle | Muhle kakhulu

<u>Ukwamukelela</u>



Akwamukeleki neze | Akwamukeleki | Akunankinga | Kuyemukeleka | Kuyemukeleka kakhulu

Ngiyabonga

APPENDIX V: PAIRED PREFERENCE TEST IN ISIZULU

Paired Preference Test

Sicela uxubhe umlomo wakho ngamanzi ngaphambi kukoqala.

Sicela uzwe lezinhlobo ezimbili zokudla ngendlela ezihlelwe ngayo, kusukela kwesokunxele kuyakwesokudla.

Sicela ubeke uphawu enambeni yesampula oyikhethayo.

318 ____049____

Siyabonga ngokubamba iqhaza kuloluncwaningo

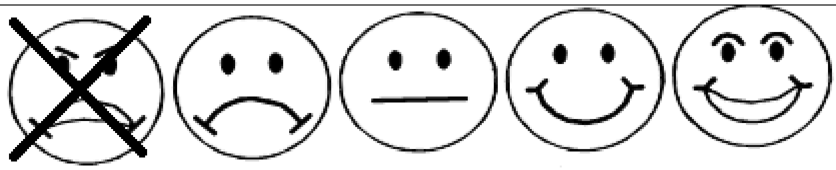
APPENDIX W: SENSORY EVALUATION IN ENGLISH

Impact of combining provitamin A-biofortified maize and orange sweet potato on consumer acceptance of selected traditional maize based foods consumed in KwaZulu-Natal, South Africa

Instructions:

- Please rinse your mouth with water before starting.
- Please rinse your mouth with water after tasting each sample.
- Please taste the samples in the order presented, from left to right.
- Please rate the taste, texture, aroma, colour and overall acceptability of the samples by putting a cross on the picture that best describes that sample.
- You may re-taste the sample if you wish.

Example :

Aroma	 Very bad Bad Average Good Very good

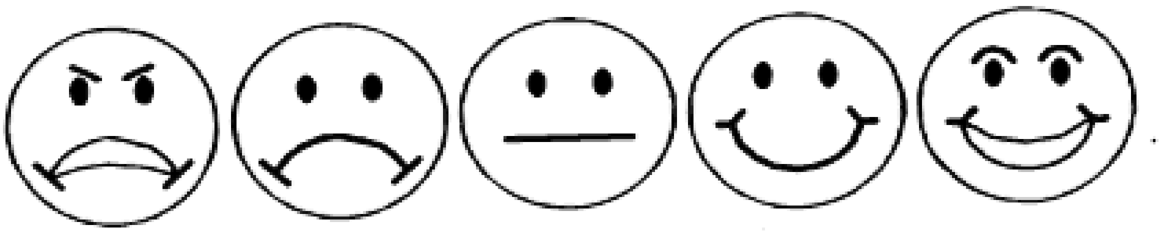
Participant number :

Sample number :

Sensory Evaluation

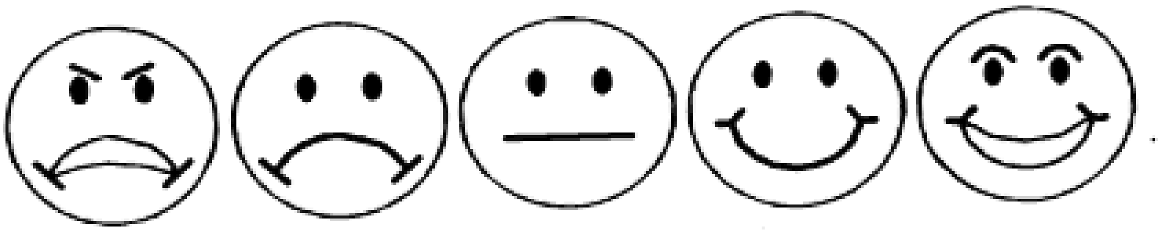
Date of birth (dd/mm/yy): ____________________

Taste



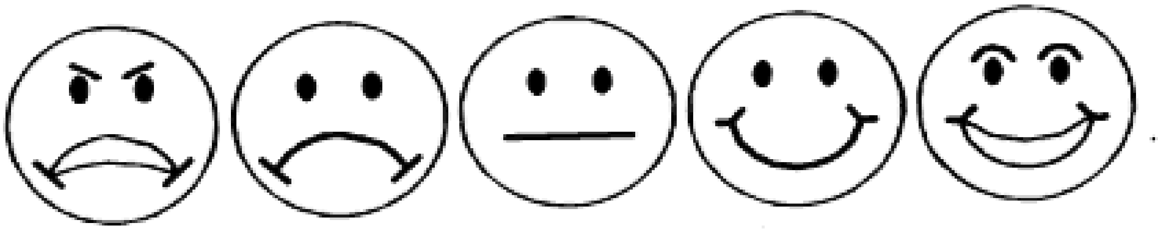
Very bad Bad Average Good Very good

Texture

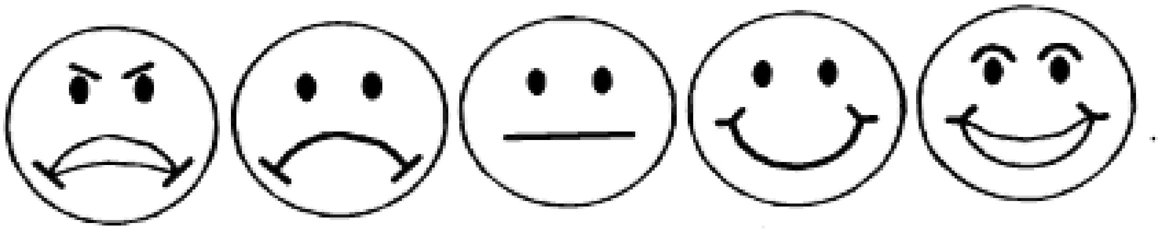


Very bad Bad Average Good Very good

Aroma

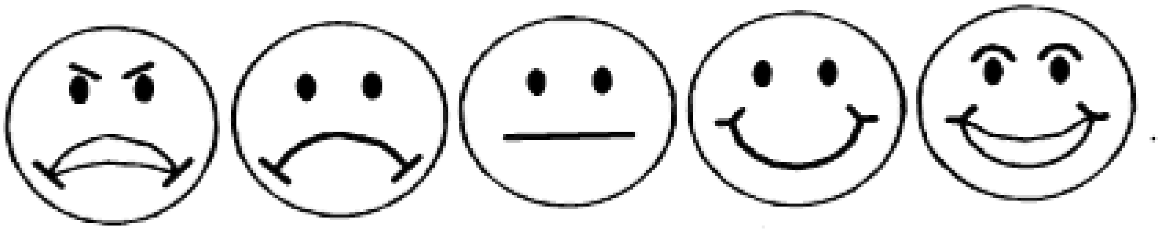


Colour



Very bad Bad Average Good Very good

Overall acceptability



Very bad Bad Average Good Very good

Thank you

APPENDIX X: PAIRED PREFERENCE TEST IN ENGLISH

Paired Preference Test

Please rinse your mouth with water before starting.

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

Please circle the number of the sample that you prefer.

318 ____049____

Thank you for taking part in this study