NUTRITIONAL COMPOSITION AND CONSUMER ACCEPTANCE OF A COMPLEMENTARY FOOD MADE WITH ORANGE-FLESHED SWEET POTATO AND DRIED BEANS

By

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ABSTRACT

Introduction

In South Africa (SA), nutrient deficiencies such as vitamin A, zinc, iron deficiency, and protein energy malnutrition (PEM) are common among children, especially during the complementary feeding stage. This is despite various strategies implemented by the South African Department of Health (DoH) to reduce malnutrition. These strategies include food fortification, micronutrient supplementation and promotion of dietary diversity. Vitamin A deficiency (VAD) is the most common micronutrient deficiency in SA and is regarded as a major public health concern. Biofortification, which involves enhancing the micronutrient content of staple crops, is a new strategy that aims to address micronutrient deficiencies, especially in low-income areas where commercially fortified foods and micronutrient supplementation are not easily accessible. Orange-fleshed sweet potato (*Ipomoea batatas* L.) (OFSP) is a biofortified staple crop that contains significant amounts of naturally bioavailable provitamin A carotenoids, that can be converted to vitamin A.

Aim

The aim of this study was to determine the nutritional composition and consumer acceptance of a complementary food made with OFSP and dried beans (*Phaseolus vulgaris* L.).

Objectives

i) To determine the nutritional composition of a complementary food product made with OFSP and dried beans.

ii) To assess the consumer acceptance of a complementary food product made with OFSP and dried beans by black African infant caregivers.

iii) To determine the perceptions of black African caregivers towards a complementary food made with OFSP and dried beans.

Methods

This was a cross-sectional study, which involved the assessment of the nutritional composition and consumer acceptance of a complementary food made with OFSP and dried beans, OFSP and white-fleshed sweet potato (WFSP) (control). The complementary foods made with OFSP and dried beans, OFSP and WFSP were all analysed for their nutritional composition using referenced analytical methods. The sensory acceptability of the different complementary foods was assessed using a five-point facial hedonic scale. Focus group discussions were used to determine the caregivers' perceptions towards the complementary food made with OFSP and dried beans.

Results

The complementary food made with OFSP and dried beans contained statistically significantly higher fat, ash (total mineral content), fibre and zinc contents than found in the complementary food made with OFSP alone, and the complementary food made with WFSP. Furthermore, although not statistically significant, the protein and iron content were higher in the complementary food made with OFSP and dried beans compared to the complementary food made with OFSP alone and the complementary food made with WFSP. The complementary food made with OFSP and dried beans contributed more than 100% of the recommended dietary allowance (RDA) for protein in both age groups studied (8-12 months and 13-24 months). The sensory attribute ratings of the complementary food made with OFSP and dried beans and OFSP alone were not statistically significant from the sensory ratings of the complementary food made with WFSP. The panellists expressed a willingness to purchase OFSP if it had a comparable price to that of WFSP or if it was cheaper.

Conclusions

The complementary food made with OFSP and dried beans had a superior nutritional composition compared to the complementary foods made with OFSP alone and WFSP alone, respectively. In addition, the complementary food made with OFSP and dried beans was found acceptable to caregivers of children aged 8-24 months in the eThekwini district of KwaZulu-Natal. A complementary food prepared with OFSP and dried beans has the potential to improve the nutritional intake of children aged 8-24 months, who are vulnerable to VAD and PEM. However, there is a need to improve the availability and accessibility of the OFSP in order to increase its utilisation.

PREFACE

The work presented and described in this dissertation was carried out in the School of Agricultural, Earth and Environmental Sciences (SAEES), University of KwaZulu-Natal from February 2015 to September 2016, under the supervision of Dr Kirthee Pillay and Dr Muthulisi Siwela.

Signed: ____________________ Date: _____________________

Ntuthuko Khanyile (Candidate)

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

Signed: ____________________ Date: _____________________

Dr Kirthee Pillay (Supervisor)

Signed: ____________________ Date: _____________________

Dr Muthulisi Siwela (Co-supervisor)

DECLARATION

I, Ntuthuko Khanyile, declare that:

1. This dissertation is my original work and does not contain other people's work without this being acknowledged.

2. This dissertation or any part of it has not been submitted at any other university or college for examination purposes.

3. Where the work of others has been used their words have been re-written but the general information attributed to them has been referenced and where their exact words have been used, their writing has been placed inside quotation marks and referenced.

4. This dissertation does not contain text, graphics or tables copied and pasted from the internet, unless specifically acknowledged, and the source being detailed in the dissertation and in the relevant reference section.

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Ntuthuko Khanyile (Candidate)

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1.1 Importance of the study

According to the World Health Organization (WHO), 6.3 million children less than 5 years of age died in 2013 and 45% of these deaths were linked to malnutrition (WHO 2014). The WHO (2002) reported that over half of all childhood mortality cases had malnutrition as a causative factor, either directly or indirectly. According to Black, Morris & Bryce (2003), in the year 2000, 16 of the top 17 countries with the highest under-five mortality rate (per 1000 births) were from Africa, with only Afghanistan representing non-African countries. Children in sub-Saharan Africa (SSA) are 15 times more likely to die before the age of five years than children in developed countries (WHO 2014). In 2001, 50-70% of diarrhoeal, measles, malarial and lower respiratory tract infections were attributed to malnutrition (WHO 2002).

Malnutrition can be classified as Protein Energy Malnutrition (PEM), which is readily diagnosed using anthropometric measurements and/or micronutrient malnutrition, known as hidden hunger [Department of Health (DoH 2012)]. Under nutrition can be classified into underweight (low weight for age), wasting (low weight for height) and stunting (low height for age). Stunting is a result of chronic malnutrition (Brown, de Kanashiro & Dewey 1995) while wasting indicates acute malnutrition (DoH 2012). Globally, 36% of children are underweight, while an estimated 8 million (8%) are wasted [United Nations Children's Fund (UNICEF), WHO & The World Bank 2012]. In 2011, an estimated 156 million children under five years (26%) were stunted globally, with Africa showing the highest prevalence (36%). Both Africa and Asia are estimated to be the home of more than 90% of the world’s stunted children (UNICEF *et al* 2012). According to the South African Vitamin A Consultative Group (SAVACG) (1994) one in four South African children were stunted in 1994, indicating long term malnutrition (Labadarios & van Middelkoop 1995). This translates to 1 520 000 children being stunted, with the highest prevalence found in children 12 to 24 months old. The prevalence of stunting (23%), underweight (9%) and wasting (3%) in children between 6 to 71 months old as reported by Labadarios & van Middelkoop (1995) showed that South African children suffered from chronic malnutrition rather than acute malnutrition. Lesiapeto, Hanekom, Du Plessis & Faber (2010) found a 20.5% prevalence of stunting in children aged 6-12 months which increased to 30.9% in children aged two years in KwaZulu-Natal (KZN) and the Eastern Cape. The prevalence of stunting in KZN has been reported to be 15% for children aged between one to nine years (UNICEF 2010).

Vitamin A, iodine, iron and zinc deficiencies are still common worldwide and result in increased morbidity and mortality (WHO 2002). Vitamin A deficiency (VAD) is the most common form of micronutrient deficiency in South Africa, followed by iron and zinc with 33.3%, 21.4% and 10.6%, prevalence respectively (Faber, Laurie, Ball & Andrade 2013b). The National Food Consumption Survey (NFCS) (1999) showed that in the 1-9 year age group, 50% or more consumed less than half the recommended amount of micronutrients including calcium, vitamin A, zinc and iron (Labadarios, Steyn, Maunder, Macintyre, Swart, Gericke, Huskisson, Dannhauser, Vorster & Nesamvuni 2000). Labadarios, Moodie & van Rensburg (2007) reported that KZN was the province with the highest VAD prevalence (88.9%). Children are most vulnerable to VAD due to their rapid growth resulting in increased requirements, increased risk for infections and the inability to consume enough vitamin A-rich foods to meet their higher vitamin A needs (Faber *et al* 2013b).

In 2002, the South African DoH introduced the vitamin A supplementation programme as a strategy to combat VAD in children under the age of five years (Labadarios, Steyn, Mgijima & Daldla 2005b). According to this programme, all children under the age of five years receive vitamin A in the form of a capsule every six months. The DoH also promotes dietary diversification through the promotion of nutrition education, healthcare facility gardens and/or community gardens as another strategy to decrease VAD in South Africa (DoH 2012). Dietary diversity refers to eating a diet which consists of a variety of foods. The majority of people in South Africa particularly those in rural areas are unable to access a wide variety of foods due to lack of financial resources (Labadarios *et al* 2005b). In South Africa all maize meal and wheat flour are fortified with a variety of vitamins and minerals including vitamin A. This is an additional strategy to combat VAD (DoH 2012). Despite these interventions, the vitamin A status of South African children has worsened (Labadarios *et al* 2005b).

According to Hendricks, Bourne & Eley (2006) the National vitamin A Supplementation Programme reached 72.8% of children aged 6-11 months, while the coverage in the 12-59 age group was only 13.9%. A study conducted by Van Stuijvenberg, Schoeman, Lombard & Dhansay (2012) on children 1-6 years of age who had not received vitamin A supplementation in the six months preceding the study found that 40% (n=243) of the children were never exposed to vitamin A supplementation. Even more significant was the fact that this study was conducted in children attending a Primary Health Care Facility. Van stuijvenberg *et al* (2012) concluded that the reasons for the deterioration of the VAD situation in South Africa included poor vitamin A supplementation programme coverage. The fact that not everyone has access to commercially fortified foods has also been proposed as another reason for the worsening VAD situation (Faber & Wenhold 2007). The sustainability of vitamin A supplementation has been questioned and the need for more sustainable solutions has been suggested (UNICEF 2007).

Biofortification is an additional strategy that is currently being investigated to combat VAD. Biofortification is a process by which staple crops are bred to contain increased levels of micronutrients, including vitamin A precursors (provitamin A) and has the potential to be a long-term solution to address the VAD situation in SA (Faber *et al* 2013b). Three crops have been targeted for biofortification with provitamin A carotenoids. These include maize, cassava and sweet potato. The biofortification initiative is led by HarvestPlus, a challenge programme of the Consultative Group on International Agricultural Research (CGIAR). HarvestPlus is involved in the development of biofortified crops, identification of target groups, testing of consumer acceptance, marketing and circulation (Bouis, Hotz, McClafferty, Meenakshi & Pfeiffer 2009). Biofortification is targeted at rural communities, where other programmes such as commercial food fortification and industrial supplementation are inaccessible. After the initial investment in biofortification, seedlings can be shared and used among food producers all over the world making this programme cost effective (HarvestPlus 2012).

The risk of malnutrition is increased in infants after six months of age as breast milk is no longer sufficient in meeting the infant's nutritional requirements (WHO 2002). According to Smuts, Faber, Schoeman, Laubscher, Fincham & Oelofse (2004), malnutrition in KZN peaks in the 12-23 months and 24-60 months age groups. Children in these age groups are more prone to stunting, underweight and wasting compared to children who are 12 months or younger. Poor nutritional quality and overfeeding (complementary feeding replaces breast milk) are some of the possible reasons for the increased risk of malnutrition (WHO 2002). Plant products supply 80% of vitamin A in the African diet, which is less bioavailable than the vitamin A found in animal products (Codjia 2001). According to Faber (2005), in South Africa, the intake of both animal products and vitamin A-rich vegetables and fruits was lowest in the 6-9 month age group. Overall, only 18% of children consume vitamin A-rich fruits and vegetables in South Africa. The predominant complementary food in KZN is soft white maize meal porridge. The low intake of vitamin A in the 6-9 month age group highlights the need for complementary foods high in vitamin A in South Africa (Faber 2005).

According to Woolfe (1992), globally, only wheat, rice, maize, potato, barley and cassava are produced more than sweet potato. Sweet potato is a high-yielding, multipurpose (young tips and roots can be boiled, roots are edible and can be processed), energy dense crop. Sweet potato (*Ipomoea batatas* L.) is one of more than 1 000 species of the Convolvulacae family. Both roots and flesh of sweet potatoes can be white, cream, yellow, orange or reddish-purple and it is grown in more than 100 countries worldwide (Woolfe 1992). Orange-fleshed sweet potato (OFSP) is a staple crop that offers high amounts of naturally bioavailable beta-carotene that is converted to vitamin A in the body (De Brauw, Eozenou, Gilligan, Kumar & Meenakshi 2012; Faber *et al* 2013b). According to Laurie (2004), OFSP is highly suitable to the South African setting due to its ability to adapt under different conditions, its high yield per time capabilities, minimum labour requirements and input, good storage quality (does not need refrigeration) and its ability to be a multipurpose crop. Many countries in SSA use OFSP as a staple food, either as a secondary or primary staple food (Brauw *et al* 2012). The most common vitamin A-rich plant food sources consumed by South African children between the ages of 6-12 months are butternut and pumpkin (Faber 2005). Three quarters of a cup of butternut yields 500 micrograms (µg) Retinol Activity Equivalents (RAE)/day of vitamin A, while to get 500 µg RAE/day (which is half the recommended daily dose of vitamin A for children aged 7-12 months) a child needs to consume only two tablespoons of OFSP (Faber *et al* 2013b).

The vitamin A content per gram is particularly suitable for South African children, as studies have shown that these children usually consume smaller amounts of food than the recommended quantities (Faber 2005). OFSP has a higher nutrient density compared to other beta-carotene-containing foods such as butternut, spinach, carrots and pumpkin, which is the most commonly, consumed vitamin A-rich crops in South Africa. OFSP also yields higher protein, vitamin A, vitamin C, vitamin K, thiamin, folate, riboflavin, niacin and vitamin B6 per 100g when compared to the crops previously mentioned (Faber *et al* 2013b). OFSP-based complementary foods have been found to be a better source of vitamin A than maize and legume based complementary foods (Amagloh & Coad 2013). The authors concluded that giving vitamin A-rich OFSP-based complementary foods could reduce VAD prevalence more than giving unfortified maize and legume-based cereals (Amagloh & Coad 2013).

Although OFSP is a good source of vitamin A, it is deficient in protein (Woolfe 1992). The addition of dried beans to the OFSP may improve the overall protein and energy content making it an ideal complementary food for children eight months and older. The reason for choosing this age group is that the KwaZulu-Natal Department of Health (KZN-DoH) (2015) Complementary Feeding Guidelines recommends that dried beans be introduced when the child is seven to eight months old (KZN-DoH 2015). However, there are no published studies that have assessed the nutritional composition and consumer acceptance of such a complementary food. Therefore, this study aimed to assess the nutritional composition and consumer acceptance of a complementary food made with OFSP and dried beans by caregivers of infants who are eight months and older.

1.2 Aim of the study

The aim of the study was to determine the nutritional composition and consumer acceptance of a complementary food made with OFSP and dried beans.

1.3 Type of study

This was a cross-sectional study.

1.4 Research objectives

i) To determine the nutritional composition of a complementary food product made with OFSP and dried beans.

ii) To assess the consumer acceptance of a complementary food product made with OFSP and dried beans by black African infant caregivers.

iii) To determine the perceptions of black African caregivers towards a complementary food made with OFSP and dried beans.

1.5 Hypotheses

i) The nutritional composition of a complementary food made with OFSP and dried beans is superior to that of complementary foods prepared with white fleshed or orange fleshed sweet potato only.

ii) The complementary food made with OFSP and dried beans is less acceptable compared to a complementary food made with white fleshed sweet potato due to unfamiliar sensory properties.

iii) The complementary food made with OFSP and dried beans is perceived to be unsuitable for infant feeding.

1.6 Study parameters

i) This study was limited to black African caregivers who had children between the age of eight months and two years in their care at the time of the study.

ii) The study was limited to caregivers attending Newtown Community Health Centre (NCHC) only.

iii) The complementary food product made with OFSP and dried beans was analysed for vitamin A, protein, moisture, fibre, fat, ash, iron, zinc and calcium only due to financial limitations.

1.7 Study assumptions

The following assumptions were made:

i) The panellists consumed cream/white-fleshed sweet potato on a regular basis.

ii) All panellists understood the questionnaire and answered the questions truthfully without any bias. The panellists who participated in the focus groups were honest in their responses and not influenced by other panellists.

iii) It was assumed that the caregivers who participated in the study were a true representation of caregivers living in the Inanda area.

1.8 Definitions of terms

i) Biofortification – The process of breeding staple crops with enhanced micronutrients (Faber *et al* 2013b).

ii) Caregiver – A person who takes care of another person that is unable to take care of themselves (Hermanns & Mastel-Smith 2012).

iii) Complementary foods – Foods that are added to an infant's diet to supplement breast milk after six months of life (WHO 2009).

iv) Dried beans – Dried beans are annual legumes that grow during the warm season. They are usually kidney shaped (Department of Agriculture Forestry and Fisheries 2011).

v) Orange-fleshed sweet potato (OFSP) – A sweet potato characterised by a distinctive orange colour indicating the presence of carotenoids hence high in provitamin A (Faber *et al* 2013b).

vi) Vitamin A deficiency – Vitamin A deficiency is diagnosed when serum retinol is less than 0.7 µmol/l. VAD can lead to xerophthalmia, keratomalacia, irreversible damage to the cornea, night blindness, vomiting, hair loss, anorexia, muscle weakness, poor immune function, and increased susceptibility to infection (Faber *et al* 2013b*;* Chapman 2012).

1.9 Abbreviations

DoH – Department of Health

KZN – KwaZulu-Natal

OFSP – Orange-fleshed sweet potato

PEM – Protein Energy Malnutrition

UNICEF – United Children’s Fund

VAD – Vitamin A Deficiency

WFSP – White-fleshed sweet potato

WHO – World Health Organization

1.10 Summary

Malnutrition remains one of the major contributors towards child mortality globally. The under-five mortality rate remains highest in African countries, particularly in SSA. VAD is the most prevalent micronutrient deficiency in SA. SA has introduced a number of strategies to combat VAD, which include industrial fortification of targeted foods, vitamin A supplementation and dietary diversification. However, VAD has continued to escalate. OFSP is a biofortified crop that is high in provitamin A carotenoids, however, it is low in protein. Combining it with a protein source such as dried beans could result in a viable complementary food suitable for children who are eight months old and ready for the introduction of vegetables and legumes. However, there are no published studies that have assessed the nutritional composition and consumer acceptance of such a complementary food. Therefore, the aim of this study was to determine the nutritional composition and consumer acceptance of a complementary food made with OFSP and dried beans

CHAPTER 2 : LITERATURE REVIEW

This review of related literature covers the burden of malnutrition in children, especially vitamin A deficiency (VAD) and strategies that have been employed to address VAD in South Africa. Biofortification as a new strategy to combat VAD is reviewed as well as complementary feeding. The potential of using OFSP and dried beans as a complementary food to improve nutritional status in children, particularly vitamin A status, is also reviewed..

2.1 Childhood malnutrition

2.1.1 Classification of malnutrition

Ten million infants and children are estimated to die every year in developing countries before reaching their fifth birthday. Half of these deaths are thought to be related to malnutrition (WHO 2000) and the majority of these occur in the first year of life (WHO & UNICEF 2003). Malnutrition can manifest as either over nutrition or under nutrition (Figure 2.1). Under nutrition can be further categorised as protein-energy malnutrition (PEM) and/or micronutrient malnutrition which includes iron and vitamin A deficiency among other vitamins and minerals (Faber & Wenhold 2007).

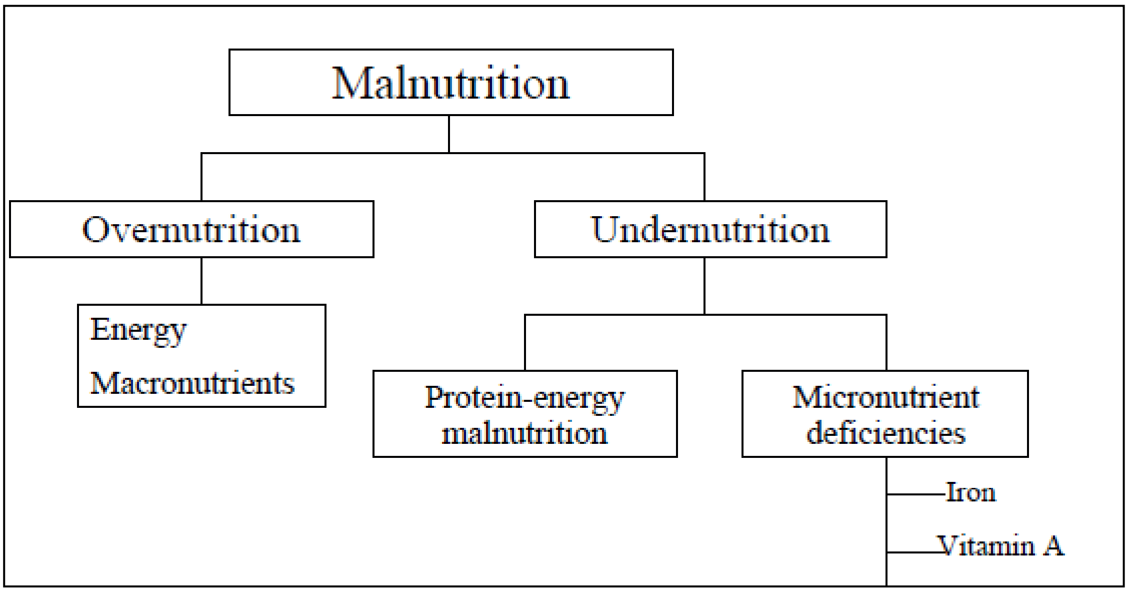


Figure 2.1 Classification of malnutrition (Faber & Wenhold 2007)

PEM is the most readily recognised form of malnutrition. By taking weight and height measurements and making clinical observations of a child, it can be determined whether the child is stunted, underweight, moderately wasted (Moderate Acute Malnutrition often referred to as MAM), severely wasted (Severe Acute Malnutrition often referred to as SAM) and/or has a combination of these forms of malnutrition (DoH 2012). According to Manary & Sandige (2008), PEM is caused by a diet that is low in energy and protein. Table 2.1 shows the classification of malnutrition using anthropometric measurements.

Table 2.1 Classification of malnutrition using anthropometric measurements (Grover & Ee 2009)

Anthropometric Measurement	**Measurement**	**Classification**
Weight for height	Below -3SD (standard deviation)	Severe Acute Malnutrition
	Above -3SD, Below -2SD	Moderate Acute Malnutrition
Mid-upper arm circumference (MUAC) (Children aged 6-60 months)	Less than 11.5 cm	Severe Acute Malnutrition
	Above 11.5 cm, Below 12.5cm	Moderate Acute Malnutrition
Weight for age	Below -2 SD; Below -3	Underweight; severe underweight for age
Height for age	Below -2SD; Below -3	Stunting; severe stunting

Globally, micronutrient malnutrition affects more than 50% of the population with children and women being most affected in developing countries (Ortiz-Monasterio, Palacios-Rojas, Meng, Pixley, Trethowan & Peña 2007). Deficiencies of micronutrients, namely vitamin A, iodine, iron, zinc and folate are highly prevalent in developing countries (Ramakrishnan 2002). Micronutrient deficiencies are not as readily diagnosed when compared to macronutrient deficiencies and are referred to as hidden hunger (Stein 2010). This is because micronutrient deficiencies take a long time to manifest clinically, often at a stage when the damage is irreversible (UNICEF 2015). Micronutrient deficiencies are just as devastating as macronutrient deficiencies, if not worse (Stein 2010).

2.1.2 Causes of malnutrition

Sub-optimal complementary feeding together with reduced breastfeeding rates result in increased risk of infections in children between 6-24 months old. This places them at a greater risk of malnutrition, and subsequently growth faltering and development (Faber & Wenhold 2007). According to Black, Allen, Bhutta, Caulfied, de Onis, Ezzati, Mathers & Rivera (2008) the causes of malnutrition are multispectral in nature (Figure 2.2).

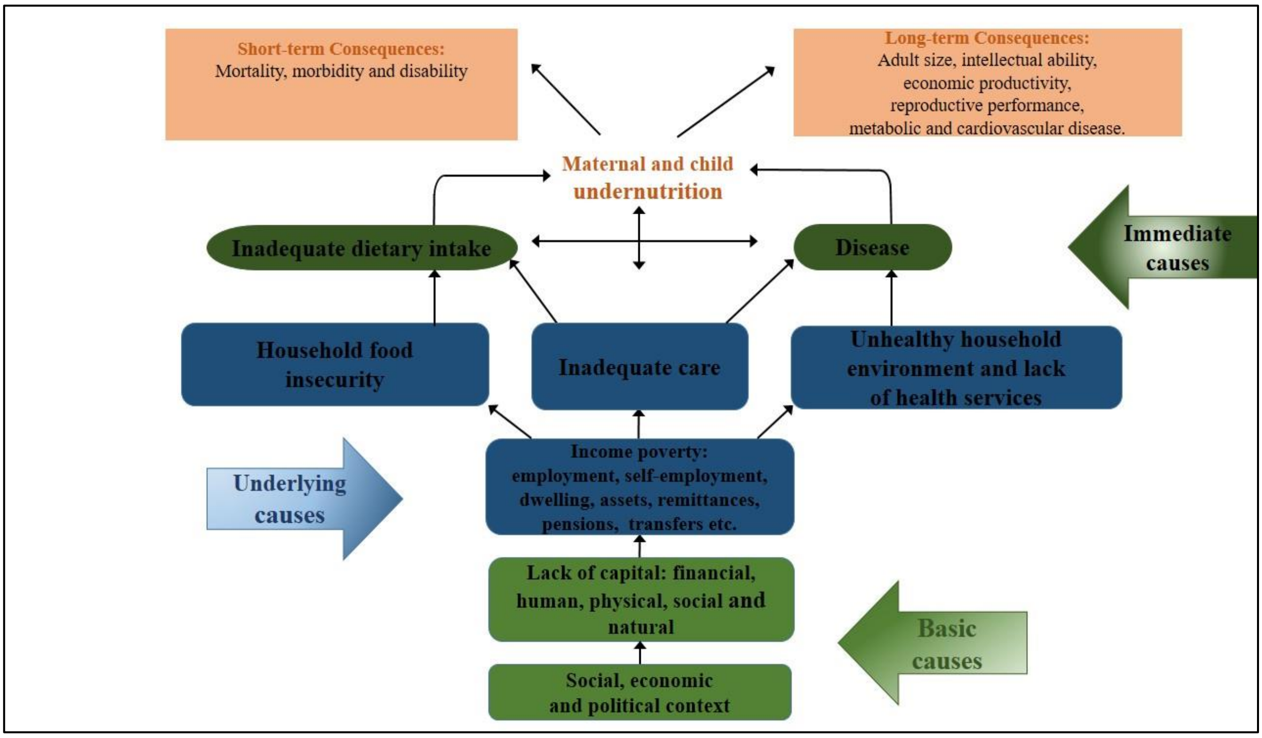


Figure 2.2 Multispectral causes and consequences of malnutrition (Black *et al* 2008)

Basic causes including social, economic and political context are at the bottom which yields underlying causes of low income from a plethora of sources ultimately resulting in a malnourished child. The malnourished child gets sick easily, has a greater chance of death or disability and when the child grows up, he or she is less productive. This in turn has negative consequences on social, economic and political development (Black *et al* 2008). According to Bain, Awah, Geraldine, Kindong, Sigal, Bernard & Tanjeko (2013) many developing countries find it difficult to escape the vicious cycle of hunger and poverty. Many children do not get enough nutritionally adequate food and subsequently develop malnutrition. When children have malnutrition, they do not develop optimally and experience irreversible stunting which results in less productive lives and less chance of being freed from poverty. Low education levels, adverse climatic change which yields droughts and floods aggravates the problem (Bain *et al* 2013).

Figure 2.2 shows that food insecurity (causing hunger) is one of the underlying causes of malnutrition. According to Labadarios, Swart, Maunder, Kruger, Gericke, Kuzwayo, Ntsie, Steyn, Schloss, Dhansay, Jooste & Dannhauser (2008) one in two households experienced hunger and one in three were at risk of hunger according to the 2005 National Food Consumption Survey-Fortification Baseline (NFCS-FB-1). Similarly, in the South African National Health and Nutrition Examination Survey (SANHANES-1), 54.3% of households in 2013 either experienced hunger or were at risk of hunger. The majority of these people resided in informal urban settlements or formal rural areas and, were black (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).

Labadarios *et al* (2000) also found high rates of food insecurity in SA. In SA, 55% of children aged 0-4 years were negatively affected by poverty. The majority of these children lived in rural areas in disadvantaged provinces. Their biological parents did not care for the majority of these children but by extended family members using money from government grants (Labadarios *et al* 2000). The causes of malnutrition in developing countries are a result of many interrelated factors, which ultimately results in inadequate dietary intake and disease. Inadequate dietary intake and diseases are immediate causes of malnutrition and child mortality is linked to malnutrition. In SA, children are particularly vulnerable to malnutrition, particularly children under the age of five years. The next section reviews malnutrition in South African children.

2.1.3 Malnutrition in South African children

In South Africa, vitamin A deficiency (VAD) is the most common micronutrient deficiency (Faber 2007a). The National Food Consumption Survey (NFCS) (1999) which included 2 894 South African children aged between 1-9 years reported high VAD rates along with inadequate intake of calcium, iron, zinc, folate, vitamin B6, niacin, riboflavin, vitamin C and vitamin E (Labadarios, Steyn, Maunder, MacIntryre, Gericke, Swart, Huskisson, Dannhauser, Vorster, Nesmvuni & Nel 2005a). One of the findings of the NFCS of 1999 was that stunting was the most commonly found nutritional disorder in South African children. The NFCS (1999) showed a 21.6% stunting prevalence with younger children being more prone to stunting. Underweight for age and wasting (an indicator of acute malnutrition) were the less common conditions, with 10.3% and 3.7% prevalence respectively. Households who experienced hunger and those who were at risk of hunger were the households most likely to have children who were stunted and/or underweight for age (Labadarios *et al* 2005a). Similar findings were also reported by Zere & McIntyre (2003) using data for children under five years of age from the Living Standards and

Development study which showed stunting (24%) to be the most common condition, followed by underweight (18%) and wasting (8.9%).

The National Food Consumption Survey-Fortification Baseline-1 (NFCS-FB-1) of 2005 also showed that stunting was the most common malnutrition condition experienced by children aged 1-9 years old, with one in four children being stunted (Labadarios *et al* 2008). A study by Schoeman, Faber, Adams, Smuts, Ford-Ngomane, Laubscher & Dhansay (2010) which measured 411 children aged 0-59 months, found that stunting (21%) was the most common nutritional condition compared to underweight (2,3%), wasting (1%) and overweight (5.7%) in two KZN districts (UMkhanyakude and Zululand) and one Eastern Cape district (OR Tambo district). Kimani-Murage, Kahn, Pettifor, Tollman & Dunger (2010) also showed similar findings in a study conducted in Mpumalanga Province, South Africa comprising of 3511 children and adolescents aged between 1-20 years. Stunting (18%) was found to be the most prevalent form of under-nutrition in the 1-4 year age group. The SANHANES-1 of 2013 also similarly reported that stunting was the number one nutritional disorder in children, peaking in the 0-3 year age group (Shisana *et al* 2013).

The complementary feeding stage in a child is associated with a higher risk of malnutrition, mainly due to inadequate dietary intake, lack of exclusive breastfeeding, early introduction of complementary foods and incorrect preparation of formula (Faber & Wenhold 2007; Faber & Benadé 2007). Stunting and/or underweight rates are two times higher in the second year of life compared to the first (Faber & Wenhold 2007). Stunting is a long-term indicator of nutritional status and is often associated with complementary feeding (Brown *et al* 1995). Stunting is potentially irreversible when the child reaches two years of age and unlike weight-related indicators, it does not respond rapidly to nutritional intake and often occurs in areas with high poverty rates (Cogill 2003). Furthermore, stunting and severe stunting rates (chronic malnutrition) have increased in South African children aged 0-3 years in recent years, while wasting (acute malnutrition) and underweight-for-age rates have decreased. Other forms of malnutrition have relatively stayed the same (Figure 2.3) (Shisana *et al* 2013).

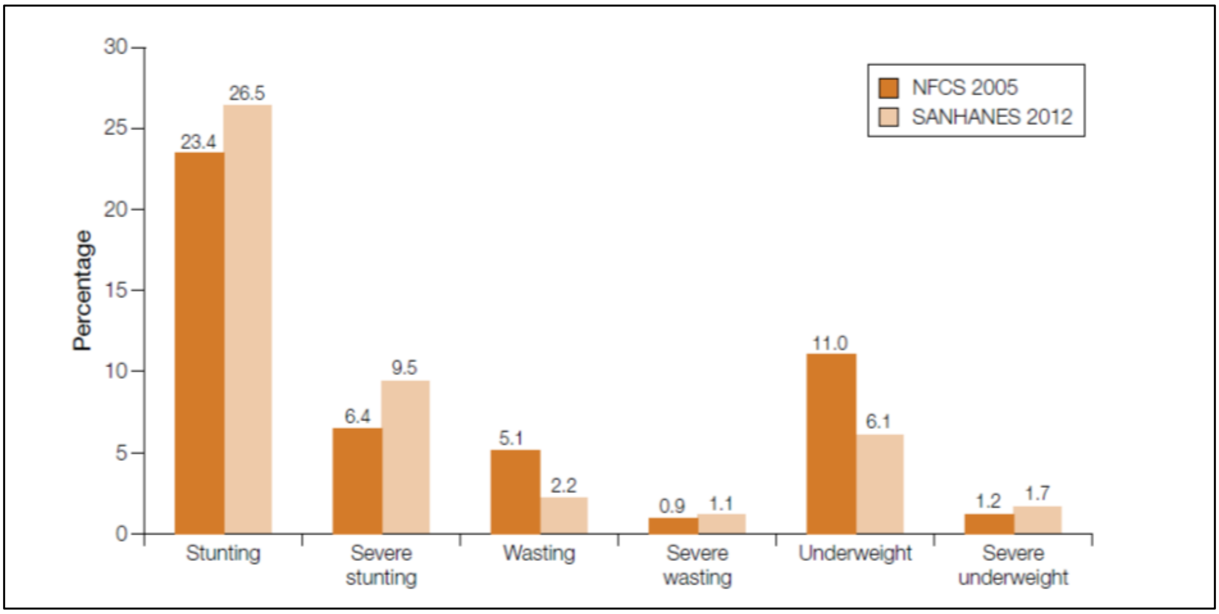


Figure 2.3 Under nutrition rates in South Africa (Shisana *et al* 2013)

The role of vitamin A in human health, groups at risk of VAD and food sources of vitamin A are discussed next.

2.2 Vitamin A

Vitamin A is a fat soluble vitamin. Retinol and retinyl esters form preformed vitamin A, while carotenoids, primarily β-carotene, α-carotene and β-cryptoxanthin form provitamin A. Preformed vitamin A is found in animal products, while carotenoids are found in products of plant origin and are converted to active vitamin A by the body. Vitamin A is stored in the liver until the body requires it later (Zempleni, Rucker, McCormick & Suttie 2007).

2.2.1 Role in human health

According to Loveday & Singh (2008), vitamin A plays a role in immunity, vision, development and growth, protein synthesis and has anti-oxidant properties. Children with VAD are particularly prone to infections such as measles, and have an increased mortality rate compared to well-nourished children. Faber, van Jaarsveld, Kunneke, Kruger, Schoeman & van Stuijvenberg (2015) investigated 747 pre-school children randomly selected from four different provinces in SA and found that children with VAD were more likely to suffer from fever and chronic illnesses than those who were not vitamin A deficient. This study also found that children who were stunted were also more likely to be vitamin A deficient (Faber *et al* 2015). When the vitamin A status of children aged six to 59 months was improved in areas affected by VAD, the overall mortality rate decreased by 23% (Beaton, Martorell, Aronson, Edmonston, McCabe, Ross & Harvey 1993). This highlights the critical role that vitamin A plays in the growth of children.

2.2.2 Food sources and bioavailability

According to Brody (1999, p554), preformed vitamin A is primarily found in animal products and is the form most readily absorbed in the body (DoH 2012). Animal products which contain high amounts of vitamin A include beef liver, egg yolks, full cream milk, cheddar cheese, butter and certain types of fish such as sardines, tuna and mackerel (Brody 1999, p554). Provitamin A, which is less bioavailable compared to preformed vitamin A (Faber & Wenhold 2007) is found in spinach, carrots, orange-fleshed sweet potatoes, mature squashes and pumpkin (Brody 1999, p554). According to Faber, Laurie & van Jaarsveld (2013c), yellow or orange fruit such as ripe pawpaw and ripe mango contain provitamin A. In fruit, the colour serves as an indicator of the vitamin A content. Unripe mango, which is coloured dark green, contains minimal provitamin A while ripe orange contains significant amounts of vitamin A (Faber *et al* 2013c). Vitamin A-containing fruit and vegetables have been found to be the least consumed food items by the South African adult population (Labadarios, Steyn & Nel 2011). Preformed vitamin A is found in animal sources which are unaffordable to poorer households (Faber *et al* 2013c), especially rural communities (Harrison 2012). Hence, these communities have limited access to high quality vitamin A food sources (Faber & Wenhold 2007).

2.3 Vitamin A deficiency (VAD)

2.3.1 Groups at risk of VAD

According to Faber *et al* (2013b), groups most vulnerable to VAD include children younger than five years; children with measles, acute or prolonged diarrhoea, acute lower respiratory infection, and severe PEM; children living under poor socio-economic conditions; non-breastfed infants; and pregnant and lactating women (Underwood 2000). According to Faber *et al* (2013a), vitamin A is important for sustained good health and normal development and growth in children. When children suffer from conditions such as measles, severe PEM and acute lower respiratory infections, vitamin A requirements increase. The unborn child uses vitamin A from the mother to grow; hence, women who are pregnant have increased requirements. During breastfeeding, vitamin A not only helps the mother stay healthy but is also passed through to the baby during breastfeeding. Rapid growth, frequent infections and a lack of adequate food to meet their requirements all predispose children to VAD more than other life stage group (Faber *et al* 2013a). In South Africa, children who are in the 6-59 month age group and/or live in rural areas have been found to have increased risk of VAD (Labadarios

& van Middelkoop 1995). People from low income countries fail to obtain micronutrient-rich diets regularly, and are consequently at increased risk of suffering from micronutrient deficiencies, including VAD (HarvestPlus 2012).

2.3.2 VAD in children

According to the WHO (2009), VAD is diagnosed when serum retinol levels are lower than 20 µg/dl. The prevalence of vitamin A deficiency is estimated to be 33% in children under five years old worldwide. Asia and Africa are the two continents with the highest prevalence (49.9% and 44.4% respectively) (WHO 2009).

According to Black *et al* (2003), neonatal conditions and diarrhoea are the leading causes of death in children under 5 years old. In the year 2000, a predicted 3 000 diarrhoeal deaths were associated with VAD in South Africa (Steyn, Bradshaw, Norman, Joubert, Schneider & Steyn 2006a; Steyn, Maunder, Labadarios & Nel 2006b). Night blindness, which refers to difficulty in seeing in dim light, is a sign of vitamin A deficiency (DoH 2012). It has the potential to progress to permanent eye blindness in severe cases of VAD. Estimates show that between 250 000 and 500 000 children go blind every year due to VAD. Two thirds of these children die within a month of going blind (WHO 2009). Vitamin A deficiency has also been associated with higher rates of stunting, wasting and risk of being underweight in preschool children. In a cross-sectional study of 340 children surveyed in Sri Lanka, severe stunting was associated with low mean serum vitamin A levels (Marasinghe, Chackrewarthy, Abeysena & Rajindrajith 2015). Faber *et al* (2015) also found that VAD was associated with increased stunting rates (4.9%) in children aged between 1.5-6 years old.

VAD in SA is a serious public health concern according to the WHO criteria (WHO 2009) and VAD rates are higher in South African rural areas compared to urban areas (Faber & Wenhold 2007). In 1994, the SAVACG study reported that one in three children were vitamin A deficient in South Africa (Labadarios & van Middelkoop 1995). According to Labadarios *et al* (2007), the VAD situation has worsened in South Africa as the NFCS-FB (2005) reported that two in three children had VAD. The SANHANES-1 study reported a 43.6% prevalence of VAD in children less than five years old. This was significantly higher than the national VAD prevalence of 33% reported by SAVACG in 1994 and less than the 63.6% reported by the NFCS-FB (2005) (Shisana *et al* 2013). The SAVACG (1994) study showed that only the Limpopo Province had a higher prevalence of VAD (43.5%) than KwaZulu-Natal (38%). Both these figures were higher than the national reported prevalence of 33% and the prevalence was higher in rural areas compared to urban areas (37.9% vs. 25.1% respectively) (Labadarios & van Middelkoop 1995). The mean serum vitamin A levels were lower in children under the age of two years compared to children aged two and above; children in formal rural areas had the highest prevalence of VAD (Shisana *et al* 2013).

SA has introduced a variety of strategies to address VAD. These strategies are aimed at people who are unable to consume enough vitamin A from their diet to meet their nutritional requirements. These strategies are reviewed in the next section.

2.4 South African strategies to address VAD

The South African Department of Health has established various strategies to address VAD. These include food fortification, the vitamin A supplementation programme and emphasis on dietary diversity in communities (DoH 2012).

2.4.1 Food fortification

The NFCS (1999) showed that maize and bread were the most frequently consumed staple foods in SA. This led to these foods being used as food fortification vehicles in SA (Faber & Wenhold 2007). In terms of the South African Food Fortification Programme all white/bread flour and maize meal are fortified with vitamin A, thiamin (vitamin B1), riboflavin (vitamin B2), niacin (vitamin B3), folic acid, pyridoxine (vitamin B6), iron and zinc (DoH 2012). Faber *et al* (2015) found that more children who consumed homemade bread were vitamin A deficient when compared to children who consumed commercial bread. This suggests that the fortification of wheat flour as part of the South African Food Fortification Programme has had an impact on the vitamin A status in certain communities. However, it also shows that not everyone has access to commercially fortified foods (Dary & Mora (2002). According to Faber & Wenhold (2007) meeting nutritional requirements through dietary intake remains the most significant solution to micronutrient deficiency. However, the impact of food fortification is likely to be minimal, particularly in children as they are unable to eat large portions of staple foods (Faber & Wenhold 2007).

According to the DoH (2012) one of the biggest challenges with this strategy is that manufacturers do not adhere to the recommendations set out by the DoH. A recommended dietary allowance (RDA) of at least 31% of vitamin A should be supplied by fortified maize meal (159g - 319g) for children aged 1-9 years (DoH 2003). A study by Pretorius & Schönfeldt (2012) found that the average fortified maize meal in South Africa supplied only 17% of the RDA for vitamin A for children 1-4 years and 13% for children aged 4-9 years. This is considerably lower than the 31% target set by the DoH. This study used 455 g of soft maize porridge/person/day as this was the portion size reported by Steyn *et al* (2006b) as the average portion size of soft maize porridge consumed by the average 1-9 year old child in SA. This suggests that even if food fortification reaches every child in SA, meeting the set targets and reducing VAD via this route may still prove difficult. In South Africa, the average percentage retention of vitamin A was found to be 39.8% when the fortified maize was cooked into porridge (Pretorius & Schönfeldt 2012), further decreasing the potential vitamin A supplied by the fortified maize.

2.4.2 Dietary diversity

According to Ruel (2001) dietary diversity is regarded as a long-term solution in the fight against malnutrition and can work hand in hand with supplementation and food fortification. Both growth and nutritional status of children in developing countries are affected by poor dietary diversity (Ruel 2003). Diets that are low in dietary diversity result in a low height for age Z-score, an indicator of chronic malnutrition in children aged 6-24 months (Arimond & Ruel 2004). Darapheak, Takano, Kizuki, Nakamura & Seino (2013) showed that increasing dietary diversity had a positive effect on the rates of stunting in Cambodia, South East Asia in a study that included 6209 children aged 12 to 59 months. Children who consumed a diet low in diversity in rural Bangladesh were also found to be more prone to stunting (Rah, Akhter, Semba, Pee, Bloe, Campbell, Moench-Pfanner, Sun, Badham & Kraemer 2010). Faber, Phungula, Venter, Dhansay & Benade (2002) found that the availability of food sources was more likely to result in optimal nutrition compared to nutritional education without the availability of food.

Laurie & Faber (2008) also echo the above-mentioned findings through a study conducted in the Eastern Cape. South Africans living in urban areas, particularly informal settlements were found to have low dietary diversity (Drimie, Faber, Vearey & Nunez 2013). These sentiments were also supported by Steyn & Ochse (2013) and Steyn, Nel, Nantel, Kennedy & Labadarios (2006c), who also concluded that the South African diet was low in dietary diversity. A diet that is low in diversity impacts negatively on the growth of children (Steyn *et al* 2006c). Vegetables and fruits seem to be a problem in particular. A South African survey conducted by Faber, Laubscher & Laurie (2013a) found that none of the 10 most frequently consumed foods in SA were vegetables or fruits. According to Faber *et al* (2013a) fruit and vegetable intake in South Africa is less than the WHO recommendation of 400 g/day. When vegetables are eaten, they are usually eaten in very small amounts (43g-73g/day) (Faber *et al* 2015). In the same study none of the children were reported to have consumed vitamin A-rich vegetables (Faber *et al* 2015). The low intake of vegetables and fruit, in addition to the low dietary diversity could be the reason why many South Africans have a very low micronutrient intake. The findings of Faber *et al* (2015) are similar to those of Nel & Steyn (2002) who reviewed data from SA consumption studies, conducted in different populations between 1983-2000. Nel & Steyn (2002) found that the intake of fruit and vegetables was approximately 200g per day, also less than the WHO recommendation.

2.4.3 Vitamin A supplementation

The South African Department of Health introduced the vitamin A Supplementation Programme in 2002. According to this programme, a child aged 6-59 months should be given vitamin A capsules as part of routine immunisation. Vitamin A was also initially given to women during the postpartum period and as part of the integrated management of illness in children (Labadarios *et al* 2005b). However, this has since been revised and routine vitamin A supplementation to pregnant women has been stopped in line with current WHO recommendations (DoH 2012).

An 80% coverage is recommended by the WHO in order for vitamin A supplementation to drastically reduce child mortality (Ross 2002). According to UNICEF (2007), approximately 60% of children will receive at least one dose of vitamin A globally; children from rural and poor communities are less likely to receive vitamin A supplements. According to the (NFCS-FB) (2005) vitamin A supplementation programmes reached only 20.5% of children aged 12-59 months in South Africa (Labadarios *et al* 2008). The vitamin A Supplementation Programme coverage was found to be 28.8% in rural KwaZulu-Natal, 44.2% in rural Limpopo, 3.0% in urban Northern Cape and 20.4% in urban Western Cape (Faber *et al* 2015). The Eastern Cape had an even lower reported vitamin A supplementation coverage rate of 13.4% (Magasana, Witten, Romano & Beeforth 2004). Hendricks *et al* (2006) also found a national vitamin A supplementation coverage of 13.9% in the 12-59 months age group in SA. Kenya also reported similar figures for vitamin A supplementation programme coverage (Clohossey, Katcher, Mogonchi, Nyagoha, Isidro, Kikechi, Okoth & Blankenship 2014) showing that South Africa is not the only country with this problem.

According to Mitra (2012), despite considerable resources being put into synthetic capsule-based approaches to address VAD in recent years, the VAD situation in developing countries has not improved. According to Mason, Greiner, Shrimpton, Sanders & Yukich (2014) supplementing children with high dose vitamin A capsules every 6 months had little or no effect on low serum retinol levels. Although vitamin A supplementation has been proven to reduce mortality, it remains a short-term solution to the VAD epidemic (Imdad, Herzer, Mayo-Wilson, Yakoob & Bhutta 2010; Kraemer, Waelti, Pee, Moench-Pfanner, Hathcock, Bloem & Semba 2008). The fact that rural communities are too far away from health institutions also limits access to vitamin A supplements (HarvestPlus 2012).

According to Edejer, Aikins, Black, Wolfson, Hutubessy & Evans (2005), current strategies are not effective enough to solve the problem of hidden hunger and are potentially unsustainable. Meeting nutritional requirements through diverse dietary intake remains the most significant potential contributor to eradication of micronutrient deficiency but it will take decades before this can be a reality to the global community (Bouis *et al* 2009). The impact of food fortification is likely to be minimal, particularly in children as they are unable to eat large portions of staple foods (Faber & Wenhold 2007). Vitamin A supplementation remains a short-term solution and is unlikely to reach all vulnerable populations. Although food fortification, vitamin A supplementation and promotion of dietary diversity were introduced after the NFCS (1999) the VAD situation has worsened in SA (Labadarios *et al* 2005b). New strategies that are sustainable, cost effective and able to reach rural communities are required. While industrial supplementation and fortification are effective, they often fail to reach remote rural areas. Some people living in rural areas cannot afford to go to the city to buy fortified staples or to go to health institutions to obtain vitamin A supplements (HarvestPlus 2012). Biofortification of staple crops, which is a food-based approach, has the potential to be a long-term solution in the fight against hidden hunger and VAD. This is discussed in the next section.

2.5 Biofortification as a new strategy to address VAD

2.5.1 Current biofortification initiatives

Biofortification involves breeding staple crops to produce nutritionally enhanced crops (Ortiz-Monasterio *et al* 2007). The aim of biofortification is to produce crops that are high in certain micronutrients. These micronutrient dense crops are then reproduced and distributed as needed (HarvestPlus 2012). Biofortified crops are ideal for communities that depend on self-production for their staple foods (HarvestPlus 2012). According to Mulualem (2015), biofortification is practical, and the most cost effective strategy in reducing the burden of micronutrient malnutrition. Unlike commercial fortification and supplementation, after the initial investment to breed crops with high micronutrients, the biofortified crop can be multiplied and grown continuously (Bouis *et al* 2009). The biofortification initiative is led by HarvestPlus which is part of the Consultative Group on International Agricultural Research (CGIAR) Research Program on Agriculture for Nutrition and Health (A4NH). HarvestPlus efforts are geared towards ending global hidden hunger particularly vitamin A, zinc, and iron deficiencies, predominantly in developing countries (Bouis *et al* 2009). Two types of biofortified crops can be produced. The one type has visible traits such as orange-fleshed sweet potato, yellow/orange maize and yellow cassava (all these products are commonly consumed white/cream). The other type including iron pearl millet and iron beans are also enriched but do not show visible traits (Bouis *et al* 2009). HarvestPlus uses specific crops to deliver specific nutrients and different countries are leading research in specific crops (HarvestPlus Brief 2006).

- Beans (*Phaseolus vulgaris* L.) are used as vehicles to deliver iron. Programmes testing the feasibility of beans are based in the Democratic Republic of the Congo (DRC) and Rwanda and were started in the year 2012.
- In the DRC and Nigeria, efforts to deliver high vitamin A using biofortified cassava (*Manihot esculenta* Crantz) have also been evaluated since 2011.
- Biofortified maize (*Zea mays* L) has been researched in Zambia and Nigeria since 2012.
- India has been researching pearl millet and wheat (*Triticum aestivum* L.) since 2012 and 2013, respectively.
- Rice biofortified with zinc has been evaluated in India and Bangladesh since 2013.
- Since 2007, Mozambique and Uganda have been the home of the vitamin A-rich OFSP [*Ipomoea batatas* (L.) Lam.].
- Wheat biofortified with zinc has been evaluated in India and Pakistan since 2013 (Bouis *et al* 2009).

HarvestPlus is involved in the development of the biofortified crops, from identifying the target population to supporting the handover, marketing and testing the consumer acceptance of the biofortified crops. The ultimate goal is the improved nutritional status of the target populations (Figure 2.4).

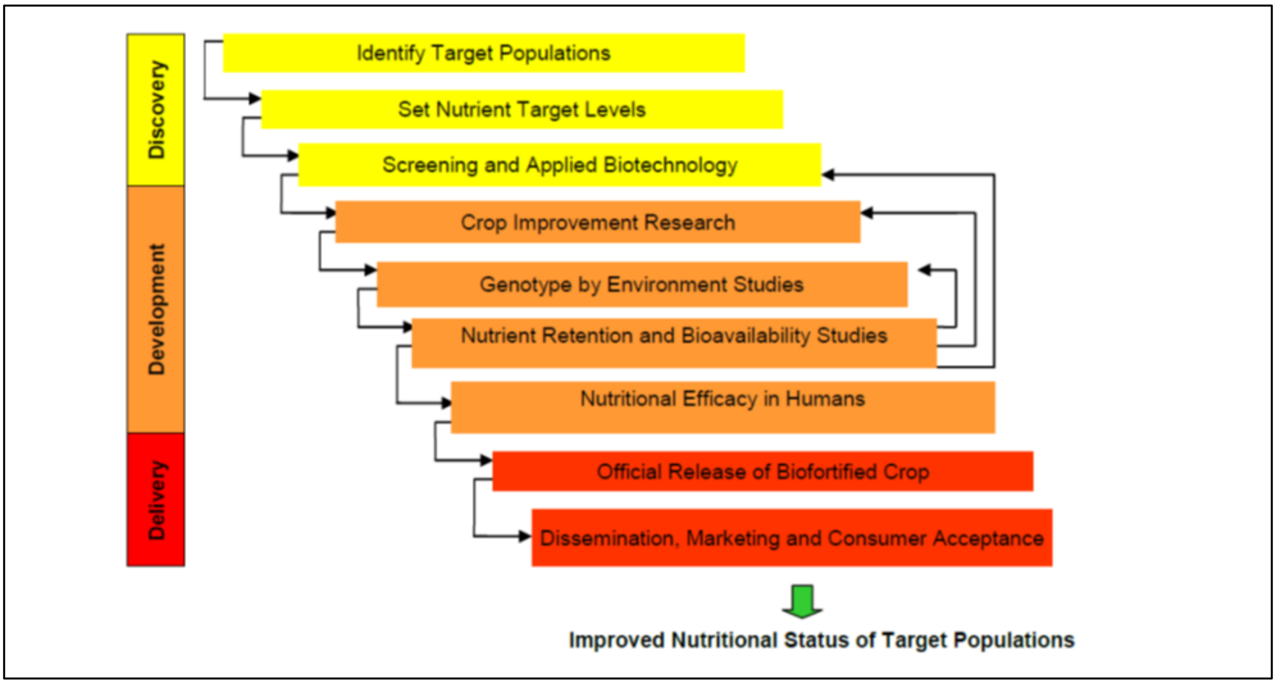


Figure 2.4 HarvestPlus impact pathway

Biofortification has both advantages and disadvantages which must be considered. The advantages and disadvantages of biofortification are evaluated in the next section.

2.5.2 Advantages and disadvantages of biofortification

According to HarvestPlus the three main advantages of biofortification are:

- Biofortification primarily targets rural communities, which is where the majority of disadvantaged people reside (HarvestPlus 2012).
- Although an initial investment is needed to produce biofortified crops, the same crops can be reproduced and disseminated to other regions at a lower cost (HarvestPlus 2012).
- Biofortification targets staple crops that are familiar and already being consumed, thus making it sustainable. Seedlings can be shared among food producers globally or be stored for later usage (HarvestPlus 2012).

Besides complementing strategies like food fortification and dietary approaches, biofortification also has the potential to fill the gaps that current strategies employed to fight VAD cannot fill in developing countries (Ortiz-Monasterio *et al* 2007). Practically, biofortified crops offer a sustainable approach to improve nutrition in rural areas where infrastructure or resources to deliver supplements or fortified processed foods are lacking (Tanumihardjo, Palacios & Pixley 2010). Because biofortification targets staple crops that are the predominant food in most under-resourced communities it has the following benefits:

- The targeted communities are already eating these crops regularly and in large amounts. Even if the biofortified crop contains minute amounts of the specific micronutrient, the chances of the nutritional requirements being met are greater due to the large portion sizes consumed (Tanumihardjo *et al* 2010).
- Biofortification involves substituting a staple crop with another similar staple crop. It does not introduce completely new foods as it has been found that consumers are more likely to accept familiar staple crops than unfamiliar, new foods (Mitra 2012).

According to Muzhingi, Langyintuo, Malaba & Banziger (2008), biofortification can bring about changes in colour, texture and flavour in the staple. This may result in consumers being reluctant to change from consuming the original crop to consuming the biofortified crop. The next section reviews consumer acceptability of biofortified foods in SA.

2.5.3 Consumer acceptability of biofortified foods in SA

Consumer acceptability studies on biofortified foods in SA are limited. Khumalo, Schönfeldt & Vermeulen (2011) tested the acceptability of yellow maize in Giyani, Limpopo province. The majority of the subjects expressed a willingness to accept yellow, biofortified maize if they knew the nutritional benefits of the yellow maize (Khumalo *et al* 2011). Pillay, Derera, Siwela & Veldman (2011) also evaluated the acceptability of popular maize food products (*phuthu*, thin porridge and samp) made with yellow, biofortified maize using 212 subjects in rural KwaZulu-Natal. Pillay *et al* (2011) found that preschool children preferred the food products made from yellow maize compared to those made with white maize. Adults and secondary school subjects favoured products made with white maize compared to those made with yellow maize. Govender, Pillay, Derera & Siwela (2014) assessed the acceptability of a complementary food (soft porridge) made with provitamin A-biofortified maize using 60 black African female infant caregivers in uMgungundlovu District, KwaZulu-Natal province. There were no significant differences in the acceptability of the soft porridges made with either white maize or provitamin-A biofortified maize. Caregivers expressed that if yellow maize was readily available, more affordable and had health benefits they would feed it to their infants (Govender *et al* 2014). Amod, Pillay, Siwela & Kolanisi (2016) tested the acceptability of a composite complementary food made with provitamin A-biofortified maize and chicken stew. In this study, the complementary food made with yellow maize was just as acceptable as those made with white maize and consumers expressed a willingness to use provitamin A-biofortified maize as a complementary food (Amod *et al* 2016).

2.6 Complementary feeding in South Africa

According to WHO (2009) complementary feeding refers to the introduction solid foods at six months, when breast milk is no longer nutritionally adequate. The stage at which solid foods are introduced is linked with higher malnutrition rates in many countries (WHO 2009). The next section discusses complementary feeding.

2.6.1 Complementary feeding practices

Infants obtain all the required nutrients for optimal growth from breast feeding in the first six months of life. After six months, infants require additional foods which are universally termed complementary foods to supplement breast milk (WHO 2009). In developing countries complementary foods are usually of lower nutritional quality and are often given in lesser amounts. This increases the risk of malnutrition during the complementary feeding stage (WHO 2012; WHO 2002).

2.6.2 The nutritional quality of South African complementary foods

An infant's dietary intake has a direct effect on the child's nutritional status. Before six months of age, the child can obtain all of its nutritional requirements from breast milk alone. After six months, breast milk alone cannot provide enough nutrients in the correct amounts to meet the nutritional requirements of the growing child. Additional foods are needed to complement the breast milk (WHO 2012). According to the WHO (2002) infants are most vulnerable to malnutrition from 6 months onwards and deficiencies suffered at this age are often very difficult to compensate for later in life. The SAVACG study (1995) found that children aged 6-23 months were not only more likely to be anaemic but were also the age group most affected by stunting (Labadarios & van Middelkoop 1995).

Faber (2005) studied the eating patterns of 475 infants aged 6-12 months using a cross-sectional survey at the Valley of a Thousand Hills, in rural KwaZulu-Natal. In this survey mothers/caregivers of the children were interviewed in their local language (IsiZulu) by experienced fieldworkers. Items such as fresh foods, plastic food models and three-dimensional sponge models were used to aid data collection. Dry oats were used to determine the average portion sizes and the fieldworkers using measuring spoons then quantified this. Animal products were consumed by less than 20% of infants while butternut and pumpkin (vitamin A rich foods) were consumed by less than 18% of infants. The diet consumed by the participants in this study had a low micronutrient density but was found to contain adequate energy and protein (Faber 2005).

Faber & Benadé (1999) found that infants in KZN who were mainly given soft maize meal porridge as a complementary food had poor iron and vitamin A status. The infant's diets were also found to be low in fruits and vegetables. Although the soft porridge eaten was made with fortified maize and often had margarine added, it was often over-diluted and overcooked making it nutritionally inadequate (Faber & Benadé 1999). Soft maize meal porridge was also found to be the most common first food introduced by caregivers in Limpopo province in SA (Mushaphi, Mbhenyane, Khoza & Amey 2008). Caregivers in this study introduced solid foods very early, with 77.3% introducing solids before 6 months (Mushaphi *et al* 2008).

A survey of 505 infants aged 6-12 months found that the intake of vitamin A-rich foods was very low (Faber 2007a). Approximately 20% of these infants had VAD and a host of other micronutrient deficiencies. A number of infants were found to consume carbonated beverages, with 12% consuming it at least 4 days a week. Complementary foods were introduced too early, with 61% of mothers giving solid foods before the infant reached 4 months of age. A poor intake of fruit and vegetables and animal products were also found to predispose the infants to VAD during the complementary feeding stage (Faber 2007a). Complementary foods lacked dietary diversity, making them low in micronutrient density including vitamin A. Intakes of vitamin A were low during complementary feeding, resulting in a high prevalence of VAD even when fortified maize was eaten. The next section reviews the potential of a complementary food made from OFSP in addressing VAD in South Africa.

2.7 The potential of a complementary food made with OFSP in addressing VAD in South Africa

Sweet potato (*Ipomoea batatas* L.) which originates from Central America is one of the staple crops targeted for biofortification (HarvestPlus 2009). In South Africa sweet potato is mainly produced in the Limpopo, Mpumalanga and the Western Cape Provinces (Department of Agriculture, Forestry and Fisheries 2011). According to Hagenimana & Low (2000), OFSP has the potential to be the most significant food source of provitamin A in rural areas.

2.7.1 Nutritional composition of sweet potato

2.7.1.1 Macronutrient components

The white-fleshed sweet potato is a significant energy source. Some of the selected reported energy values for sweet potato range from 318 kJ/100g (International Potato Center 2015) to

323 kJ/100g (Wolmarans, Danster, Dalton, Rossouw & Schönfeldt 2010) to 376 kJ/100g reported by the United States Department of Agriculture (USDA) (2015). Starch is the predominant macronutrient found in sweet potato. The International Potato Centre (2015) estimates the carbohydrate content of the sweet potato to be about 17.72 g/100g. Wolmarans *et al* (2010) reports the carbohydrate content of sweet potato to be 15.9 g/100g while the USDA (2015) reports 20.9 g/100g. Protein is the second most dominant macronutrient component of sweet potato in terms of mass. The International Potato Centre reports 1.3 g/100, while Wolmarans *et al* (2010) reports a range of 1.1 g/100g to 2.01 g/100g protein content in sweet potato. The lowest macronutrient component is fat. Fat content in the sweet potato is low ranging between 0.14 g/100g (International Potato Centre 2015) and 0.15g/100g (USDA 2015). Fibre is also a major component in sweet potato with 2.5 g/100g of fibre reported by Wolmarans *et al* (2010) and 3.3 g/100g reported by the USDA (2015). With an average of 1.5 g/100g, protein content of the sweet potato is low. Protein is not the only macronutrient lacking in sweet potato. The fat content contributes a mere 0.15% to the sweet potato mass. Complementary feeding requires foods that are nutritionally balanced. Since the OFSP is low in both protein and fat, the OFSP needs to be combined with foods that complement it by providing the lacking macronutrients. Dried beans are a cheap source of protein compared to animal protein. If dried beans are paired with OFSP, it would improve the protein content and amino acid profile of the combined foods. To make the combined foods even more nutritionally balanced, the fat content could be enhanced through the addition of margarine.

2.7.1.2 Micronutrient components

Vitamins are the major micronutrients that make up the chemical composition of sweet potato. According to the USDA (2015) an average WFSP contains 19.6 mg/100g of vitamin C, 0.107 mg/100g of thiamin, 0.106 mg/100g of riboflavin, 1.487 mg/100g of niacin, 0.286 mg/100g of vitamin B6, 6 μg/100g of folate and 0.71 mg/100g of vitamin E. Approximately 960.9 RAE/100g of vitamin A is contained in the OFSP while negligible amounts are found on the white/cream fleshed sweet potato. The vitamin profile of both the white/cream fleshed sweet and OFSP is comparable except for the vitamin A content. The white/cream fleshed contains negligible beta-carotene while OFSP contains significant amounts (Rose & Vasanthakaalam 2011). The sweet potato also contains minerals which include iron (0.5 mg/100 g), zinc (0.2 mg/100 g), calcium (34 mg/100 g), potassium (298 mg/100 g) and phosphorous (29 mg/100 g) (USDA 2015).

2.7.2 The efficacy of OFSP in addressing VAD

Van Jaarsveld, Faber, Tanumihardjo, Nestel, Lombard & Benadé (2005) found an improvement in the vitamin A status of South African primary school children consuming OFSP. The sample size for this study was n=90, 5-10 year old children in grades 1-3 in a primary school 40 km from the city of Durban, KwaZulu-Natal province. This area had not only been found to have low vitamin A intake prior to the study, but had also been identified as having a high VAD prevalence. Children were fed 125 g of either OFSP or white-fleshed sweet potato for 53 days during their mid-morning school break. Measures were taken to ensure that exchanging of the sweet potato between the two groups did not occur. There was an improvement in the serum retinol levels in the children who consumed OFSP while no significant improvement was noted in children consuming white-fleshed sweet potato. The authors concluded that OFSP could be a sustainable tool in improving vitamin A status, complementing programs like supplementation and food fortification (van Jaarsveld *et al* 2005).

Low, Arimond, Osman, Cunguara, Zano & Tschirley (2007) investigated the effect of introducing OFSP in Mozambique. The researchers introduced OFSP to the intervention group while the control group did not receive any sweet potato at all. Baseline results showed that the VAD prevalence was the same in both the intervention and the control groups. At the end of the study, the prevalence of VAD had decreased in the intervention group while it remained relatively the same in the control group. Introducing OFSP to young children in rural Mozambique increased the average serum retinol concentration in the intervention group and decreased the morbidity prevalence (Low *et al* 2007). Furthermore, Jones & Brauw (2015) recently showed that vitamin A rich-OFSP had a protective effect against diarrhoea. Children who consumed OFSP were less likely to suffer from diarrhoea, and if they did contract diarrhoea, it was shorter for a shorter duration (Jones & Brauw 2015). Hotz, Loechl, Lubowa, Tumwine, Ndeezi, Masawi, Baingana, Carriquiry, de Brauw, Meenakshi & Gilligan (2012), found that introducing OFSP in a similar way to that of Low *et al* (2007) in rural Uganda increased vitamin A intake among children. This suggests that vitamin A intake could be increased through consumption of OFSP. In the study by Hotz *et al* (2012), OFSP was introduced in certain communities while other communities did not consume any OFSP at all. For a functional food to serve its intended purpose, it needs to be accepted by the population it is intended for. The next section reviews studies that have investigated the consumer acceptance of OFSP.

2.7.3 Consumer acceptance of OFSP

In Nigeria, Omodamiro, Afuape, Njoku, Nwankwo, Echendu & Edward (2013) evaluated the acceptance of 15 types of sweet potato, ranging from white-fleshed to deep orange-fleshed genotypes. Twenty semi-trained panellists, drawn from the National Root Crops Research Institute staff and Michael Okpara University of Agriculture participated in the study. Panellists scored the samples for general acceptability, mouth feel, flavour and colour. The panellists scored the food products made with OFSP highest, indicating that they liked it more than products made from other varieties of sweet potato. Similarly, Leksrisompong, Whitson, Truong & Drake (2012) evaluated 12 different varieties of sweet potatoes using 90 adult sweet potato consumers in the United States of America (USA). OFSP was also found to be most preferred by the consumers compared to other sweet potato varieties. Ssebuliba, Muyonga & Ekere (2006) tested the acceptability of OFSP among adults and children residing in Iganga and Kamuli districts, Eastern Uganda. The Iganga and Kamuli districts were chosen because they plant and consume white-fleshed sweet potato regularly. Children accepted and rated the OFSP more highly compared to the local white-fleshed sweet potato (Ssebuliba *et al* 2006).

Van Jaarsveld *et al* (2005) also tested the acceptability of OFSP. The majority (92%) of the children accepted the OFSP and were willing to consume it every day. The taste was found to be acceptable and 67% of the children wanted to consume a larger portion size of the OFSP. In a Kenyan study by Hagenimana, Oyunga, Low, Njoroge, Gichuki & Kabira (1999) approximately 300 children aged five years and below were accepting of OFSP. This study was a food-based study conducted in two rural villages in Kenya to introduce OFSP in local communities. In one community the introduction of OFSP was accompanied by additional support in terms of nutrition education, training in sweet potato processing methods and technical assistance while the community that served as the control did not receive any additional support. The community that received additional support (intervention) showed an increase in the intake of vitamin A-rich foods, while the control group experienced a decrease in the consumption of vitamin A-rich foods during the course of the study.

A Tanzanian study to test the acceptability of OFSP compared to white-fleshed sweet potato found that both adults and children accepted the OFSP. In addition, children seemed to prefer the OFSP to the white-fleshed sweet potato (Kulembeka, Rugutu, Kanju, Chirimi, Rwiza & Armour 2004). The above mentioned findings were also reported by Tomlins, Ndunguru, Stambul, Joshua, Ngendello, Rwiza, Amour, Ramadhani, Kapande & Westby (2007) who found that children aged 10-15 years preferred OFSP more than the other sweet potato varieties.

Birol, Meenakshi, Oparinde, Perez & Tomlins (2015) concluded that consumers generally accept biofortified crops with visible traits, even in the absence of nutritional knowledge regarding the crop. When the promotion of these foods was accompanied by nutritional information, acceptance improved and consumers chose the biofortified foods more readily compared to the unbiofortified foods. According to Kulembeka *et al* (2004) adults preferred sweet potato that was high in dry matter while children did not feel the same. There are many interventions in place to combat VAD and more recently biofortified crops have been introduced to assist in the fight against VAD. Specific biofortified crops are intended for specific populations as not all interventions can be equally efficient in delivering vitamin A to every population. The next section reviews the advantages of using OFSP to address VAD.

2.7.4 Advantages of using OFSP to address VAD

OFSP is a relatively new crop in South Africa (Faber *et al* 2013a). Since OFSP has been introduced as an alternative to white-fleshed sweet potato which is already consumed, it is more likely to be accepted compared to introducing a completely new food (Mitra 2012). Retention, which refers to the difference in nutrients levels in a particular food in its raw state and cooked state (Bergström 1994), is another important factor to consider with biofortified staple crops. Retention of vitamin A in OFSP during cooking has been found to be high. Van Jaarsveld, Harmse, Nestel & Rodriguez-Amaya (2006) found that the retention of beta-carotene was 80% when OFSP was cooked using the boiling method.

Assuming 75% vitamin A retention post cooking, consumption of 39 g of OFSP resisto variety grown at a rural village was enough to supply the RDA for vitamin A for a 7-12 month old child and 31 g of the same product could meet the vitamin A RDA for a 4-8 year old child (Faber *et al* 2013c). The high concentration of beta-carotene in OFSP makes it ideal for children who have a small stomach capacity and cannot consume large quantities of food. In addition, this trait is advantageous to people who live in countries where sweet potato is consumed in small amounts as a vegetable instead of as a staple (Faber *et al* 2013c)

The initial breeding provitamin A target for OFSP as set by HarvestPlus was 35 µg/g, however, some varieties contain more than 300 µg/g (Figure 2.5). The potential vitamin A contribution of OFSP is higher per mass than any other biofortified crop (Bouis *et al* 2009). This makes OFSP ideal for children who need concentrated sources of nutrients such as vitamin A because of their small stomach capacity. OFSP is also soft textured making it ideal for children (Faber *et al* 2013a).

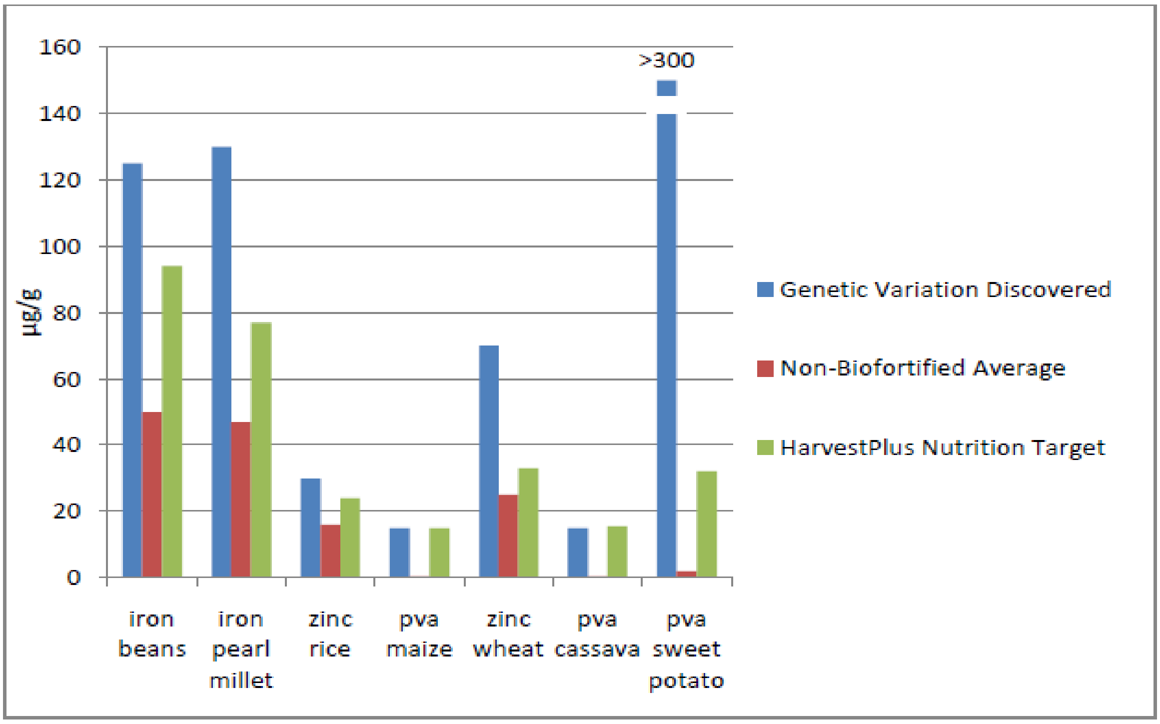


Figure 2.5 Micronutrient content of stable crops (Bouis *et al* 2009)

Laurie, van Jaarsveld, Faber, Philpott & Labuschagne (2012) compared the nutritional composition of a 125 g portion of 12 sweet potatoes in SA, nine of which were OFSP and the rest all white-fleshed sweet potato varieties. The portions of the OFSP varieties were found to contribute more than 100% of the RDA for vitamin A for a child aged 4-8 years old. In the darker orange varieties such as the resisto variety, 125 g provided four times the RDA for vitamin A for a 4-8 year old child. This suggests that only 31.25 g of OFSP per day would be required to meet the child's vitamin A requirements. When compared to the cream-fleshed sweet potato, OFSP contained more calcium and magnesium. All the OFSP varieties analysed in this study contained β-carotene in the *trans*-form, which has higher vitamin A potency compared to the *cis*-form (Laurie *et al* 2012).

2.8 Conclusion

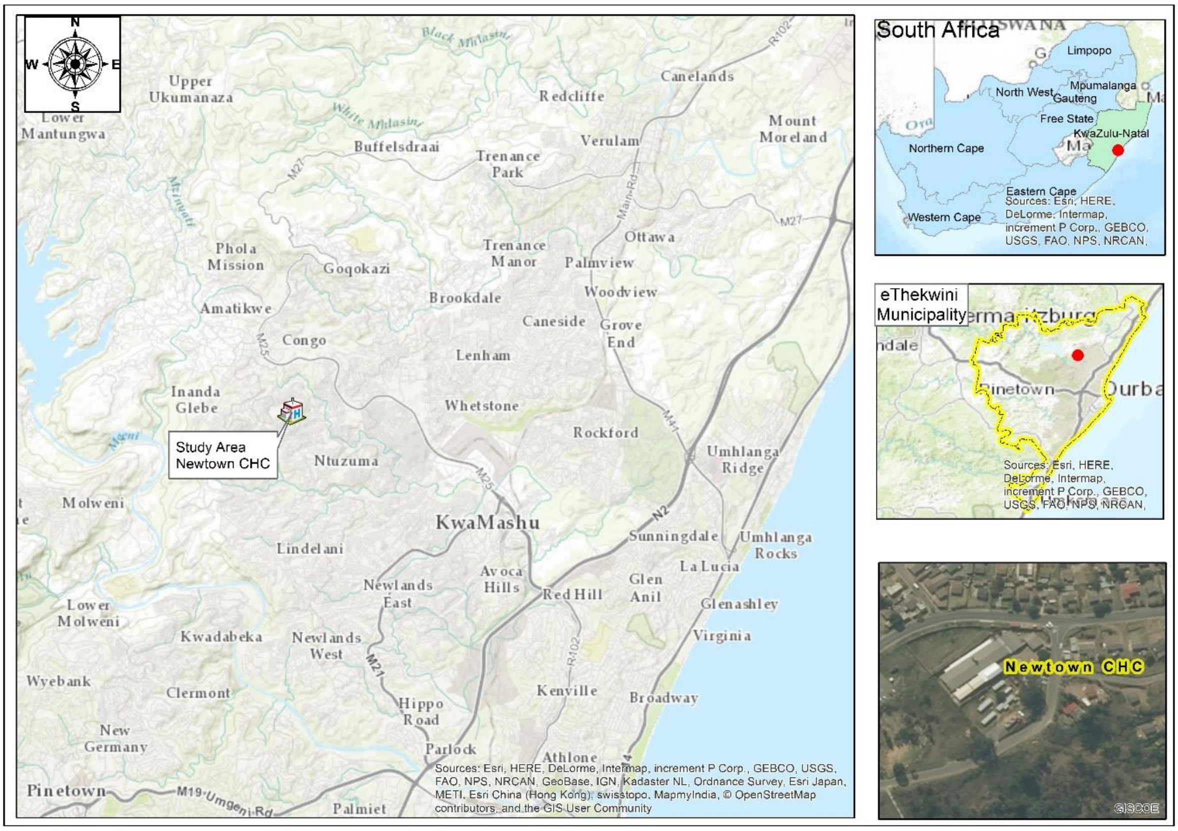
South African children suffer from chronic malnutrition more than acute malnutrition. Chronic malnutrition is caused by a diet that lacks variety, resulting in micronutrient malnutrition, also known as "hidden hunger." Rural communities are most vulnerable to micronutrient malnutrition in SA. The prevalence of VAD remains high in SA, despite a variety of strategies that have been implemented to address it. Commercially fortified foods and health institutions are often inaccessible to those living in remote, rural areas, resulting in minimal benefit from food fortification and vitamin A supplementation. Dietary diversification remains out of reach for poor communities as knowledge without access to food hinders the practical application of this strategy. New strategies that are sustainable and available to the most vulnerable communities are needed to combat VAD. Biofortification is a new strategy that has the potential to combat micronutrient deficiencies, including VAD. Biofortification involves breeding crops to have enhanced micronutrient content. Once a biofortified crop has been developed/bred, it can be reproduced and/or seedlings can be distributed to other regions ensuring sustainability. In SA, the prevalence of malnutrition, including VAD, is highest during the complementary feeding stage. Most complementary foods are maize-based and lack micronutrients, including vitamin A which is essential for infant growth and development. OFSP, which is biofortified with vitamin A, has been found to improve the vitamin A status of children. OFSP is also soft textured making it ideal for children, especially during the complementary feeding stage. Although OFSP is a good source of vitamin A it is deficient in protein. Adding dried beans to OFSP may improve the overall protein content thus creating an ideal complementary food for children eight months and older. The consumer acceptance of such a complementary food has not been tested in South Africa. Therefore, the aim of this study was to assess the nutritional composition and acceptability of a complementary food made with OFSP and dried beans by caregivers of infants who are eight months and older.

CHAPTER 3 : METHODOLOGY

This chapter describes the background of the study site, study design, materials and methods, data analysis and ethical considerations.

3.1 Background of the study site

This study was conducted at the Newtown Community Health Centre (CHC) within the eThekwini Health District in KwaZulu-Natal (Figure 3.1). This CHC is situated at Inanda Newtown "A" and primarily serves Inanda and surrounding areas, including, but not limited to, some areas of Ntuzuma. The Inanda area is approximately 30 km away from central Durban, towards the north west side of the City. This CHC offers basic health services to the community, including integrated management of childhood illnesses (IMCI) which includes growth monitoring and promotion (GMP) services to children under five years of age.



<u>Figure 3.1</u> Location of the study site within the eThekwini Health District

3.2 Study design

The study employed a cross-sectional design, which is shown in Figure 3.2.

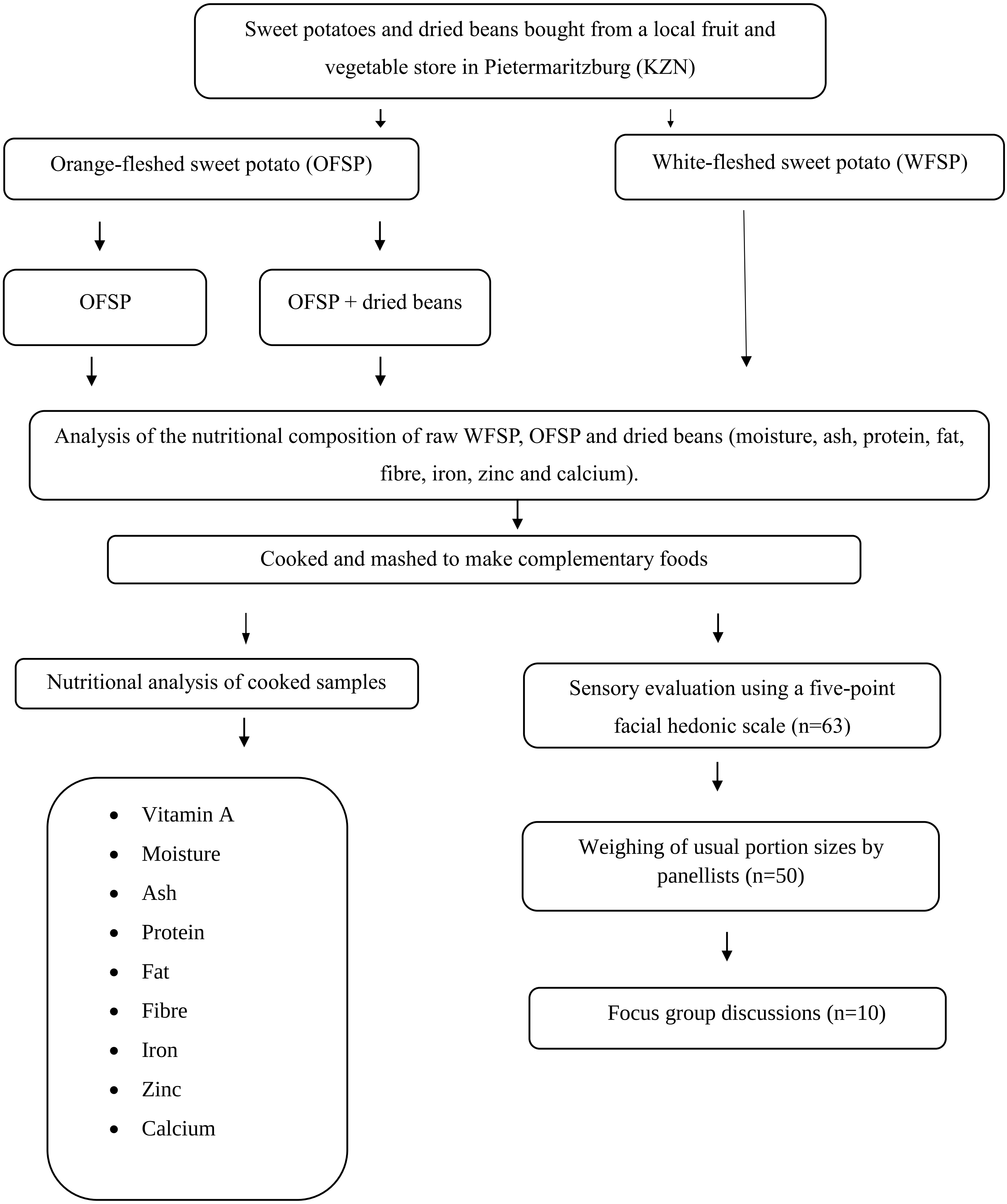


Figure 3.2 Study design

3.3 Study materials and methods

3.3.1 Sweet potato samples

The sweet potato (both OFSP and WFSP) used in this study were bought from a local fruit and vegetable store. Figures 3.3 and 3.4 show the raw sliced OFSP and WFSP respectively.

Figure 3.3 Sliced raw orange-fleshed sweet potato

Figure 3.4 Sliced raw white-fleshed sweet potato

3.3.2 Dried beans

The dried beans were also bought from a local store (Figure 3.5). The dried beans were soaked overnight in a pot filled with cold water the day preceding cooking. The water used for soaking was discarded before cooking.

Figure 3.5 Dried beans *(Phaseolus vulgaris* L*.).*

3.3.3 Preparation of the complementary foods

The complementary foods used were prepared by an adult black African female, from rural Inanda with experience in cooking local dishes for children during the complementary feeding stage. All samples were cooked on the day that the sensory evaluation was conducted. The OFSP, WFSP and dried beans ware each cooked in separate pots. Dried beans are usually cooked with table salt added, hence 1g of table salt was used in the cooking of the dried beans. With the aid of a normal household spatula, the OFSP and dried beans were then prepared into a mash consistency in one pot to yield the complementary food made with OFSP and dried beans. The preparation of this complementary food did not involve a predefined recipe. The aim in making this complementary food was to add enough dried beans to provide nutritional enhancement, with minimal effect on the mash consistency of the food. A trial preparation of the complementary food was conducted in the Food Science Laboratory at Dietetics and Human Nutrition on three separate occasions to establish an appropriate OFSP to dried beans ratio. On the third trial, the best OFSP to dried beans ratio selected was 448g OFSP to 137.1g dried beans. This decision was taken with the help of two senior researchers in the discipline of Dietetics and Human Nutrition at the University, UKZN, Pietermaritzburg campus. Meanwhile the OFSP and WFSP were also individually prepared into mash consistencies in their own separate pots, with no additional ingredients, as that is how sweet potato is usually prepared for the purpose of complementary feeding. After preparation, these items were dished out into separate plastic containers with tight-fitting lids for transportation to the study site. Figures 3.6, 3.7 and 3.8 show mashed OFSP, mashed WFSP and mashed OFSP and dried beans complementary foods respectively.

Figure 3.6 Mashed OFSP complementary food

Figure 3.7 Mashed WFSP complementary food

Figure 3.8 Mashed OFSP and dried beans complementary food

3.3.4 Nutritional analysis

The raw samples (OFSP, WFSP and dried beans) and cooked samples (OFSP, WFSP and OFSP and dried beans) were transported from the study site to the Animal and Poultry Science Department, UKZN, Pietermaritzburg campus, to be freeze-dried. After the samples were freeze-dried, a cold chain was maintained until the samples were transported to the laboratories for nutritional analysis. The nutritional analyses of the samples were done in duplicate. The nutritional composition of all samples was analysed using standard methods at Soil Science and Analytical Services, CEDARA College of Agriculture in KwaZulu-Natal. The vitamin A analyses was conducted at the Agricultural Research Council (ARC) in Irene, Gauteng.

3.3.4.1 Protein

Protein was measured using the Dumas combustion method by the leco trumac instrument. The samples were subjected to combustion at 800-900°C to convert all forms of nitrogen to nitrogen oxide. This was then reduced to nitrogen gas which was quantified by the thermal conductivity detector (Jung, Rickert, Deak, Aldin, Recknor, Johnson & Murphy 2003).

3.3.4.2 Fibre

Fibre was determined by the Van Soet method using the digestion block instrument. The fibre was analysed as neutral detergent fibre (NDF) (Goering & Van Soet 1970).

3.3.4.3 Fat

Fat was determined by the Sohxlet method described in the AOAC official method 920.39. Petroleum ether was used for extraction (AOAC 1980).

3.3.4.4 Ash and individual elements

Ash (total mineral content) was analysed using the AOAC Official Method 942.05. The hunter process was utilised in the analysis of the individual minerals (AOAC 1980).

3.3.4.5 Moisture

Moisture was analysed according to the AOAC method 934.01. A crushed sample was weighed to the nearest mg and then placed uncovered in an oven at 105°C for 16 hours. The sample was removed from the oven, covered tightly, cooled and weighed. Moisture content was calculated and reported as percentage (W/W) using the formulae:

$$Moisture = \frac{(g\ received\ sample - g\ oven\ dried\ sample) \times 100\ g}{g\ as\ received\ sample}$$ (AOAC 1980).

3.3.4.6 Vitamin A

As stated in the literature review chapter, in plants vitamin A exists in the precursor form as provitamin A. However, in this study, the provitamin A levels in the samples were analysed using a method that inherently quantifies, and expresses them as retinol equivalents. The samples were subjected to alkaline saponification to expel fat and natural provitamin A in the cells. Provitamin A was then extracted using ether, after which a high performance liquid chromatography (HPLC) was used to quantify the amount of retinol present. A quaternary gradient pump (model LC-20AD), a solvent degasser (model DGU-20A5), an auto-injector (model SIL-20A, 230V), a photodiode array detector (DAD), thermostatted standard cell (model SPD-M20A) and control and integration software (LCsolution Ver. 1.1) made up the HPLC system. A guard column incongunction with Nucleodur 250X4 mm reverse phase C18 column (5μm particle size), mobile phase of 97% methanol in deionised water with a flow rate of 1.0 mL/min was used at 325nm to identify and quantify provitamin A carotenoids as retinol equivalents (Hulshof 2002).

3.4 Pilot study

A pilot study of the sensory evaluation was conducted prior to the main study. All the subjects who participated in the pilot study were isiZulu-speaking African females. The participants were recruited from the Newtown CHC Paediatric Outpatient Department (POPD). The researcher briefly explained the study to all the caregivers in the waiting room and then randomly selected 10 participants from those that were willing to participate. All caregivers who agreed to participate were then taken to another room where the study took place. Ten caregivers participated in the sensory evaluation of which five were randomly selected to participate in the focus group discussions. The focus group discussions were conducted after the sensory evaluations had been concluded. The panellists who participated in the pilot study were not permitted to participate in the main study to reduce bias. The researcher ensured this by conducting the pilot study on a Monday in the first week of the month while the main study was conducted on Tuesday, Thursday and Friday of the third week of the month. The pilot study was a trial run for the main study and served to streamline all procedures and processes to be followed in the main study.

The main findings of the pilot study were as follows:

1. The recruitment and the sensory evaluation needed to start earlier in the morning before the patients had been seen by the nursing staff to maximise the number of patients recruited per day. During the pilot study it was found that the patients who had already consulted the nursing staff chose not to participate in the study.
2. The venue for the study needed to be changed. The venue used in the pilot study was too far away from the POPD which made recruitment difficult. The venue was also too small and could not comfortably accommodate all participants.
3. The samples needed to be warmed for six seconds before the sensory evaluation using a microwave oven set on medium heat.

3.5 Sensory evaluation

A total of 63 caregivers (panellists) who had children aged eight to 24 months in their care at the time of the study participated in the main sensory evaluation. The sensory evaluation took place at the Newtown CHC conference room, adjacent to the POPD. All the panellists were recruited from POPD. A five-point facial hedonic scale was used to rate the OFSP and dried beans complementary food, OFSP and WFSP (control). The panellists rated each sample either “very bad”, “bad”, “neutral”, “good” or “very good” for various sensory attributes (Figure 3.9).

Figure 3.9 Caregivers participating in the sensory evaluation

The attributes rated were taste, texture, colour, aroma and overall acceptability of the samples. The researcher briefly explained the study to all the caregivers in the waiting area and invited them to participate. The researcher requested to see the Road to Health Booklets of the children to ensure that the caregivers had children of between eight to 24 months of age in their care at the time of the study. Four panellists evaluated the samples in each session. The panellists were escorted to the conference room where a consent form was issued and explained. The consent form was presented either in isiZulu (Appendix A) or English (Appendix B), depending on the panellist's preference. The sensory evaluation started as soon as all the panellists had signed the consent form. The researcher then proceeded to give every panellist a pen, the questionnaire in isiZulu (Appendix C) or English (Appendix D), depending on preference, a polystyrene cup of water for cleaning the palate in between tasting samples, a plastic spoon and a serviette. The samples were coded using three digit random numbers from the Table of Random Numbers (Heymann 1995). The questionnaires were copied on coloured paper and this served as a coding system for the different samples i.e. blue was for OFSP only, white (OFSP and beans) and yellow for the control (white-fleshed sweet potato). The samples were served from left to right in a randomised order. Each panellist received 30 ml of the sample in a 200 ml polystyrene cup. The samples were plated by the research assistants and warmed for six seconds in the microwave oven (set on medium) immediately before being served to the panellists. The researcher and research assistants ensured that there were no spoiled or blank questionnaires.

3.6 Determination of usual portion sizes

After the panellists had completed the sensory evaluation they proceeded to the weighing station. While all the 63 panellists were invited to participate in the main sensory evaluation, only 50 panellists participated in the determination of usual portion size due to space limitations on the last day of the study. At the weighing station a pot of the complementary food made with OFSP and dried beans, a bowl and a serving spoon were placed on a table (Figure 3.10). All the panellists were then requested to plate up the amount of the complementary that they would plate up if they were dishing up for their child at home. Before the researcher weighed the portion of the complementary food the scale was balanced using the "tare" button with the empty bowl on the balance. The age and gender of the child for whom they were plating up was also recorded.

Figure 3.10 Portion size weighing station

3.7 Focus group discussions

A smaller sample (n=10) of the 63 panellists was randomly selected to participate in focus group discussions to determine their perceptions of the sweet potato-based samples evaluated. The focus group discussion participants were volunteers from the sensory evaluation panellists. Focus group discussion questions were prepared in English (Appendix E) and isiZulu (Appendix F) prior to the study. Two focus group discussions took place, one with six participants and the other with four participants. Space limitations restricted the focus group discussions to a maximum of six seated panellists per session, hence the decision to split the group into two smaller groups. A trained facilitator who spoke the local language (isiZulu) facilitated the focus group discussions. The sessions were recorded using a digital recording device while notes were taken by one of the research assistants (scribe). The focus group discussion responses were translated from isiZulu to English by the facilitator. The English responses were cross-checked against the recordings for accuracy by a person fluent in both English and isiZulu.

3.8 Data analysis

The results were analysed using the Statistical Package for Social Science (SPSS) version 15.0 SPSS Inc, Chicago, Illinois, USA. The one-way analysis of variance (ANOVA) and Dunnett tests were used to assess statistical significance in the differences of means. A p-value of greater than 0.05 was regarded as significant. The focus group discussion transcripts were analysed using Content Analysis to identify and interpret key themes.

3.9 Ethical considerations

Ethical approval to conduct this study was obtained from the University of KwaZulu-Natal (UKZN), Humanities and Social Sciences Ethics Committee (Reference number: HSS/0486/01514) (Appendix G). Approval to use subjects from the eThekwini District for the sensory evaluation was granted by the KZN Department of Health, Health Research & Management sub-component (Reference: HRKM180/15 (Appendix H). A letter of support was also issued by the Medical Manager of the Newtown CHC (Appendix I). All subjects were given a consent form to read in the language they understood before commencing with the study. Panellists were also encouraged to ask questions if they did not understand anything or if they needed clarification regarding the information on the consent form. The panellists who needed clarification were attended to individually by the researchers until they received clarification and signed. The sensory evaluation only commenced once all panellists had signed the consent form.

CHAPTER 4 : RESULTS

This chapter presents the results of the study.

4.1 Nutritional composition of the complementary food samples

Table 4.1 shows the nutritional composition of the various complementary food samples (OFSP and dried beans, OFSP and WFSP). WFSP served as the control.

Table 4.1 Nutritional composition of OFSP and dried beans, OFSP and WFSP [dry basis (db)]

	Moisture (g/100g)	**Ash (g/100g)**	**Fat (g/100g)**	**Crude protein (g/100g)**	**NDF (g/100g)**	**Vitamin A (µg /100g)**	**Iron (mg/100g)**	**Zinc (mg/100g)**	**Calcium (mg/100)**
Raw Samples									
Dried beans	**11.44[a] (0.46)[b]**	**4.17 (0.42)[c]**	**1.53 (0.01)**	**21.30 (1.78)**	**23.03 (3.56)**	0.00	**8.50 (0.42)**	**3.80 (0.00)**	15 (0.00)
OFSP	89.13 (2.94)	**3.07 (0.08)**	**1.24 (0.15)**	**4.29 (0.02)**	11.93 (0.65)	0.00	1.60 (0.62)	**0.90 (0.00)**	28 (8.49)
WFSP	85.72 (12.13)	2.02 (0.08)	0.58 (0.13)	1.33 (0.14)	11.69 (0.65)	0.00	3.70 (0.71)	0.40 (0.00)	12 (0.00)
Cooked samples									
OFSP and dried beans	10.07 (0.44)	**3.70 (0.12)**	**13.50 (0.40)**	14.64 (1.34)	**17.38 (1.30)**	NM	4.40 (0.28)	**1.80 (0.14)**	15 (0.72)
OFSP	15.56 (1.95)	**2.68 (0.47)**	**1.35 (0.24)**	9.28 (1.14)	9.47 (0.66)	NM	2.95 (0.64)	0.75 (0.21)	18 (3.54)
WFSP (control)	13.53 (1.07)	2.07 (0.05)	0.30 (0.18)	11.61 (0.41)	8.48 (0.06)	NM	3.60 (0.28)	0.85 (0.07)	20 (2.83)

NDF= Neutral detergent fibre
NM= Not measured
[a] Mean of at least two determinations
[b] Standard deviation
[c] Total minerals
Values in bold are statistically significantly different from the control (raw WFSP for the raw samples, and cooked WFSP for the cooked samples) for that nutrient (Dunnett test, $p < 0.05$)

Raw samples

The ash content of the dried beans [4.17 g/100g (±0.42)] was significantly higher than the ash content in the WFSP [2.02 g/100g (±2.02)]. Both the dried beans [1.53 g/100g (±0.01)] and OFSP [1.24 g/100g (±0.15)] had higher fat content compared to the WFSP [0.58g/100g (±0.13)]. Dried beans had the highest protein content [21.30 g/100g (±1.78)] compared to both the OFSP [4.29 g/100g (±0.02)] and WFSP [1.33 g/100g (±0.14)]. The neutral detergent fibre (NDF) content of the dried beans [23.03 g/100g (±3.56)] was significantly higher than that of the OFSP [11.93 g/100g (±0.65)] and WFSP [11.69 g/100g (±0.65)], respectively. The iron content of the dried beans [8.50 mg/100g (±0.42)] was higher than that of the OFSP [1.60 mg/100g (±0.62)] and WFSP [3.70 mg/100g (±0.71], respectively. A significantly higher zinc content was also found in the dried beans [3.80 mg/100g (±0.00)] compared to the OFSP [0.90 mg/100g (±0.00)] and WFSP [0.40 mg/100g (±0.00)]. No vitamin A was detected in any of the samples.

Cooked samples

The OFSP and dried beans complementary food had the highest ash (total mineral) content [3.70 g/100g (±0.12)] compared to the OFSP [2.68g/100g (±0.46)] and WFSP [2.07 g/100g (±0.05)] complementary foods. The fat content of the complementary food made with OFSP and dried beans [13.5 g/100g (±0.40)] was higher than that that of the OFSP alone [1.35 g/100g (±0.24)] and WFSP alone [0.3 g/100g (±0.05)], respectively. The fibre content was highest in the OFSP and dried beans complementary food [17.38 g/100g (±1.30)] compared to the OFSP [9.47 g/100g (±0.66)] and WFSP [8.48 g/100g (±0.06)] complementary foods.

4.2 Usual portion and percentage of Recommended Dietary Allowance met

Table 4.2 shows the average portion sizes, minimum, maximum, median and standard deviations of the weighed samples of the complementary food made with OFSP and dried beans (n =50) for both the 6-12 and 13-24 month age groups.

Table 4.2 Usual portion size of the complementary food made with OFSP and dried beans for both the 6-12 and 13-24 month age groups (n =50)

Participants (n = 50)	**6-12 months (n=27)**	**13-24 months (n=23)**
Mean portion size (g)	121	165
Minimum (g)	32	70
Maximum (g)	280	296
Median (g)	101	175
Standard Deviation (SD)	51	62

The mean usual portion size for the 13-24 month old age group (165 ± 62 g) was higher than the 6-12 month old age group (121 ± 51 g).

Table 4.3 shows the estimated usual portion of the complementary food made with OFSP and dried beans, the amount of nutrients provided by the usual portion, the RDA and percentage of RDA met for selected nutrients in the age groups studied (6-12 months and 13-24 months).

Table 4.3 Percentage of the RDA met for selected nutrients for the different age groups when a usual portion of OFSP and dried beans complementary food is consumed

	Crude protein (g/100g)	**Fat (g/100g)**	**Iron (mg/100g)**	**Zinc (mg/100g)**	**Fibre (mg/100g)**	**Calcium (mg/100g)**
6-12 months						
RDA	11	30	11	3	ND	260
Amount provided by usual portion	17.71	16.34	5.32	2.18	20.57	18.15
RDA met (%)	161.0	54.47	48.4	72.6	N/A	7.0
13-24 months						
RDA	13	ND	7	3	19[a]	700
Amount provided by usual portion	23.86	N/A	7.21	2.97	28.05	24.75
RDA met (%)	183.5	N/A	103.0	99.0	147.6	3.5

The usual portion for the 6-12 month age group was determined as 121 g (From Table 4.2)

The usual portion for the 13-24 month age group was determined as 165g (From Table 4.2)

ND = Not determinable due to lack of data of adverse effects in this age group and concern with regard to lack of ability to handle excess amounts. Source of intake should be from food only to prevent high levels of intake (United States Department of Agriculture: Food and nutrition information center 2016).

NA = Not available due to lack of values.

[a] Acceptable macronutrient distribution range (AMDR).

4.3 Sensory acceptance of the complementary foods

The age groups of the sensory evaluation participants are shown in Table 4.4.

Table 4.4 Sensory evaluation panellists grouped according to age (n=63)

Age (years)	**Number (n)**	**Percentage (%)**
15-20	12	19
21-25	26	41
26-30	8	13
31-45	7	11
46-55	10	16

All the panellists (n=63) who participated in the study were black African female caregivers.

The highest proportion of panellists was in the 21-25 year age group (n=26; 41%), followed by the 15-20 year age group (n=12; 19%) and the 46-55 year age group (n=10; 16%). Table 4.5 and Figure 4.1 present the results of the sensory evaluation.

Table 4.5 Sensory acceptability of the OFSP and dried beans complementary food, OFSP and WFSP (control) according to sensory attributes

	Sensory attributes				
Samples	**Taste**	**Texture**	**Aroma**	**Colour**	**OA**
OFSP and dried beans	3.14[a] (1.39)[b]	3.46 (1.18)	3.51 (1.05)	3.57 (1.27)	3.77 (1.14)
OFSP	3.57 (1.09)	3.60 (1.04)	3.49 (1.16)	3.95 (0.94)	3.93 (1.00)
WFSP (control)	3.46 (1.10)	3.59 (1.09)	3.62 (1.04)	3.43 (1.10)	3.56 (1.05)

OA= overall acceptance

[a] Mean of at least two values

[b] Standard deviation

According to the Dunnett test, the sensory attribute ratings for the complementary foods made with OFSP and dried beans and that made with OFSP alone were not statistically significant from the sensory ratings for the complementary food made with WFSP alone (control).

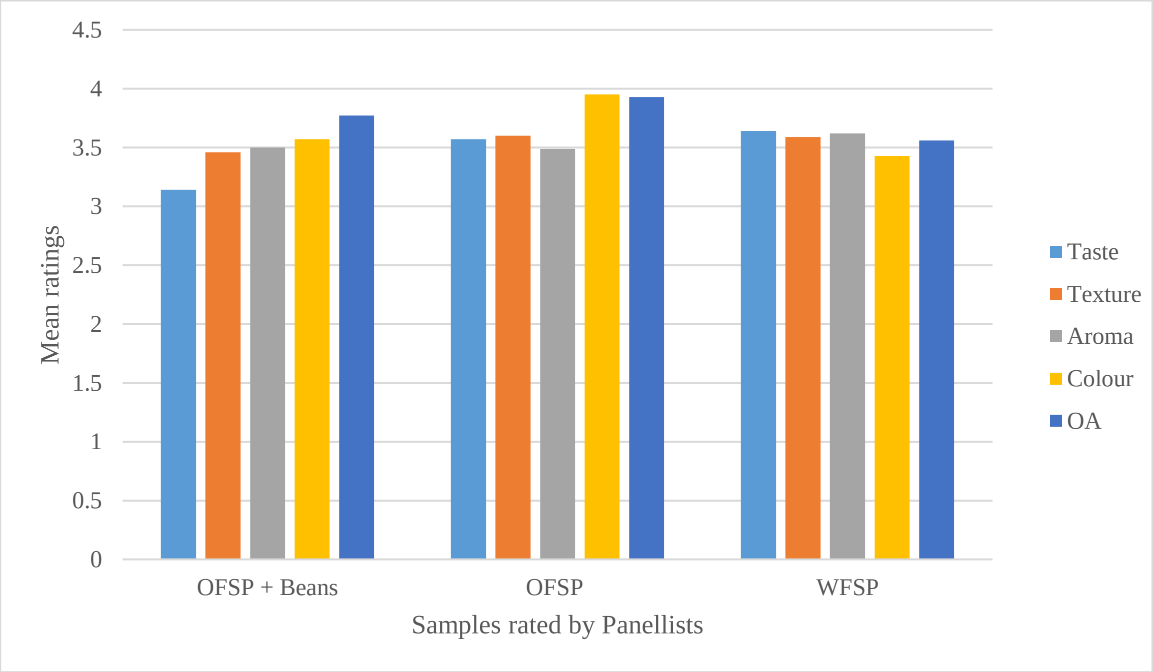


Figure 4.1 Sensory attribute ratings for the complementary foods made with OFSP and dried beans, OFSP and WFSP (control)

Table 4.6 shows the sensory acceptance ratings of the three samples evaluated for their sensory attributes.

Table 4.6 Number and percentage of panellists who gave the different ratings for the sensory attributes evaluated (n=63)

Complementary food Samples	Attributes (n)	Very bad n (%)	Bad n (%)	Neutral n (%)	Good n (%)	Very good n (%)
OFSP alone	Taste	3[a] (4.8)[b]	7 (11.1)	17 (27.0)	23 (36.5)	13 (20.6)
	Texture	4 (6.3)	2 (3.2)	21 (33.3)	24 (38.1)	12 (19.0)
	Aroma	4 (6.3)	8 (12.7)	18 (28.6)	19 (30.2)	14 (22.2)
	Colour	0 (0)	6 (9.5)	11 (17.6)	26 (41.0)	20 (31.7)
	OA	1 (1.6)	5 (7.9)	13 (20.6)	23 (36.5)	21 (33.3)
OFSP and dried beans	Taste	10 (15.9)	11 (17.5)	17 (27.0)	10 (15.9)	15 (23.8)
	Texture	3 (4.3)	12 (19.0)	15 (23.8)	19 (30.2)	14 (22.2)
	Aroma	3 (4.8)	6 (9.5)	21 (33.3)	22 (22)	11 (17.5)
	Colour	3 (4.8)	13 (20.6)	12 (19.0)	15 (23.8)	20 (31.7)
	OA	1 (1.6)	9 (14.3)	16 (25.4)	14 (22.2)	23 (34.5)
WFSP alone	Taste	3 (4.8)	9 (14.3)	19 (30.2)	20 (31.7)	12 (19.0)
	Texture	3 (4.8)	7 (11.1)	17 (25.4)	24 (38.1)	13 (20.6)
	Aroma	3 (4.8)	5 (7.9)	17 (27.0)	26 (41.3)	12 (19.0)
	Colour	4 (6.3)	8 (12.7)	18 (28.6)	23 (36.5)	10 (15.9)
	OA	3 (4.8)	4 (6.3)	9 (14.3)	30 (47.6)	17 (27.0)

OA= overall acceptability

[a] number of panellists

[b] percentage of total number of panellists

Acceptability rating 1-5: 1=very bad; 2=bad; 3=neutral; 4=good; 5= very good

Figures 4.2, 4.3 and 4.4 show the percentage of panellists who rated each sensory attribute as very bad, bad, neutral, good or very good for complementary foods made with OFSP and dried beans, OFSP alone and WFSP alone, respectively.

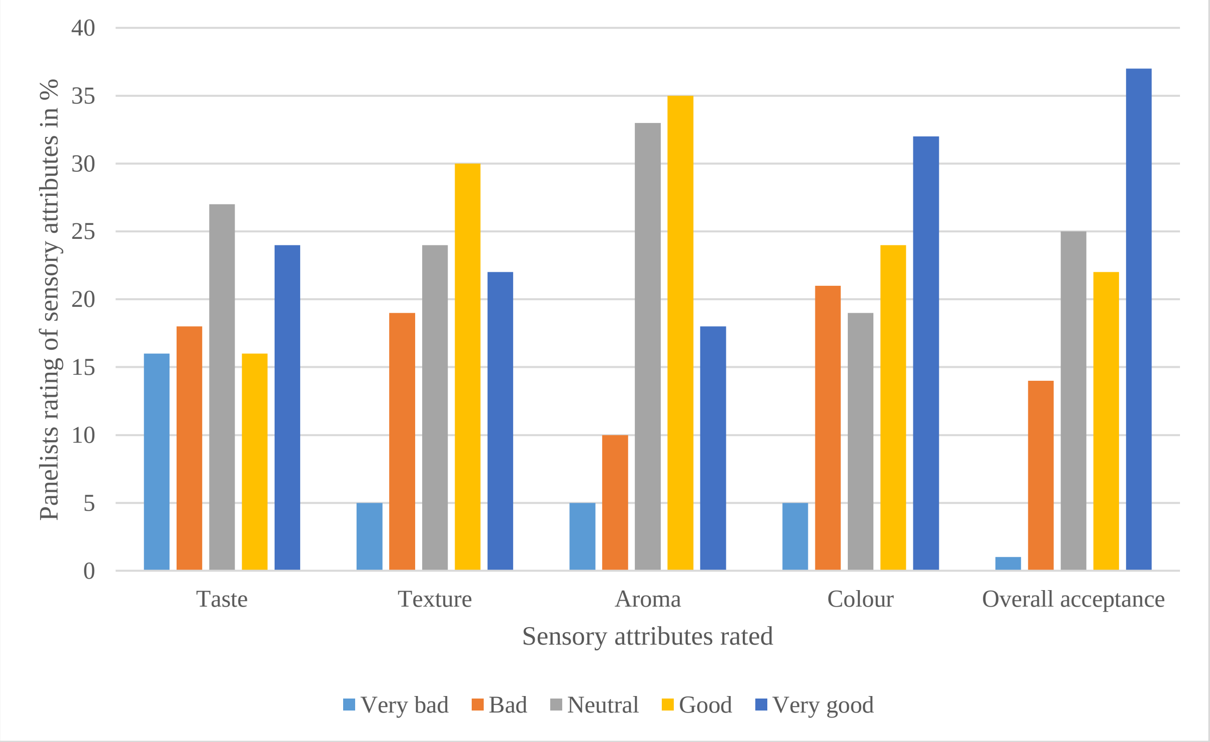


Figure 4.2 Sensory acceptance of a complementary food made with OFSP and dried beans

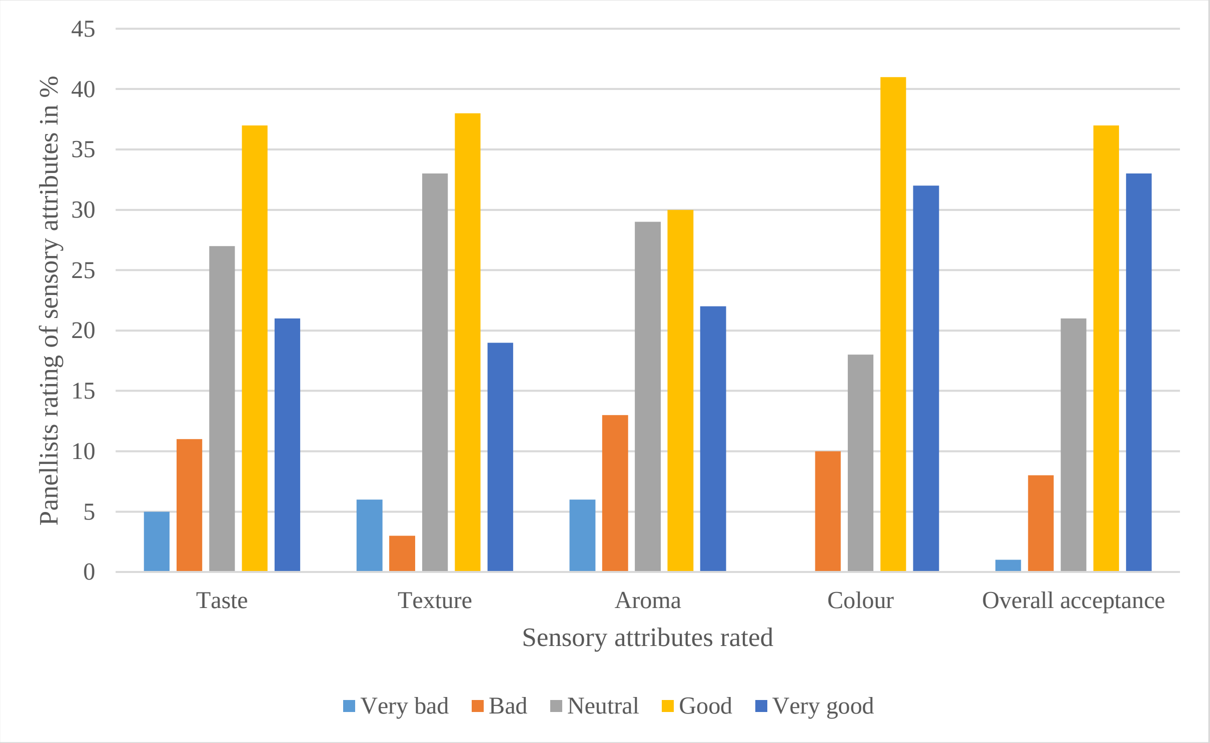


Figure 4.3 Sensory acceptance ratings of a complementary food made with OFSP alone

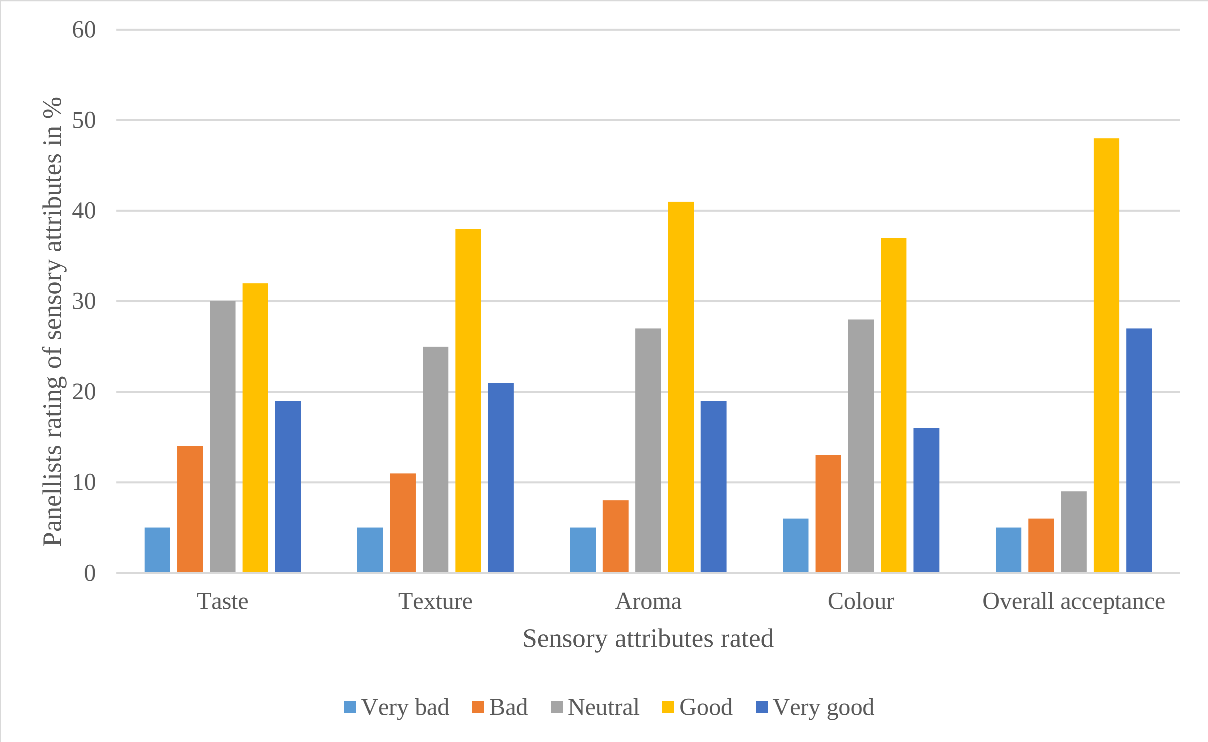


Figure 4.4 Sensory acceptance ratings of a complementary food made with WFSP alone

4.4 Focus group discussions

The panellists who participated in the focus group discussions had positive perceptions of the OFSP based complementary food evaluated. All the panellists who participated in the focus group discussion had not seen or tasted the OFSP before. When the panellists indicated their perception regarding the taste, texture, colour and the aroma of the samples they had tasted, the OFSP was lauded the most for its colour and texture. The panellists associated the soft texture with less risk of choking and felt that the bright colour would appeal to children. The panellists were willing to buy the OFSP from food markets if it was cheaper or had a lower price compared to the WFSP. The findings of the focus groups discussions are presented and discussed in Table 5.1 (Chapter 5).

4.5 Summary of results

The raw dried beans contained significantly higher ash, fat, crude protein, fibre, iron and zinc compared to both the raw OFSP and WFSP. The complementary food made with OFSP and dried beans contained significantly higher ash, fat, fibre and zinc compared with the complementary foods made with OFSP alone and WFSP alone, respectively. The complementary food made with OFSP and dried beans met 100% of the RDA for protein in both age groups and iron in the 13-24 month age group. In addition, the complementary food made with OFSP and beans met more than half the RDA for zinc in both the age groups and fat in the 8-12 month age group. The complementary food made with OFSP and dried beans was as acceptable as the complementary foods made with OFSP alone and WFSP alone, respectively. The taste, texture, aroma, colour and overall acceptability of the complementary food made with OFSP and dried beans did not differ significantly from the one made with OFSP alone and the control. The focus groups showed that while the OFSP was unfamiliar, the OFSP-based complementary foods were acceptable to consumers and they would buy the OFSP over the WFSP if it was cheaper or the same price as the WFSP.

CHAPTER 5 : DISCUSSION

In this chapter the results presented in Chapter four are discussed.

5.1 Nutritional composition of the complementary foods

The first objective of this study was to investigate the nutritional composition of a complementary food made with OFSP and dried beans, compared to complementary foods made with OFSP alone and WFSP alone. The complementary food made with OFSP and dried beans was found to be nutritionally superior to the complementary foods made with OFSP alone and WFSP alone, respectively. Compared to the OFSP and WFSP, the complementary food made with OFSP and dried beans contained a significantly higher fat, ash (total mineral content), fibre, and zinc content. Moreover, although not statistically significant, the complementary food made with OFSP and dried beans was higher in both protein and iron compared to the complementary foods made with OFSP alone or WFSP alone.

The highest fat content was found in the complementary food made with OFSP and dried beans, followed by the complementary foods made with OFSP alone and WFSP alone. Furthermore, the OFSP on its own had a higher fat content in both the raw and cooked state, when compared to the WFSP. The higher fat content in the complementary food made with OFSP and dried beans was due to the addition of margarine during preparation. The fat content of the OFSP on its own was also higher than that of the WFSP on its own. Although energy was not analysed in the current study, it is known that sweet potato is naturally a good source of energy (Hagenimana *et al* 2001) and adding margarine was expected to have increased the energy density of the dish even more. The addition of fat in the form of vegetable oils to increase the energy density of complementary foods is recommended by the FAO/WHO (1998). Furthermore, fat also increases the bioavailability of vitamin A (Morgan & Dickerson 2003) and improves the palatability and overall acceptability of food (Schönfeldt, Pretorius & Hall 2013).

In this study, vitamin A was not detected in the raw samples. This was rather surprising as OFSP was expected to contain vitamin A in the form of provitamin A carotenoids. As a result of these findings, vitamin A analysis was not done in the cooked samples. A possible reason for this might be that the methodology used in the current study was not sensitive enough to detect any vitamin A in the raw samples. It is also possible that the vitamin A levels in the raw OFSP could have decreased to undetectable levels due to decomposition. Undesirable storage conditions, including exposure to heat and light, which are known to destroy provitamin A carotenoids, could have caused decomposition of provitamin A carotenoids which were presumably in the freshly harvested OFSP.

Ash (total minerals) content was the highest in the complementary food made with OFSP and dried beans. Additionally, the ash content was higher in the complementary food made with OFSP alone compared to that made with WFSP alone. These findings are consistent with recently published findings by Sanoussi, Adjatin, Dansi, Adebowale, Sanni & Sanni (2016), who found that orange and yellow sweet potato varieties contained higher amounts of ash compared to white/cream fleshed varieties. While the OFSP had a higher ash content than the WFSP, the addition of dried beans to the OFSP increased the ash content further. This is evidenced by the significantly higher ash content found in the complementary food made with OFSP and dried beans compared to the OFSP and WFSP. The higher total mineral content suggests that the complementary food would benefit populations with micronutrient deficiencies.

The fibre content in the raw OFSP and WFSP did not differ significantly and a similar finding was observed in the cooked OFSP and WFSP. This differs from Sanoussi *et al* (2016) who found that orange-yellow sweet potato varieties contained higher fibre compared to WFSP varieties. In the current study, raw dried beans contained significantly higher amounts of fibre compared to those found in both the OFSP and WFSP respectively. The complementary food made with the OFSP and dried beans contained the highest amount of fibre (17.38 g/100g) compared to the complementary foods made with OFSP alone (9.47 g/100g) and that made with WFSP alone (8.48 g/100g). Dried beans are a good source of fibre (Messina 2014), and this contributed significantly to the higher fibre content found in the complementary food made with OFSP and dried beans. Fibre found in dried beans is mostly in the form of soluble fibre (Galisteo, Duarte & Zarzuelo 2008). Soluble fibre dissolves in the presence of water, softening the stool and making it easier to pass through the gastrointestinal tract, thus preventing or treating constipation (British Nutrition Foundation 2016). A lack of fibre has been shown to cause constipation in children (Roma, Adamidis, Nikolara, Constantopouos & Messaritakis 1999) and found to be just as effective as lactulose in alleviating constipation in children (Kokke, Scholtens, Alles, Decates, Fiselier, Tolboom, Kimpen & Benninga 2008). The high fibre content of the complementary food made with OFSP and dried beans could improve fibre intake in children thereby reducing risk for constipation.

Zinc was also found in highest amounts in the complementary food made with OFSP and dried beans. Zinc content in the sweet potato varieties did not differ significantly while dried beans contained significantly more zinc than the sweet potato varieties. This was the case in the analysis of both raw and cooked samples. It can be concluded that the zinc content of the dried beans enhanced the overall zinc content of the complementary food made with OFSP and dried beans. Zinc is an important micronutrient as it plays a role in immune response (Stefanidou, Maravelias, Dona & Spiliopouloou 2006) and has been shown to improve immunity in developing countries (Zinc Investigators' Collaborative Group 1999; Shankar & Prasad 1998). Optimal zinc intake decreases mortality and morbidity rates in children due to the role it plays in the treatment of diarrhoea (Lazzerini & Ronfani 2011; Sharief, Butta, Schauer, Tomlinson, Zloktin 2006; Baqui, Black, EL Arifeen, Yunus, Chakraborty, Ahmed &Vaughan 2002; Dutta, Mitra, Datta, Niyogi, Dutta, Manna, Basak, Mahapatra & Bhattacharaya 2000). According to Gibson, Yeudall, Drost, Mtitimuni & Cullinan (1998), soaking dried beans in water may increase zinc absorption which is antagonised by the phytate found in the beans. The dried beans used in the current study were soaked in cold water overnight before cooking. A complementary food made with OFSP and dried beans has the potential to improve zinc intake, especially in SA where complementary foods lack micronutrients, including zinc (Faber 2005).

Raw dried beans alone contained significantly higher iron than both raw OFSP and raw WFSP. Dried beans are naturally a good source of iron (Messina 2014). While not statistically significant, the OFSP and dried bean complementary food contained more iron compared to the complementary foods made with OFSP alone and WFSP alone, respectively. Iron deficiency is one of the most common micronutrient deficiencies in South Africa (Faber *et al* 2013b). The NFCS (1999) found that iron intake in all SA provinces was less than two-thirds of the RDA (Labadarios *et al* 2005a). In 1994, 21.4% of children in SA were anaemic and those aged 6-23 months old were at highest risk for this condition (Labadarios & Van Middelkoop 1995). This number increased to 28.9% in the NFCS conducted in 2005 but has since decreased. Shisana *et al* (2013) reported a prevalence of 10.7% in the SANHANES-1 study. Faber & Benadé (1999) found poor iron status in KZN children, with 43.2% of children under the age of two years having serum ferritin levels <10 μgL^{-1} indicating low iron stores. Faber (2007b) reported a higher prevalence of iron deficiency anaemia (35%) in KZN children aged 6-11 months compared to the national figure of 9.3%. Anaemia is most frequently caused by a diet low in iron (Shisana *et al* 2013). Diets low in iron have been found to be associated with a higher prevalence of anaemia in KZN (Faber 2007b). In addition, children who are iron deficient have been found to have a higher risk of being underweight and/or stunted (Faber 2007b; Labadarios & van Middelkoop 1995). Children that suffer from severe and/or chronic iron deficiency in infancy have also been found to have poor cognitive outcomes ten years later (Luzoff, Jimenez, Hagen, Mollen & Wolf 2000).

5.2 Contribution of the complementary food made with OFSP and dried beans to the Recommended Dietary Allowance (RDA) for selected nutrients

The results of this study showed that consuming the usual portion of the complementary food made with OFSP could meet the RDA for protein in both age groups (6-12 and 13-24 months). This has potential implications for both acute and chronic malnutrition, especially in SA. Stunting (chronic malnutrition) and wasting are still prevalent in SA (Shisana *et al* 2013). A chronic insufficient protein intake is one of the major causes of stunting and is potentially irreversible (Cogill 2003). Stunting is most common in children in their first or second year of life (Smuts *et al* 2004). High-quality protein is usually derived from animal sources. Although plants offer a significant protein content, it is of a lower quality (Millward 1999). In developing countries, protein is often derived from sources of plant origin (Messina 2014). Dried beans are a cheaper source of protein (Drewnowski 2010) hence it is a major protein contributor in developing countries (Messina 2014). According to Faber (2005) animal products with high biological value protein are consumed by less than 20% of children in KZN, suggesting that most children obtain protein from plant sources.

Stunted children often do not reach their optimal cognitive development, have decreased immune function and are more at risk of morbidity (Mendez & Adair 1999). The complementary food made with OFSP and dried beans has the potential to contribute to the fight against PEM, as PEM is caused by a diet low in energy and protein (Manary & Sandige 2008). In SA, the effect of PEM is most noticeable in the first year of life as the death rate due to PEM is estimated at 3.30% in children aged 0-12 months. This number rises to 6.85% in the 1-4 year age group (Bradshaw, Bourne & Nannan 2003).

According to WHO (2008), iron deficiency is still one of the most prevalent micronutrient deficiencies in the world. Iron requirements are high in childhood due to low concentrations in breast milk and rapid growth (Dewey 2007). If the usual portion of the complementary food made with OFSP and dried beans were consumed, 100% of the RDA for iron for children aged

12-24 months would be met, while 50% of the RDA for iron would be met in the 6-12 month age group. This is of significance, as South African children aged 6-23 months have been found to be the age group most affected by iron deficiency anaemia (Labadarios & van Middelkoop 1995). The NFCS (1999) also found inadequate iron intake in South African children (Faber 2005). Furthermore, Faber & Benadé (2007) reported that in KZN complementary foods were found to deficient in iron. Iron is found primarily in animal products (Schönfeldt *et al* 2013) and there is poor intake of iron-rich products among KZN children (Faber 2005).

The usual portion of the complementary food made with OFSP and dried beans would provide 99% and 72.67% of the RDA for zinc for the 12-24 month and 6-12 month age groups respectively. This is important as studies have shown that zinc intake during complementary feeding is less than half of the recommended amounts (Faber 2005). Zinc was one of the micronutrients found to be lacking in a study conducted by Faber & Benadé (2007). The complementary food made with OFSP and dried beans has the potential to prevent zinc deficiency, provided that the usual portion is consumed on a regular basis by the relevant age groups.

The usual portion of the complementary food made with OFSP and dried beans provided only 0.96% and 3.53% of the RDA for calcium in the 6-12 month and 12-24 month age group respectively. This suggests that the complementary food prepared with OFSP and dried beans was a poor source of calcium and that caregivers should be encouraged to feed other calcium-rich foods to their children. Calcium intake has been found to be low in KZN during complementary feeding (Faber & Benadé 2007). Calcium is also amongst the most prevalent micronutrient deficiencies in the world during the complementary feeding stage (WHO 2008).

The complementary food made with OFSP and dried beans has the potential to make significant contributions to the intake of fat and protein. This could contribute significantly in the fight against PEM. Furthermore, significant contributions could be made towards meeting the RDA for iron and zinc if the usual portions are consumed on a regular basis. This could also help to address micronutrient deficiencies in children.

5.3 Sensory acceptance of the complementary foods

This study found that the complementary food made with OFSP and dried beans was as acceptable as the complementary foods made with OFSP alone and WFSP alone (control). There were no statistical differences among the three samples evaluated for their sensory properties (taste, texture, smell, aroma and overall acceptability). There are no published studies which have assessed the acceptability of a complementary food made with OFSP and dried beans. However, there are studies that have accessed the acceptability of the biofortified OFSP on its own (Omodamiro *et al* 2013; Leksrisompong *et al* 2012; Hagenimana *et al* 2009; Ssebuliba *et al* 2006; Van Jaarsveld *et al* 2005; Kulembeka *et al* 2004). Of all these studies, only the one by Ssebuliba *et al* (2006) included complementary foods.

Studies have shown that chemical changes during the biofortification process change the sensory properties of the biofortified food, making it undesirable (Muzhingi *et al* 2008). Two recent studies conducted in rural KwaZulu-Natal reported similar findings as the current study, in which complementary foods made with biofortified foods were just as acceptable as the non-biofortified controls (Amod *et al* 2016; Govender *et al* 2014). However, both studies by Amod *et al* (2016) and Govender *et al* (2014) utilised provitamin A-biofortified yellow maize instead of the OFSP used in the current study. However, both studies used similar age groups, comparable communities and similar data collection tools to the current study. The complementary foods made with the yellow maize were just as acceptable as those made with the white maize, which served as the control. These studies suggest that there is potential for complementary foods made with biofortified plant foods to be used in KZN, thus increasing vitamin A intake. This could ultimately reduce the VAD burden in the province. This is particularly true for the OFSP, as it has been shown to improve serum vitamin A levels in primary school children in KZN (Van Jaarsveld *et al* 2005).

Studies on the acceptability of OFSP-based complementary foods are lacking. The only published acceptability study was conducted by Ssebuliba *et al* (2006) in Uganda relevant for children 7-12 months old and 1-5 years old, age groups which partly correspond with the current study's age group of 8-24 months. Ssebuliba *et al* (2006) found that there was a definite preference for OFSP over WFSP while in the current study OFSP products were just as acceptable as WFSP. The definite preference of the OFSP over the WFSP in the study by Ssebuliba *et al* (2006) compared to the lack of definite liking of OFSP over WFSP in the current study may be due to a few factors. In the current study, caregivers tasted the samples and then decided on the suitability of the products for children while in Ssebuliba *et al* (2006) farmers tasted the samples. Ssebuliba *et al* (2006) also used four different varieties of OFSP and two WFSP varieties, while the current study only used one variety of OFSP and WFSP respectively. Furthermore, the current study used a complementary food made with OFSP and dried beans while Ssebuliba *et al* (2006) tested OFSP alone. In the current study caregivers of children were used to assess the samples because the children were too young to taste and give feedback. In addition, it is well known that when the caregiver accepts and consumes a certain food, they are more likely to feed that food to their child (Blissett & Fogel 2013).

Omodamiro *et al* (2013), Leksrisompong *et al* (2012) and Tomlins *et al* (2007) all found a definite higher acceptance of OFSP over WFSP. The study by Tomlins *et al* (2007) differed to the current study in that the children aged 10-15 years tasted the samples themselves and gave feedback while in the current study caregivers tasted the samples on behalf of the children aged 8-24 months. The study by Omodamiro *et al* (2013) also assessed the acceptability of OFSP using semi-trained adult panellists and included 15 varieties of OFSP and WFSP in the sensory evaluation. In the study by Leksrisompong *et al* (2012), the sensory evaluation was conducted on adults, which is different from the current study where caregivers assessed complementary foods aimed at children between 8-24 months old.

While some studies have investigated the acceptability of biofortified OFSP against the non-biofortified WFSP, this is the first study to investigate a complementary food made with OFSP and dried beans in KZN, South Africa. Dried beans are a cheaper protein source compared to animal protein sources (Messina 2014) and are a valuable source of protein in poorer communities. Dried beans are one of the foods with the cheapest price per nutrient in the median nutrient rich foods index, along with nuts and seeds (Drewnowski 2010). This study has demonstrated that the addition of dried beans did not negatively affect the acceptability of the OFSP complementary food and that OFSP and dried beans is acceptable for use in complementary feeding in children aged 8-24 months in KZN. Therefore, it can be concluded that a complementary food made with OFSP and dried beans has the potential to be used as a nutritious, complementary food in rural areas of KZN.

5.4 Interpretation of focus group discussions

The aim of the focus group discussions was to determine the perceptions of the panellists towards the OFSP-based complementary food products. Perceptions towards the familiarity, the sensory attributes and the willingness of the panellists to use complementary foods made with OFSP are presented in Table 5.1

Table 5.1 Black female caregiver's perceptions towards OFSP complementary food products.

Question	Theme/s	Concept/s	Quotes	Discussion
Participants familiarity with OFSP	Participants encounter with OFSP	OFSP was unfamiliar to all the panellists who participated in the focus group discussions	"*I thought this was butternut if you had not said this is sweet potato I wouldn't have known that this is sweet potato.*" *"Where would I buy this?"*	All the participants in the focus group discussion reported that they had not seen or tasted the OFSP before. Some of the participants thought that the OFSP was pumpkin or butternut. Some participants were interested to know where they could buy the OFSP from. According to Faber *et al* (2013a), OFSP is a relatively new crop in SA, which may explain why the focus group discussion participants were not familiar with it. Because OFSP is not very familiar, this could be an advantage in its acceptability. Provitamin A-biofortified yellow maize, another biofortified crop has been stigmatised in KZN (Govender *et al* 2014; Pillay *et al* 2011) and in other parts of sub-Saharan Africa (Muzhingi *et al* 2008) due to past experiences. The provitamin A-biofortified maize stigmatisation comes from past experiences where it was used as animal feed. The association of yellow maize with animal feed and food aid has been its downfall in acceptability surveys. Since OFSP is new in SA, there is an opportunity for it to be introduced as a suitable food for children, the major target group of VAD programmes. Since the probability of stigmatisation with OFSP is low, the acceptability of the OFSP will be based solely on its sensory attributes thereby increasing chances of acceptability. While the OFSP used in the current study was sourced from a local store, it is noteworthy that not all stores including the major retailers stock OFSP.

				This may be the other main reason why OFSP was found to be unfamiliar to participants.
Consumer perception towards OFSP products	Physical properties of OFSP-based complementary foods	Consumer perception of sensory quality of OFSP: • Colour • Texture • Taste • Smell Combination of OFSP with dried beans	*"The colour of the OFSP is good for kids since it is bright and kids like colourful things."* *"The orange one is very soft which is good for the kids since they will not choke while eating it as kids choke very easily, the white one is more suitable for adults."* *"This (orange sweet potato) is good and it is a bit sweet and kids like sweet things even though this is not too sweet."* *"This sweet potato is different from the normal one since the normal one is a bit dry compared to this one, children will not choke if they eat this one."* *"It's texture, the softness. If you compare this to the vegetable Purity, they are the same. The white one is ok for adults but this would be best for kids. Kids that eat Purity would fit perfectly."* *"The taste of beans is overwhelming; it would have been better if the beans were mashed completely without skin."* *"The sweet potato alone but not with beans, the advantage of OFSP is that it is very soft but when you add beans*	The softness and colour of the OFSP appealed the most to the participants. The bright colour of the OFSP was regarded as a positive attribute as children like colourful and bright things. The colour of the complementary food made with OFSP alone was rated higher than the complementary food made with OFSP and dried beans and the control, WFSP. The panellists likened the texture of the OFSP to baby foods such as Purity.® According to the panellists, the softness of the OFSP makes it ideal for children compared to the WFSP which is dry in comparison. Adult consumers have been found to prefer OFSP which has a higher dry matter content (Tomlins *et al* 2007; Masumba, Kapinga, Tollan, Mary & Yongolo 2007). In the current study, low dry matter was positively associated with acceptability. The taste and the smell of the OFSP was also well received. When dried beans were added to the OFSP, the texture of the end product changed. The panellists felt that adding dried beans to the OFSP made the complementary food dry. The dried beans were also reported to mask the "good" taste of the OFSP. Some panellists felt that the taste of the dried beans in the dish was overwhelming. From the focus group discussions, OFSP on its own as a complementary food was well accepted and could be easily introduced without supporting nutrition education and encouragement. The acceptance and utilisation of the complementary food made with OFSP and dried beans on

			it becomes a bit dry like the white one."	the other hand, may require additional education and encouragement, highlighting its health benefits.
Willingness of participants to purchase and use OFSP-based complementary foods	Willingness	• Affordability • Availability in local stores	*"I will buy it if it was equal or less expensive than the white one."* *"I will choose the orange one over the white one if they were both in the shops and I had to choose one for my child."*	The participants expressed a desire to purchase the OFSP instead of WFSP if prices were comparable or if the OFSP was cheaper than the WFSP. This differs to some studies which found that consumers were willing to consume biofortified foods, only if it was cheaper than the non-biofortified foods (Pillay *et al* 2011; De Groote & Kimenju 2008; Tschirley & Santos 1995). However, these studies utilised biofortified maize while the current study used OFSP. The availability of the OFSP in local stores also seemed to have a positive correlation with the willingness of the participants to use OFSP in preparing complementary foods for their children.

The participants in the focus groups were not familiar with the OFSP, with all of them stating that they had not seen or tasted OFSP before. The participants had a definite liking of the softness and the texture of the OFSP on its own. The complementary food made with OFSP and dried beans was perceived to be dry in texture; the dryness was compared with that of the WFSP. The consumers were willing to buy OFSP over WFSP for their children if the price was the same or lower than that of WFSP and if the OFSP was available at the local stores.

CHAPTER 6 : CONCLUSIONS AND RECOMMENDATIONS

The aim of this study was to determine the nutritional composition and the acceptability of a complementary food made with OFSP and dried beans. The research objectives were: (i) To determine the nutritional composition of a complementary food product made with OFSP and dried beans; (ii) To assess the consumer acceptance of a complementary food product made with OFSP and dried beans by black African infant caregivers; (iii) To determine the perceptions of black African caregivers towards a complementary food made with OFSP and dried beans.

In this chapter, conclusions and recommendations of the study are presented.

6.1 Nutritional composition of the complementary foods

The complementary food made with OFSP and dried beans was found to be nutritionally superior compared to both the complementary foods made with OFSP alone and WFSP alone, respectively. This statement is supported by the higher ash, fat, protein, fibre, iron and zinc content found in the complementary food made with OFSP and dried beans compared to the complementary foods made with OFSP alone and the WFSP (control), respectively. Therefore, the hypothesis stated in chapter 1, section 1.5 (i) is accepted. The complementary food made with OFSP and dried beans has the potential to improve nutrient intake and should be promoted as a nutritious, complementary food item for children 8 months and older in KZN.

6.2 Contribution of the complementary food made with OFSP and dried beans to the Recommended Dietary Allowance (RDA) for selected nutrients

The complementary food made with OFSP and dried beans made a significant contribution to the RDA for many nutrients for children between 6-12 and 13-24 months of age. The complementary food made with OFSP and dried beans met the RDA for protein for both age groups and for iron in the 13-24 month age group. A significant contribution towards the RDA for fat in the 6-12 month age group was also observed, with half of the RDA for this nutrient being met. Furthermore, the complementary food made with OFSP and dried beans also made significant contributions towards meeting the RDA (> 50%) for zinc in both age groups. In the current study, the complementary food made with OFSP and dried beans was found to make a significant contribution towards meeting the RDA for a variety of nutrients. This suggests that it has the potential to contribute to improving nutrient intake and should be promoted as a nutritious complementary food for the prevention of PEM and micronutrient deficiency.

6.3 Sensory acceptance of the complementary foods

The complementary food made with OFSP and dried beans was well received by the participants in this study. Furthermore, the complementary food made with OFSP on its own was also well accepted. Both the OFSP-based complementary foods were found to be as acceptable as the control, WFSP. Therefore, there is not enough evidence to support the hypothesis stated in chapter 1.2 (ii). This suggests that WFSP could be substituted with OFSP by caregivers during the period of complementary feeding in children 8 months and older in the rural eThekwini District of KZN. Dried beans could be utilised to create a complementary food that is more nutritious than both OFSP on its own and WFSP on its own, while still being acceptable at the same time.

6.4 Interpretations of the focus group discussions

All participants in the focus group had not seen or tasted the OFSP prior to this study. The complementary food made with OFSP alone was well received and the general consensus was that OFSP alone was soft and made an ideal complementary food. Although the sensory evaluation showed that both the OFSP based complementary foods were found to be as acceptable as that made with the WFSP, the participants felt that the addition of the dried beans to the OFSP made the complementary food dry and they compared the dryness with that of the complementary food made with WFSP. This suggests that while caregivers may easily accept the OFSP in place of the WFSP, the use of the complementary food made with OFSP and dried beans may require promotion, perhaps through the use of nutrition education on its health benefits. The participants were willing to purchase the OFSP instead of WFSP if the prices were comparable or if the OFSP was cheaper. The colour and softness of the OFSP was very acceptable to the participants who felt that these two attributes would be most appreciated by children. In the current study, there is not enough evidence to support the hypothesis stated in chapter 1, section 1.5 (iii).

6.5 Study limitations

6.5.1 None of the samples were analysed for energy, starch, amino acid and other micronutrient contents due to financial constraints.

6.5.2 This study was conducted at one health facility in a single district and the findings are limited to this facility, its surroundings and district. Further studies at other health facilities in other districts are required.

6.6 Recommendations for future studies

6.6.1 Further studies should be conducted in the rural areas of other provinces and districts in South Africa.

6.6.2 Future research should investigate further the nutrient composition of the complementary food made with OFSP and dried beans. This study was limited to only a few nutrients.

6.6.3 A cost analysis should be conducted to determine how much a portion of the complementary food made with OFSP and dried beans would cost. This is important as the cost of the complementary food made with OFSP and dried beans would also influence its overall acceptance and potential for use in poor communities.

6.7 Implications for future research

6.7.1 Future studies should aim to improve awareness and availability of the OFSP as none of the participants in this study had ever seen or tasted OFSP prior to this study.

6.7.2 Given the fact that the complementary food made with OFSP and dried beans was found to be drier than the OFSP on its own, future studies should investigate improving its sensory qualities, particularly the dryness.

6.7.3 Future studies should investigate the possibilities and opportunities of incorporating OFSP and dried beans into home gardens, particularly the home gardens of rural populations.

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APPENDIX A CONSENT FORM FOR FEMALE CAREGIVERS IN ISIZULU

ISIBOPHEZELO SOMAMA NABANAKEKELI BEZINGANE

ISIHLOKO: UKWAMUKELEKA NOKUHLOLWA KOMSOCO KOKUDLA OKWENZIWE NGOBHATATA O-ORANGE NOBHOTSHISI OKWENZELWE INGANE EZINEZINYANGA EZIYISISHAGALOMBILI KUYA PHEZULU.

Siyakubingelela

Ngingumfundi oqhamuka enyuvesi yakwaZulu-Natal owenza izifundo zakhe kwi-Dietetics. Inhloso yokuresearcher kwami ukucwaninga ukuba ukudla okwakhiwe wubhatata o-orange ngaphakathi nobontshisi ungadliwa yini izingane ezinezinyanga eziyisi-8 kuya phezulu. Ngingathanda ukwazi ukuba omama noma abanakekeli bezingane bangazifunza izingane zabo ukudla okwenziwe ubhatata o-orange nobontshisi. Abantu abayingxenye yalolu cwaningo bazocelwa ukuthi bezwe amasampulo amabili okudla okwenziwe ngobhatata o-orange, nokunye okwenziwe ngobhatata omhlophe bese besebenzisa isikali esinezithombe ezinhlanu ukusho ukuthi lobhatata ezwakale unjani. Ayikho into ezozwisa abantu abazobe bebambe iqhaza kulolucwaningo ubuhlungu, ukuhlukumezeka noma ibafake engozini yokulimala.

- Umuntu owenza lolu cwaningo u-Ntuthuko Khanyile oqhamuka e-Nyuvesi yaKwaZulu-Natal, kwinxenye ye-Dietetics and Human Nutrition. Ungaxhumana naye kanje – ifoni: 0815538905 or i-email:khanyilentk@gmail.com

- Uma ufuna eminye imininingwane ungaxhumana nomphathi omkhulu wocwaningo u-Dr K Pillay (PhD) osebenza e-Nyuvesi yaKwaZulu-Natal, yena utholakala kanje – ifoni: 033-2605674 or i-email: Pillayk@ukzn.ac.za

- Abantu abamenyiwe kulolucwaningo abantu abajwaye ukudla ubhatata. Abantu abavumyo ukubamba iqhaza kuloloucwaningo bazozwiswa inhlobo zokudla ezimbile, eyodwa izobe yenziwe ngobhatata omhlope and enye izobe yenziwe ngobhtata o-orange, abantu bazobe ke sebekhetha kona abakuthanda kakhulu kunokunyethe best.

- Azikho izinto ezinobungozi noma ezizophatha kabi abantu ababambe iqhaza kulolu cwaningo.
- Ucwaningo kulindeleke ukuthi luthathe imizuzu elinganiselwa keyishumi nantathu (30 minutes).
- Awukho umkomelo noma imali ozotholakala ngokubamba iqhaza kulolucwaningo, imiphumela yalolucwaningo ingakhonjiswa kubantu ababambe iqhaza kulolucwaningo. Umuntu uzoza ingxenye yalolucwaningo ngokuvolontiya.
- Abantu abayingxenye yalolucwaningo bavumelekile ukuthi bashiye phakathi kwalo uma befisa, Akukho lutho olubi oluyokwenziwa kubona,
- Okuzo rekhodwa ngenkathi kuxoxiswana nesixuku sabantu kuzosetshenziselwa lolucwaningo kuphela futhi kuzogcinwa endaweni ephephile.
- Yonke imininingwane yalolucwaningo izolahlwa uma ingasa dingaka.

ISIBOPHEZELO

Mina______________________________________ (Amagama aphelele nesibongo) Ngiyaqiniseka ukuthi ngichazelekile kahle ngalemibuzo engizobuzwa yona futhi ngiyasiqonda isizathu salolucwaningo nokuthi yonke imiciningwane etholakele izohlolwa. Ngiyavuma ukuba ingxenye yalolucwaningo. Ngiyaqonda ukuthi kuyavolontiywa ukuba ingxenye yalolucwaningo nanokuthi ngingashiya phakathi uma ngifisa.

…………………………………………… ……………………….

SAYINA USUKU

Isayinwe (indawo) _____________________________ ngomhlaka _________________2015.

Uma ufuna eminye imininingwane ungathintana no-Dr Pillay ongumuphathi omkhulu wocwaningo (bheka ezansi)

APPENDIX B CONSENT FORM FOR FEMALE CAREGIVERS IN ENGLISH

CONSENT FORM FOR FEMALE CAREGIVERS

UNIVERSITY OF KWAZULU-NATAL

School of Agricultural, Earth and Life Science
Dietetics & Human Nutrition Private bag X01 3290 Scottsville

Tel +27 (0) 33 2605428 Fax +27 (0) 33 2606270

Tittle: ACCEPTABILITY OF A COMPLEMENTARY FOOD MADE WITH ORANGE-FLESHED SWEET POTATO AND DRIED BEANS

Dear Participant

I am a dietician by profession and student from the University of KwaZulu-Natal. I am doing an MSc degree in dietetics, the aim of my research is to assess the potential of usage of a complementary food made with Orange-fleshed Sweet Potato (OFSP) and dry beans in children 8 months and older. I would like to find out if mother/caregivers would find a complimentary food made with OFSP and dried beans acceptable to use in children aged 8 months and older. The participants will be required to taste two samples, one will be OFSP made with dried beans and the other will be white-fleshed sweet potato made with dried beans and rate the samples using a simple picture scale. There will no discomforts or hazards to participants who agree to participate in this study.

- Ntuthuko Khanyile RD (SA) who is from the Discipline of Dietetics and Human Nutrition, University of KwaZulu-Natal is the person conducting this study. Contact – 0815538905 or khanyilentk@gmail.com for further information you may contact Dr K Pillay (PhD) who is from the University of KwaZulu-Natal and is the project supervisor. Contact – 033-2605674 or Pillayk@ukzn.ac.za

- Subjects identified for the project are people who regularly consume maize products. The people who agree to take part in this study will be given different yellow/orange maize food products to taste and will then choose the products which they like the best.
- There will not be any possible discomforts or hazards involved with taking part in the study.
- The estimated time for completion of the tasting session is 30 minutes.
- There are no potential benefits from participating in the study however, results from the study will be made available to the participants. There are no payments or reimbursement of financial expenses for participating in the study.
- Audio recordings of focus group discussions will be made and these will be kept confidential and used only for the purpose of this study. Information gathered from this study will be kept confidential and all participants will remain anonymous. Information gathered from this study will be kept by the Discipline of Dietetics and Human Nutrition and will be destroyed when no longer required. If subjects decide not to participate in the study they will not be disadvantaged in any way. Participation in is voluntary and subjects are free to withdraw from the study at any stage and for any reason.

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 free to withdraw from the study at any time should I so desire.

…………………………………………… ……………………….

SIGNATURE OF PARTICIPANT DATE.

Signed at ______________________________ on ______________________2015.

If you have any questions you can contact my supervisor, Dr K Pillay at Pillayk@ukzn.ac.za

APPENDIX C SENSORY EVALUATION QUESTIONNAIRE IN ISIZULU

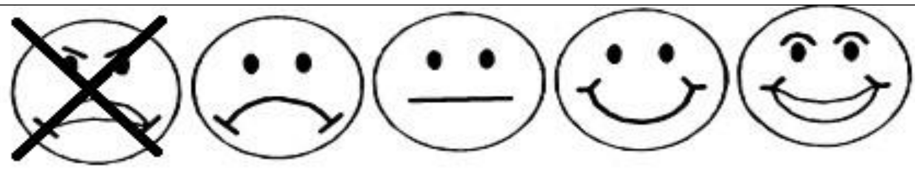
I-SENSORY EVALUATION EBHALWE NGESIZULU YOKUDLA OKWENZIWE NGOBHATATA O-ORANGE KANYE NOBHONTSHISI

Inombolo onikezwe yona:
Inombolo yesampula:
Usuku lokuzalwa(dd/mm/yy):

Ukuhlolwa kokudla okwenziwe kukabhatata usebenzisa imizwa yomzimba.

- Uyacelwa ukuthi uyakaze umlomo ngamanzi ngaphambi kokuba uqale.
- Uyacelwa ukuthi uyakaze umlomo ngamanzi emva kokuzwa isampula ngayinye.
- Uyacelwa ukuthi amasampulo obhatata uwezwe ngalandlela abekwe ngakhona, kusukela ngasesandleni sokunxele kuya kwesokudla.
- Uyacelwa ukuthi ukale ukunambitheka, iphunga, umbala kanye nokwamkeleka kwesampula ngayinye ngokuthi ufaka isiphambano phezu kwesithombe esichaza isampulo ngalinye, ungaphinda phinda ukuzwa isampulo uma ufisa.

Isibonelo:

Iphunga	 Kubi kakhulu Kubi phakathi nendawo Kumnandi mnandi kakhulu

FIVE-POINT FACIAL HEDONIC SCALE IN ISIZULU

Ubumnandi

Imbi Kakhulu yimbi phakathinendawo imnandi imnandi kakhulu

Ukunambitheka

limbi Kakhulu limbi phakathinendawo limnandi limnandi kakhulu

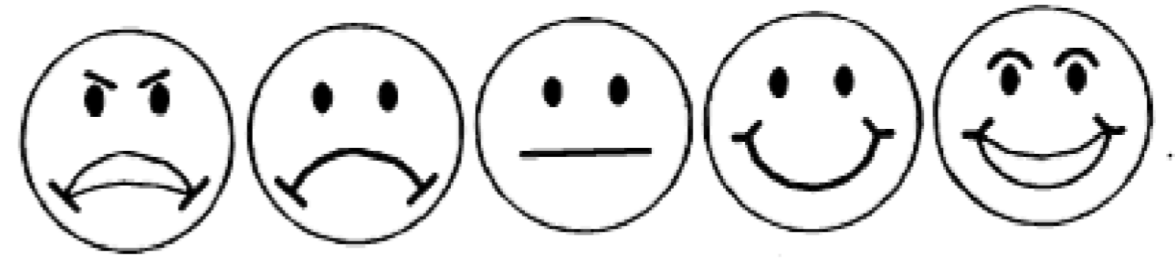
<u>Iphunga</u>

mumbi Kakhulu mumbi uphakathinendawo muhle muhle kakhulu

<u>Umbala/ukubukeka</u>

kumbi Kakhulu kumbi kuphakathinendawo kumnandi kumnandi kakhulu

<u>Isinqumo jikelele</u>



kumbi Kakhulu kumbi kuphakathinendawo kumnandi kumnandi kakhulu

Siyakubonga kakhulu ngokuthi ubambe iqhaza kulolucwaningo lwethu!

APPENDIX D SENSORY EVALUATION QUESTIONNAIRE IN ENGLISH

SENSORY EVALUATION OF SWEET POTATO BASED COMPLEMENTARY FOOD

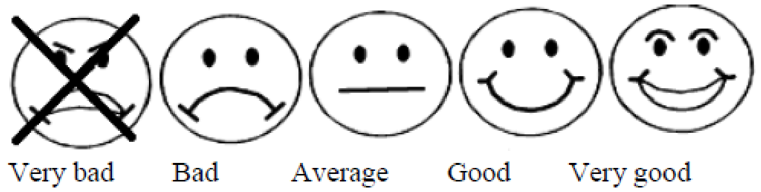
Participant number: Sample number: Date of birth (dd/mm/yy):

Instructions:

- Please rinse your mouth before starting to taste and after tasting each sample.
- Please taste the sweetpotato based samples in the order given i.e. 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 each of the sample should the need arise

Example :

Aroma



FIVE-POINT FACIAL HEDONIC SCALE IN ENGLISH

<u>Taste</u>

Very bad Bad Neutral Good Very good

<u>Texture</u>

Very bad Bad Neutral Good Very good

<u>Aroma</u>

Very bad Bad Neutral Good Very good

Colour

Very bad Bad Neutral Good Very good

Overall acceptability

Very bad Bad Neutral Good Very good

Thank you for your participation in our study!

APPENDIX E FOCUS GROUP DISCUSSION QUESTIONS IN ENGLISH

UNIVERSITY OF
KWAZULU-NATAL

College of Agricultural, Earth & Environmental Science
School of Agricultural, Earth and Environmental Science
Dietetics & Human Nutrition Private bag X01 3290 Scottsville
Tel +27 (0) 33-2605674 Fax +27 (0) 33 2606270

FOCUS GROUP DISCUSSION QUESTIONS IN ENGLISH

Focus Group Questions

1. Have you ever seen orange-fleshed sweet potato (OFSP) before?
2. Have you ever heard of OFSP before?
3. Is it the first time you have tasted a food product made with orange sweet potato? Using the attributes below, please describe how you feel about it:
    - In terms of its taste
    - Its Smell
    - Its Colour
    - And its texture
4. Is the orange-fleshed sweet potato different from other sweet potato you have eaten before, if yes; how so?
5. Today orange-fleshed sweet potato was eaten with beans, is there any other food you can make the OFSP with for your child?
6. As a mother/caregiver would you feed your child the dish you tasted today?
7. What did you like about the dish you tasted today?

8. What did you not about the dish you tasted today/what would prevent you from feeding your child the dish you tasted today?

9. Do you have access to orange sweet potato in your area?

10. If you had a choice between buying orange-fleshed sweet potato and white sweet potato which would you buy and why?

11. Would you buy orange-fleshed sweet potato if it was cheaper than white-fleshed sweet potato?

12. Would you buy OFSP if it is beneficial for your babies' health?

APPENDIX F FOCUS GROUP DISCUSSION QUESTIONS IN ISIZULU

College of Agricultural, Earth & Environmental Science
School of Agricultural, Earth and Environmental Science
Dietetics & Human Nutrition Private bag X01 3290 Scottsville
Tel +27 (0) 33-2605674 Fax +27 (0) 33 2606270

IMIBUZO YEFOCUS GROUP NGXOXISWANO

1. Engabe usuke wawubona ubhatata o-orange ngaphambilini?
2. Ngabe usuke wezwa ngobhatata o-orange ngaphambilini?
3. Engabe bekuwokokuqala udla ubhatata o-orange namhlanje?

Awuchaze usebenzisa lezizihloko ezingezansi, uwuzwe kanjani ubhatata o-orange?

- ubumnandi
- ukunuka
- umubala
- ukunambitheka kwawo

4. Engabe ubhatata o-orange uhlukile ukuno bhatata osuke wawudla ngaphambilini? Uma kunjalo, kanjani?

5. Namhlanje udle ubhatata o-orange nobhontshisi, engabe ikhona enye into ongayifaka nalobhatata ukuze ufunze ingane yakho?

6. Njengomama noma umnakekeli wengane, ungayifunza ingane yakho lokhukudla okuzwile namhlanje? uma uthi cha, sicela uchaze kabanzi

7. Yini oyithandile ngokudla okuzwile namhlanje?

8. Yini ongayithandanga noma engakwenza ungayifunzi ingane yakho lokudla okuzwile namhlanje?

9. Yini engakuvimbela ektheni ungayifunzi ingane yakho ukudla okuzwe namhlanje?

10. Unayo indlela ongathola ngayo ubhatata o-orange ngakini?

11. Uma kungathiwa khetha okukodwa phakathi kokuthenga ubhatata omhlophe ngaphakathi no-orange ngapbhakathi ungakhetha muphi?

12. Ungawuthenga ubhatata o-orange uma kungathiwa ushibhile ukunalona omhlophe ngaphakathi?

13. Ungawuthenga ubhatata o-orange uma kuthiwa unempilo?

APPENDIX G ETHICS APPROVAL LETTER FROM UKZN

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

15 June 2015

Mr Ntuthuko Khanyile 209510504
School of Agricultural, Earth and Environmental Sciences
Pietermaritzburg Campus

Dear Mr Khanyile

Protocol reference number: HSS/0486/015M
Project title: Nutritional composition and acceptability of a complementary food made with Orange-Fleshed Sweet Potato (OFSP) and dried beans

Full Approval – Expedited Application

In response to your application received on 14 May 2015, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol have been granted **FULL APPROVAL.**

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

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

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

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

Yours faithfully

Dr Shamila Naidoo
On behalf of Dr Shenuka Singh (Chair)
Humanities & Social Sciences Research Ethics Committee

/pm

Cc Supervisor: Dr Kirthee Pillay & Dr Muthulisi Siwela
Cc Academic Leader Research: Prof Onisimo Mutanga

APPENDIX H LETTER OF APPROVAL FROM THE KZN DEPARTMENT OF HEALTH

health

Department:
Health
PROVINCE OF KWAZULU-NATAL

Health Research & Knowledge Management sub-component
10 – 103 Natalia Building, 330 Langalibalele Street
Private Bag x9051
Pietermaritzburg
3200
Tel.: 033 – 3953189
Fax.: 033 – 394 3782
Email.: hrkm@kznhealth.gov.za
www.kznhealth.gov.za

Reference : HRKM180/15
NHRD Ref.: KZ_2015RP8_350
Enquiries : Ms G Khumalo
Telephone : 033 – 395 3189

Dear Mr N Khanyile

Subject: Approval of a Research Proposal

1. The research proposal titled **'Nutritional composition and consumer acceptance of a complementary food made with orange-fleshed sweet potato (OFSP) and dried beans'** was reviewed by the KwaZulu-Natal Department of Health (KZN-DoH).

The proposal is hereby **approved** for research to be undertaken at Newtown Community Health Centre.

2. You are requested to take note of the following:
   a. Make the necessary arrangement with the identified facility before commencing with your research project.
   b. Provide an interim progress report and final report (electronic and hard copies) when your research is complete.

3. Your final report must be posted to **HEALTH RESEARCH AND KNOWLEDGE MANAGEMENT, 10-102, PRIVATE BAG X9051, PIETERMARITZBURG, 3200** and e-mail an electronic copy to hrkm@kznhealth.gov.za

For any additional information please contact Ms G Khumalo on 033-395 3189.

Yours Sincerely

ELutge

Dr E Lutge
Chairperson, Health Research Committee
Date: 22/07/15.

uMnyango Wezempilo. Departement van Gesondheid

Fighting Disease, Fighting Poverty, Giving Hope

APPENDIX I LETTER OF APPROVAL FROM NEWTOWN CHC

health

Department:
Health
PROVINCE OF KWAZULU-NATAL

NEWTOWN COMMUNITY
HEALTH CENTRE
DIETICIAN DEPARTMENT
Private Bag X 039, INANDA, 4310
A 1345 cnr KING BHEKUZULU AND NHLWATHI ROADS INANDA
Tel.:031 5109830
Fax:. 031 510 1101
Email: lungile.ntenga@kznhealth.gov.za
www.kznhealth.gov.za

Dear Mr Khanyile

RE: NUTRITIONAL COMPOSITION AND ACCEPTANCE OF A COMPLEMENTARY FOOD MADE WITH ORANGE-FLESHED SWEET POTATO (OFSP) AND DRIED BEANS.

Your request to conduct the above-mentioned research at Newtown Community Health Centre (CHC) is approved, subject to approval by Department of Health Research Committee and letter of approval from the relevant ethics committee.

Yours Sincerely:

CHC MEDICAL MANAGER (DR S.C.V Mncwango)

Date: 05/06/2015

uMnyango Wezempilo . Departement van Gesondheid

Fighting Disease, Fighting Poverty, Giving Hope