Sensory quality of provitamin A biofortified maize-based foods and the effect of a provitamin A biofortified maize awareness campaign on their acceptance in KwaZulu-Natal, South Africa

BY

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PREFACE

The work described in this thesis was carried out in the School of Agricultural, Earth and Environmental Sciences, the University of KwaZulu-Natal from March 2011 to March 2017, under the supervision of Prof Unathi Kolanisi, Prof Muthulisi Siwela, and Dr Rose Mboya.

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

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DECLARATION OF ORIGINALITY

I, Ngwanamoelo Kate Ndwandwe, declare that the thesis hereby submitted by me for the degree of Doctor of Philosophy in Food Security at the University of KwaZulu-Natal is my own original and independent research work. This thesis or any part of it has not been previously submitted by me for any degree or examination to another faculty or University. The research work reported in this thesis does not contain any person’s data, pictures, graphs or other information unless specifically acknowledged as being sourced from that person.

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Date: 14/03/2018
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ABBREVIATIONS

AICRP: All India Coordinated Research Project
ANOVA: Analysis Of Variance
CEE/CIS: Central Eastern Europe/Commonwealth of Independent States
EPI: Expanded Programme on Immunization
HSRC: Human Sciences Research Council
IITA: The International Institute of Tropical Agriculture
IK: Indigenous Knowledge
IKS: Indigenous Knowledge System
INP: Integrated Nutritional Programme
KZN: KwaZulu-Natal
LSD: Least Significant Difference
MDG: Millennium Development Goal
MENA: Middle East and North Africa
NRC: National Research Council
PABM: Provitamin A Biofortified Maize
PABMP: Provitamin A Biofortified Product
PC: Principle Component
PCA: Principal Component Analysis
PVAH: Provitamin A Hybrid
SA: South Africa
SDGs: Sustainable Developmental Goals
SSA: Sub-Saharan Africa
UNESCO: United Nations Educational, Scientific and Cultural Organization
VAD: Vitamin A Deficiency
WHO: World Health Organization
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ABSTRACT

Biofortification is a food-based intervention to combat nutrient deficiencies, including vitamin A deficiency (VAD), by increasing the levels of target nutrients in crops through traditional (conventional breeding) and modern genetic manipulation methods. Maize has been selected for biofortification with provitamin A to alleviate the prevalence of VAD in sub-Saharan Africa where white maize, which is devoid of vitamin A, is a leading staple. However, when compared to white maize, provitamin A biofortified (yellow) maize (PABM), consumers in several countries in sub-Saharan Africa found it less acceptable, largely due to their negative perceptions of yellow maize and its unfamiliar sensory properties. A combination of strategies such as food product development, consumer awareness campaigns, and nutrition education could improve consumer acceptance of yellow maize.

Two provitamin A biofortified (yellow) maize food products, phuthu (crumbled porridge) and jeqe (steamed bread), and their corresponding white maize products (controls), were evaluated for their acceptability. Consumer acceptability tests were conducted with a consumer sample of 68 untrained panellists of the age range 18-85 years. A 5-point smiley pictorial Hedonic scale was used to evaluate the sensory acceptability of samples of PABM phuthu and Jeqe. The two food products were selected mainly because of their popularity amongst the KZN community. The results showed low acceptability of yellow phuthu compared to white phuthu, whilst the acceptability of yellow jeqe was similar to that of white jeqe. It was not clear why the acceptability of yellow phuthu was lower than that of white phuthu. Therefore, a descriptive sensory analysis was performed to characterise the sensory attributes of yellow phuthu and thereby reduce the influence of its sensory attributes on its acceptability.

Eleven trained panellists analysed the sensory properties (attributes) of phuthu made from three varieties of provitamin A biofortified maize hybrids. Descriptive sensory analysis data were subjected to ANOVA, Fisher’s Least Significant Difference (LSD) tests, and Principle Component Analysis (PCA). The results showed that the yellow
*phuthu* samples were characterised by lower intensity of chewiness, crumbliness, roughness, white specks, and had less malleability. The control *phuthu* had a lower intensity of stickiness and yellow colour compared to the yellow *phuthu*. The carotenoid pigments in the yellow *phuthu* were probably responsible for the yellow colour of the biofortified maize phuthu and its stickiness. It is necessary to reduce the intensity of the stickiness of yellow maize *phuthu* to enhance its acceptability.

To change the negative perceptions and lower acceptability of provitamin A biofortified maize compared to white maize, a provitamin A awareness campaign was conducted. A group of 21 community members who had negative perceptions about provitamin A biofortified maize attended a perception change workshop. This awareness campaign workshop ran over three days and attempted to change their negative perceptions of yellow (provitamin A biofortified) maize. Two learning approaches were integrated as persuasive communication, namely, Transformative learning and Indigenous learning. The two learning approaches contributed to finding a way to improve the willingness of the sample of target consumers to adopt provitamin A biofortified maize as a food-based intervention to alleviate vitamin A deficiency (VAD).
CHAPTER ONE: INTRODUCTION

1.1 Introduction and significance of the study

Micronutrients are essential for human health (Miller and Welch, 2013). About two billion people globally suffer from micronutrient deficiencies, with vitamin A, iodine, iron, zinc and folic acid being the most prevalent deficiencies (Bailey, et al., 2015). A study by Tucker (2003) found that 40% of the world’s population was affected by micronutrient deficiencies, including Vitamin A deficiency (VAD). In Sub-Saharan Africa (SSA), food insecurity was identified as the leading cause of malnutrition affecting all age groups, including children, pregnant women and the elderly (Johns and Eyzaguirre, 2007). In addition, it was reported that, in SSA, the food produced, purchased, prepared and consumed usually lacks diversity, thus exposing the consumers to nutrient deficiencies, including micronutrient deficiencies, such as VAD.

Vitamin A is an essential micronutrient that plays a vital role in immunity, vision, fighting against oxidative stress, cell differentiation, and protein synthesis as well as growth and human development (Arigony et al., 2013; Chen, 2013). Sources of Vitamin A include animal-based food products like cheese, cow’s milk, liver, and egg yolk, and plant origin foods including sweet potatoes, carrots, dark leafy greens, winter squashes, lettuce, dried apricots, cantaloupe and bell peppers. In plant foods, vitamin A occurs in the form of provitamin A carotenoids (retinyl esters) (Institute of Medicine, 2000; Reboul, 2013). β-carotene, α-carotene and β-cryptoxanthin are the main forms of provitamin A carotenoids. The retinyl esters are processed into retinol by the cells of the intestine of the human body (Reboul, 2013).

VAD is a widespread health challenge which affects mostly women and children. VAD results in unhealthy and physiological conditions, such as loss of appetite, poor or retarded physical growth in infants and children, and suppressed immunity. (Gibson,
One of the major health conditions caused by VAD is irreversible blindness; it initially starts as xerophthalmia followed by night blindness (Dhliwayo, 2014). It has been reported that 250 000 to 500 000 vitamin A-deficient children in the world are at the risk of being disabled due to loss of sight, some dying within 12 months of losing their sight (Kerab, 2014; WHO, 2016). About 48% of children aged 6 to 59 months suffer from VAD in SSA (Stevens et al., 2015).

Girum (2015) states that the major cause of VAD among millions of people in SSA is the lack of access to food sources rich in provitamin A, i.e. fruits and vegetables. These food sources are often not accessible or they are only available seasonally (Pillay, 2011; De Groote and Kimenju, 2012; Lividini and Fiedler, 2015). Other factors such as the economic status of the community also determine the form and percentage of nutrient intake (Zarnowiecki, 2014) Food sources of essential micronutrients, especially vitamin A sources, are not easily accessible to communities of low socio-economic status. Communities of socio-economic status, such as rural population groups, generally cannot afford expensive animal foods products (Kearney, 2010) Therefore, they are forced to rely on available and affordable plant sources such as green leaves, yellow/ orange-fleshed vegetables and fruits, carotenoid-rich yellow pulses, and cereals for healthy dietary intake (Faber and Wenhold, 2007). Unfortunately, most of the plant foods have limited nutrient content, e.g. vitamin A.

The high incidence of VAD is a global challenge, and it is important to find viable local solutions guided by the recently expired (2015) Millenium Development Goals (MDGs) and the new Sustainable Development Goals (SDGs). In South Africa, the Department of Health introduced an Integrated Nutritional Programme (INP) in 1995 to address malnutrition using a combination of strategies. With respect to the eradication of micronutrient deficiencies, the INP proposes that the following strategies be prioritised: dietary diversification, supplementation, and fortification (Faber et al., 2011) Although these strategies have been in place for years, South Africa has achieved little success in reducing micronutrient deficiencies.
Biofortification has been introduced as a sustainable strategy to combat nutrient deficiencies, especially micronutrient, including VAD. Biofortification is defined as a new approach of developing varieties of staple food crops with high levels of nutrients, especially micronutrients, through best traditional breeding practices and modern biotechnology (Nestel et al., 2006; HarvestPlus, 2010). Biofortification is regarded as a cost-effective food and nutrition intervention for addressing the SDGs, especially goals one, two and three, which are aimed at eliminating poverty. Poverty is more than lack of income or resources. It embraces: lack of basic services, such as education; a hunger which can be achieved through food security, improved nutrition and the promotion of sustainable agriculture; social discrimination and exclusion; and lack of participation in decision making.

Maize (Zea mays) is one of the leading staple food crops and is consumed by about half of the SSA population. The World Health Organization (WHO) stated that the average consumption of maize in the African daily diet is 106.2 g/person/day, which is calculated as the highest among other maize-consuming regions in the world (WHO, 2003). In most countries in the SSA region, including South Africa, maize is considered a staple food for almost all population groups; it contributes around 40% of the total energy intake (Labadarios et al., 2000; McCann, 2005). Thus, maize has been selected for biofortification with provitamin A to combat VAD in the SSA region (Bouis, 2011; Gannon et al., 2014). Unfortunately, studies conducted in several countries in the SSA African region have demonstrated that provitamin A biofortified maize is less acceptable to consumers compared to white maize (De Groote and Kimenju, 2008; Stevens and Winter-Nelson, 2008; Pillay et al., 2011; De Groote et al., 2010). The unfamiliar sensory properties, including the yellow/orange colour, strong flavour and aroma, and socio-cultural and psychological factors have been found to cause the low acceptability of provitamin A biofortified maize (Pillay et al., 2011; De Groote et al., 2010; De Groote and Kimenju, 2008; Stevens and Winter-Nelson, 2008).

Pillay et al. (2011) reported that the acceptability of provitamin A biofortified maize varied with the food type. The authors indicated that their findings suggested that consumer
acceptance of provitamin A biofortified maize could be improved through recipe development and identification of suitable maize food types. In addition, Pillay et al. (2011) found that the acceptability of provitamin A biofortified maize varied with the age of the consumers; the biofortified maize was more acceptable to younger consumers than the older consumers. The researchers attributed the differences in consumer acceptability depending on age to the fact that older consumers were more accustomed to the traditional white maize and had been exposed to negative information about the yellow maize over a longer time. The researchers suggested that the older consumers needed nutrition education to change their negative perceptions of yellow (including biofortified) maize. It seems that a combination of strategies, mainly recipe development, selection of suitable maize food types, and consumer education could improve consumer acceptance of the biofortified maize.

There are several consumer education strategies to improve their acceptance of a food product. Awareness campaigns are part of these strategies. However, there are few reported studies investigating the use of consumer education to improve the acceptability of biofortified maize. Further, currently, an appropriate and effective strategy for the suggested consumer education is not known.

In addition, knowledge of the sensory properties of popular maize foods in KZN, including phuthu, made with biofortified maize is scanty. Yet, knowledge of the sensory properties of the foods made with biofortified maize in place of the traditional white maize could be useful in understanding their low acceptability, as was found by Pillay et al. (2011). In this study, phuthu (crumbled maize porridge) and jeqe (steamed bread) made from Vitamin A biofortified maize were studied since they are traditionally well-known and popular amongst the rural African communities of KwaZulu-Natal (Pillay et al., 2011).
1.2 Problem statement

The South African Constitution Section 27(1b) states that everyone has the right to access sufficient food and water. Section 28(1c) of the same Constitution gives special attention to the rights of children to basic nutrition (Government Gazette, 1996). As stated in the Food and Nutrition Security policy (2014) about 13.8 million people in South Africa lack access to food (DAFF, 2014). Malnutrition is prevalent in the rural areas of KwaZulu-Natal (KZN) province. Various approaches to addressing micronutrient deficiency, including dietary diversification, supplementation and fortification (Public Health Reviews, 2010), have had little or no success in reducing micronutrient deficiency, especially amongst rural poor households in South Africa (Faber et al., 2011).

Furthermore, the KZN province is a leading agricultural region of South Africa, with a thriving subsistence and commercial agricultural production. Rural communities have access to land for both crop and animal production. Considerable food and nutrition security programmes have been rolled out in KZN, yet, micronutrient deficiencies, including VAD, are still a huge challenge. While provitamin A biofortified maize has the potential to combat VAD, its utilisation is still limited due to its low acceptance. Therefore more research with the participation of targeted VAD-vulnerable communities, such as the rural KZN communities, should be conducted to improve consumer acceptance of the biofortified maize. Ultimately, improved consumer acceptance of the provitamin A biofortified maize would contribute to the food and nutrition security of the targeted communities.

1.3 Aim of the study

The aim of the study was to determine the sensory characteristics and consumer acceptability of provitamin A biofortified maize food products, phuthu and jeqe, and to evaluate the effect of a provitamin A awareness campaign on the acceptability of the biofortified maize products.
1.4 Main research questions

1.4.1 What are the distinct sensory characteristics of provitamin A biofortified maize compared to white maize and what is the effect of these sensory characteristics on consumer acceptability of the biofortified maize?

1.4.2 What is the effect of a provitamin awareness campaign on the acceptance of traditional maize foods prepared with provitamin A biofortified maize by smallholder farmers in Empangeni, KwaZulu-Natal (KZN)?

1.5 Objectives of the study

1.5.1. To assess the perceptions and sensory acceptability of provitamin A biofortified maize phuthu and jeqe among smallholder farmers in Empangeni, KZN.

1.5.2. To determine the sensory characteristics (attributes) of provitamin A biofortified phuthu using a trained consumer panel.

1.5.3. To evaluate the effect of a provitamin A awareness campaign conducted using both modern and indigenous learning methods on the perceptions and hence acceptance of provitamin A biofortified maize among smallholder farmers in Empangeni, KZN.
1.6 Definitions

1.6.1. **Acceptability**: Adequacy in satisfying a need, requirement, or standard, an acceptable excuse; acceptable behaviour (Free Dictionary).

1.6.2. **Biofortification**: Is the process by which the nutritional quality of food crops is improved through agronomic practices, conventional plant breeding, or modern biotechnology (Melash, 2016).

1.6.3. **Carotenoids**: Yellow, orange, or red fat-soluble pigments, including carotenes, which give colour to plant parts such as ripe tomatoes and autumn leaves (Cazzonelli, 2011).

1.6.4. **Descriptive sensory analysis**: Is an analytical sensory evaluation method that involves the discrimination and description of sensory components of products by a trained panel (Singh-Ackbarali, 2014). A technique that provides complete sensory descriptions of products, determines how ingredients or process changes affect product characteristics, and identifies key sensory attributes that promote product acceptance (Chumngoen and Tan, 2015).

1.6.5. **Dietary diversification**: Access to a sufficient quantity and variety of foods that should meet the nutritional needs of the various populations (Nair, 2015).

1.6.6. **Food fortification**: The process of adding micronutrients to food to ensure that they are present at desirable levels (Salim et al., 2017).

1.6.7. **Jeqe**: A traditional South African dish, which can be best described as "steamed bread." made from a mixture of wheat and maize flour.
1.6.8. **Micronutrients**: Vitamins and minerals that are required in small amounts and are essential for health, development, and growth (Soetan, 2010).

1.6.9. **Nutrient deficiency**: The state of not having enough of a nutrient necessary for health.

1.6.10. **Perceptions**: Point of reference and or pictures built in the mind informed by one’s knowledge, beliefs, experiences and the environment.

1.6.11. **Phuthu**: A traditional preparation method of maize meal and a Southern African cuisine. It can be held in the hand as it is firm, dry, crumbly, and malleable.

1.6.12. **Provitamin A biofortified jeqe**: Jeqe made from provitamin A biofortified maize.

1.6.13. **Provitamin A biofortified phuthu**: Phuthu made from provitamin A biofortified maize.


1.6.15. **Sensory evaluation**: A scientific discipline that applies principles of experimental design and statistical analysis to the use of human senses (sight, smell, taste, touch and hearing) for the purposes of evaluating consumer products (Vijayan, 2015).

1.6.16. **Smallholder farmer**: Farmers practising agriculture on land of small size (one hectare or less) and few other assets and who lack access to high-quality inputs, credit, services and equipment. They may not access markets due to geographic isolation, poor infrastructure, lack of information or a combination of these. Their rights to land and other resources may be weak, and they may have
not yet managed to access markets in a way which can increase their productivity and lift them out of poverty (Pradhanang, 2015).

1.6.17. **Dietary supplement** is a product intended for ingestion that contains a "dietary ingredient" intended to add further nutritional value to (supplement) the diet (Mark *et al.*, 2015).

1.6.18. **Vitamin A:** A fat-soluble vitamin important for normal vision, tissue growth, and healthy skin. It is found in fish liver oils, milk, green leafy vegetables, and red, orange, and yellow vegetables and fruits (Ravisankar *et al.*, 2015).

### 1.7 Organisation of the chapters

This thesis has seven chapters, which are organised as follows:

**Chapter 1:** Introduction: Study background and problem statement (significance of the research).

**Chapter 2:** Literature review.

**Chapter 3:** Outline of study design and methodology.

**Chapter 4:** Research chapter: Smallholder farmers’ perceptions and sensory acceptability of Provitamin A biofortified maize food products in Empangeni, KwaZulu-Natal province, South Africa.

**Chapter 5:** Research chapter: Descriptive sensory analysis of provitamin A-biofortified (yellow) maize *phuthu* (crumbled porridge).

**Chapter 6:** Research chapter: An evaluation of the effect of integrated Indigenous Knowledge and Western-based methods of learning on consumers’ perceptions and
acceptability of provitamin A biofortified *phuthu* and *jeqe* prior to and after a provitamin A awareness campaign.

**Chapter 7:** Summary, conclusions, and recommendations of the study and recommendations for further studies

**Chapter 8:** Appendices

### 1.8 Summary of Chapter one

Vitamin A in the body plays a role in promoting vision, immunity, cell differentiation, and protein synthesis, growth and development, as well as acting as an anti-oxidant. Vitamin A deficiency (VAD) is acknowledged as one of the prevalent micronutrient deficiencies in the developing regions of the world, especially SSA. VAD affects mostly women of a reproductive age, children under five and disabled individuals. VAD may be caused by food insecurity among rural communities and inappropriate dietary nutritional supplements. This study focuses on the biofortification of maize. The first objective of the study assessed perceptions and acceptability of popular, traditional maize foods, *phuthu* and *jeqe*, in the KwaZulu-Natal province of South Africa. The second objective investigated the sensory characteristics of *phuthu*. The third objective evaluated the effect of a provitamin A awareness campaign (using persuasive communication) on consumer perceptions and hence acceptability of the traditional maize foods (*phuthu* and *jeqe*) prepared with biofortified maize. The popular, traditional maize foods selected for the study were *jeqe* and *phuthu*. They will be prepared with biofortified maize *phuthu* (crumbled maize porridge) and *jeqe* (steamed bread). The corresponding white maize products served as references (controls).
1.9 References


INP. (2001). The national directorate: nutrition and provincial nutrition units. Integrated nutrition programme strategic plan 2001/02 to 2006/07; November 2001


CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter is a review of the literature on vitamin A deficiency (VAD), vitamin A supplementation and the biofortification of maize with provitamin A (carotenoids). It provides a review of relevant issues around maize as a staple crop for improved food and nutrition security of maize consumers. It further looks at the significance of selecting provitamin A biofortified maize food products as a solution to hidden hunger in the form of vitamin A deficiency. Furthermore, consumer perceptions and acceptability of provitamin A biofortified maize are considered. Then, descriptive sensory analysis methods and other sensory evaluation techniques are reviewed. Finally, various intervention strategies employed to change consumer perceptions of food products are reviewed.

2.2 History of maize

Maize (Zea mays L.) belongs to the two grass families Poaceae and tribe Maydeae (Anley et al., 2013). Maize (“Zea mays) originated from an old Greek name for a food grass (Kansaki, 2015) and is known as the third most important food crop in the world (Murdia, 2016). Various hypotheses have been proposed on the origin/domestication of maize (OECD, 2006). Some people say it originated in the Mesoamerican region, which is now called Mexico and Central America (Watson and Dallwitz, 1992). Archaeological reports have proposed that the domestication of maize began at least 6000 years ago, occurring independently in regions of the Southwestern United States, Mexico, and Central America (Merrill et al., 2009). The Portuguese introduced maize to Southeast-Asia from America in the 16th century. Maize was introduced into Spain after the return of Columbus from America and from Spain it went to France, Italy and Turkey. In India, the Portuguese established the growing of maize during the seventeenth century. From India, it went to
China and later it was introduced in the Philippines and the East Indies. Maize is now being grown in many parts of the world such as the USA, China, Brazil, Argentina, Mexico, Africa, Rumania, Yugoslavia, India and Africa (Tripathi et al., 2011).

The species that are often defined as having roles in the domestication process of maize are Teosintes (Z. diploperennis and Z. mays sp. Mexicana) and Tripsacum (Galinat, 1988). Research reports suggest that an early hypothesis proposed that Z. mays sp. Mexicana was the product of a natural hybridisation of Tripsacum and Zea (Merrill et al., 2009). Extended crossings of teosinte with wild maize are assumed to have produced the contemporary races of maize. The likelihood of inter-generic hybridisation of either Z. diploperennis or Tripsacum with extinct wild maize has also been recommended as the ancestral origin of Z. mays (Radu et al., 1997; Purseglove. 1972). Eubanks (1993, 1997a) suggests that domesticated maize may have resulted from the human collection of natural hybrids between Tripsacum and Perennial teosinte.

In Africa, maize grain was introduced in the 1500s and it is still counted as Africa's leading food crop (Jaliya, 2016). Maize grains consist mainly of carbohydrates together with a few other nutrients such as vitamins A, C and E, and essential minerals, and contain 9% of protein and dietary fibres, it is, therefore, a good source of energy (Nuss, 2010; Oluwalana, 2014). Maize is now regarded as the traditional crop in many African households including those in the KwaZulu-Natal province of South Africa.

2.2.1 Global and sub-Saharan Africa maize production

Maize plays a significant role in human nutrition and is an essential element of animal feed and raw material for manufacturing of many industrial products (Chaudhary et al., 2013). The estimated percentage of maize imports in Africa from countries outside the continent is 28% (Mbabazi, 2015). This is because in Africa the crop is still cultivated mainly by smallholders and medium-scale farmers using traditional and low-input cultivation methods. Harvests under these circumstances are much lower than those
observed in Asia and Central America. Under traditional farming, maize is often ploughed in association with other (food) crops and is habitually not fertilised. Reports on maize show that it accounts for 30-50% of low-income household expenditures in Eastern and Southern Africa countries (Okweche et al., 2013).

Worldwide production of maize is 785 million tons, with the United States, China, and Brazil being the top three maize-producing countries, producing approximately 563 of the total production of 717 million metric tons/year (Ranum et al., 2014 (Table 2.1).

Table 2. 1: Top 10 maize producing countries in the world

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Production (1000.MT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>United States</td>
<td>367 680</td>
</tr>
<tr>
<td>2</td>
<td>China</td>
<td>217 000</td>
</tr>
<tr>
<td>3</td>
<td>Brazil</td>
<td>75 000</td>
</tr>
<tr>
<td>4</td>
<td>EU-27</td>
<td>71 016</td>
</tr>
<tr>
<td>5</td>
<td>Ukraine</td>
<td>25 000</td>
</tr>
<tr>
<td>6</td>
<td>Argentina</td>
<td>23 000</td>
</tr>
<tr>
<td>7</td>
<td>Mexico</td>
<td>22 500</td>
</tr>
<tr>
<td>8</td>
<td>India</td>
<td>21 000</td>
</tr>
<tr>
<td>9</td>
<td>South Africa</td>
<td>13 000</td>
</tr>
<tr>
<td>10</td>
<td>Russian Federation</td>
<td>12 000</td>
</tr>
</tbody>
</table>

Source: Earth Policy Institute from U.S. Department of Agriculture, Production, Supply, & Distribution, 2013

In 2014, South Africa was reported as the 10th largest maize producing country in the world yielding 15.5 million metric tons of maize in the same year. The crop is planted mainly in the North and North-Eastern regions of the country. In South Africa, Gauteng, North-West, Mpumalanga and Orange Free State, produce the topmost yields of maize in the country. The grain is sowed mostly between the months of September and December with the harvesting period between April and June. Different varieties of maize are produced in South Africa. Figure 2.1 shows white and yellow maize production in South Africa (NCEC, 2005-2015).
2.2.2 Nutritional composition of maize

Maize is composed of different minerals and vitamins that improve health in humans, however, it is devoid of nutrition. The composition of the edible portion of maize (dry) is given in Table 2.2 (Gopalan et al., 2007).
Table 2. 2: Composition per 100 g of the edible portion of maize (on dry basis)

AICRP on Maize, 2007

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Macronutrients and moisture</strong></td>
<td></td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>66.2 g</td>
</tr>
<tr>
<td>Moisture</td>
<td>14.9 g</td>
</tr>
<tr>
<td>Protein</td>
<td>11.1 g</td>
</tr>
<tr>
<td>Amino acids</td>
<td>1.78 mg</td>
</tr>
<tr>
<td>Fat</td>
<td>3.6 g</td>
</tr>
<tr>
<td>Fibre</td>
<td>2.7 g</td>
</tr>
<tr>
<td>Calories</td>
<td>342 mg</td>
</tr>
<tr>
<td><strong>Minerals (1.5 g)</strong></td>
<td></td>
</tr>
<tr>
<td>Phosphorus</td>
<td>348 mg</td>
</tr>
<tr>
<td>Sodium</td>
<td>15.9 mg</td>
</tr>
<tr>
<td>Sulphur</td>
<td>114 mg</td>
</tr>
<tr>
<td>Copper</td>
<td>0.14 mg</td>
</tr>
<tr>
<td>Calcium</td>
<td>10 mg</td>
</tr>
<tr>
<td>Iron</td>
<td>2.3 mg</td>
</tr>
<tr>
<td>Potassium</td>
<td>286 mg</td>
</tr>
<tr>
<td>Magnesium</td>
<td>139 mg</td>
</tr>
<tr>
<td><strong>Vitamins</strong></td>
<td></td>
</tr>
<tr>
<td>Thiamine</td>
<td>0.42 mg</td>
</tr>
<tr>
<td>Carotene</td>
<td>90 µg</td>
</tr>
<tr>
<td>Vitamin C.O.</td>
<td>12 mg</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>0.10 mg</td>
</tr>
</tbody>
</table>

Source: Gopalan et al., 2007

Figure 2.2 shows the endosperm that contains the main carbohydrates; the embryo is responsible for the parts that give rise to the next generation, while the pericarp and tip cap encircle the entire kernel. The endosperm contains approximately 80 % of the carbohydrates, 20 % of the fat and 25 % of the minerals found in the kernel, while the embryo contains about 80 % of the fat, 75 % of the minerals and 20 % of the protein found in the kernel. The starch portion of the kernel is used in foods and many other products such as adhesives, clothing, pharmaceutical tablets, and in paper production. The starch can be transformed into sweeteners and used in products such as soft drinks, sweets, bakery products, and jams. The oil from the embryo is used in cooking oils, margarine,
and salad dressings. The protein, hulls and soluble part of the maize kernel are used in animal and poultry feed (Jéan du Plessis, 2003).

Figure 2.1: Maize kernel structure.


**Figure 2.2: A maize kernel consists of an endosperm, an embryo, a pericarp and tip cap.**

Maize kernels can be processed into various food forms and consumed off the cob, parched, boiled, fried, roasted, ground, and fermented for use in bread, porridges, gruel, cakes, and alcoholic beverages (Nuss, 2010). However, maize has nutrition inhibitors that can adversely affect the bioavailability of essential nutrients for human health (Hambidge, 2010).

### 2.2.3 Nutritional composition and inhibitors in maize

Starch is the most abundant vital component present in the white maize variety, comprising nearly 71.3 % (Johnson, 2000). It is the most important source for energy (Sniffen and Robinson, 1987) whilst micronutrients make up about 1.3% of the maize kernel (FAO, 1992).

Although maize availability is considered an indicator for food security, heavy reliance on a maize-based diet and/or the consumption of a diet composed solely of maize can lead
to malnutrition. The nutritional quality of maize grain is inadequate due to its deficiency in the essential amino acids, lysine, and tryptophan. This is due to the presence of anti-nutrients such as phytate, which affect nutrient absorption by the human body. Phytate and polyphenols are considered as anti-nutritional factors because they interact with food constituents such as minerals and make them unavailable (Sokrab et al., 2014). Phytic acid (PA) and myoinositol hexaphosphate are naturally occurring compounds and they can constitute up to 1.5% of a kernel, and 60% to 90% kernel phosphate (Lott et al., 2000, Bohn et al., 2008). PA is essential for kernel germination and phosphate storage. However, it can adversely affect the bioavailability of kernel minerals essential for human health (Raboy, 2003). Calcium increases the inhibitory effect of PA, specifically, the bioavailability of zinc, by making insoluble calcium-PA-zinc salts; however, the reduced bioavailability of zinc allows for improved copper absorption (Zhou and Erdman, 1995).

Micronutrient deficiencies in populations with marginal nutritional status can be heightened by these PA-mineral attachments. The iron status in individuals can be improved if β-Carotene and ascorbic acid are added to the diet (Garcia-Casal et al., 1998; Layrisse et al., 2000; Hurrell et al., 2003). Exogenous phytase enzymes derived from microbes, plants or fungi can lead to the increased bioavailability of minerals (Hurrel et al., 2003; Revy et al., 2006). Phytate level in food can be reduced by the activity of endogenous phytase enzymes in plant tissue, or by hydrolysis with exogenous phytase enzymes. Such measures may be used to process foods for consumption by populations at risk of mineral deficiency (Troesch et al., 2009).

Although several phytases are commercially available, the majority are too expensive to manufacture for large-scale distribution and ineffective in breaking down phytate. Current improvements are concentrating on developing premixed phytases with extremely bioavailable minerals and other micronutrients for the in-home fortification of foods (Bohn et al., 2008; Troesch et al., 2009). Maize has different kinds of varieties, which differ from country to country, but it should be noticed that not all varieties have nutrition inhibitors. The yellow maize variety has more nutrition inhibitors (Hefferon, 2015).
2.2.4 Popular Maize types in sub-Saharan Africa

In sub-Saharan Africa the most familiar kernel colours of maize are yellow and white, however, in some landraces, the kernels are red, purple and brown. Several kernels on the same ear are due to the out-crossing nature of the crop. (Verheye, 2010). The kernel structure differs from the type and kind of the endosperm (Verheye, 2008). White maize is more popular for human consumption in South Africa (Ranum et al., 2014). Figure 2.3 shows the commercial white maize production in South Africa for the year 2012 to 2013.

Source: Crop Estimates Committee (2013)

**Figure 2.3: Commercial maize production by province in South Africa (2013)**

The above figure shows the commercial white maize production by province in South Africa. However, most smallholder farmers who mainly reside in rural geographical areas are active producers of maize. The primary purpose of planting maize is usually for food security rather than household nutrition security. Additionally, Table 2.3 shows the commercial consumption of the major maize types, white and yellow maize.
Table 2.2: The commercial consumption of white and yellow maize in South Africa for the marketing years (MY), 2013/14 MY (estimate), 2014/15 MY (estimate) and 2015/16 MY (forecast)

<table>
<thead>
<tr>
<th>Maize 1,000Mt</th>
<th>White</th>
<th>Yellow</th>
<th>Total</th>
<th>White</th>
<th>Yellow</th>
<th>Total</th>
<th>White</th>
<th>Yellow</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2013/14</td>
<td></td>
<td></td>
<td>2014/15</td>
<td></td>
<td>2015/16</td>
</tr>
<tr>
<td>Human</td>
<td>4,360</td>
<td>480</td>
<td>4,840</td>
<td>4,200</td>
<td>500</td>
<td>4,700</td>
<td>4,400</td>
<td>500</td>
<td>504,4</td>
</tr>
<tr>
<td>Animal</td>
<td>1,470</td>
<td>3,570</td>
<td>5,040</td>
<td>200</td>
<td>4,800</td>
<td>5,000</td>
<td>500</td>
<td>4,500</td>
<td>5,000</td>
</tr>
<tr>
<td>Other</td>
<td>110</td>
<td>270</td>
<td>380</td>
<td>100</td>
<td>200</td>
<td>300</td>
<td>100</td>
<td>300</td>
<td>4000</td>
</tr>
<tr>
<td>TOTAL</td>
<td>5,940</td>
<td>4,320</td>
<td>10,260</td>
<td>4,500</td>
<td>5,500</td>
<td>10,000</td>
<td>5,000</td>
<td>5,300</td>
<td>10,300</td>
</tr>
</tbody>
</table>

Source: SAGIS, 2016.

Yellow maize is unpopular in Africa because it is perceived as food for the poor, food for use in times of disasters such as drought or famine, and as food for livestock (HarvestPlus, 2010). Furthermore, yellow maize’s taste is perceived as inferior to that of white maize; studies have shown that poor handling of yellow maize produces chemical changes, which compromise taste (Muzhingi, 2008). These perceptions originate from the use of yellow maize as food aid in Africa (Ranum et al., 2014). The negative perceptions consumers have towards yellow maize hinder them from consuming it. Most Africans know yellow maize, but a smaller percentage of them either consume it or are aware of its nutritional qualities.
2.2.5 The importance of maize as a staple crop

Maize is viewed as a paramount crop and was projected to be the number one food to feed nine (9) billion people in 2015 (Charles et al., 2010). It is a crop that ensures stability in the food security of most households, especially in Sub-Saharan Africa, as it is the most available, accessible and most utilised food (Frelat et al., 2016). Additionally, in many rural households, maize is consumed daily, in almost every meal; in poor households maize products may be the only food available. This lack of diversity has been criticised because the nutritional content of maize cannot satisfy the dietary needs of the human body and its consumption as the main staple food aggravates malnutrition in the form of hidden hunger (Nuss and Tanumihardjo, 2011). Hidden hunger is one of the biggest challenges that Sub-Saharan Africa is faced with, although 80% of the households are producing food through agriculture. Maize is utilised as a food source where several maize products are processed in different food products such as soft porridge, stiff porridge, snacks and beverages that can be alcoholic and some not. Within countries, the popularity of food varies with ethnicity; in South Africa’s KwaZulu Natal province, phuthu and jede are popular maize products.

Nutrition interventions such as food fortification, supplementation, and food diversification that promote food and nutrition security have had reportedly had less success in Africa than in other developing countries because rural households rely on their own production (Pillay et al., 2011). This has been attributed to the limited practice of food diversification projects and the socio-economic status/infrastructure, lack of time and/or inadequate knowledge, which hinder the rural households from accessing vaccines and supplementary programmes, which have been developed to enhance food and nutrition status.
2.3 Vitamin A Deficiency (VAD)

Micronutrient deficiencies are a worldwide problem, with vitamin A, iodine, iron, zinc and folic acid being the most prevalent deficiencies (Ramakrishnan, 2002). Vitamin A deficiency has been reported to be a key public health problem in most developing countries, including South Africa, due to limited resources and reliance on monotonous diets (Pillay, 2011; Lividini and Fiedler, 2015; De Groote and Kimenju, 2011). Vitamin A is a fat-soluble vitamin important for normal vision, tissue growth, and healthy skin. It is found in fish-liver oils, milk, green leafy vegetables, and red, orange, and yellow vegetables and fruits (Ravisankar, 2015). Vitamin A is very sensitive to light and oxidising agents (e.g. iron) and moderately sensitive to heat. Stability in fortified products is good unless stored at temperatures above 45°C. Vitamin A is found in animal-based foods as retinyl esters (mainly retinyl palmitate). In fruits and vegetables it occurs as provitamin A carotenoids (mainly β-carotene, α-carotene and β-cryptoxanthin), which can be split and processed into retinol after absorption by the intestinal cells (Reboul, 2013). Vitamin A micronutrients are defined as preformed retinoids that are converted in the body into the active form from animal products (e.g. liver, fish oils, dairy, eggs), from provitamin A red, orange, yellow and dark green vegetables and orange fruits (e.g. carrots, cantaloupe, mango, sweet potato, squash, pumpkin, spinach, kale, broccoli, collards), and supplements (Rowe, 2012).

Retinol from animal sources is more bioavailable than beta-carotene. It is absorbed in the small intestine in the presence of fats and is transported to the liver if it is being stored or in specialised tissues if being used. Retinol and beta-carotene should be consumed in small amounts as they are poisonous in large amounts. Individuals suffering from vitamin A poisoning experience the following symptoms, a headache, vomiting, double vision, hair loss, joint pain, and their skin may turn orange. Pregnant women experience spontaneous abortions or may give birth to children with birth defects (Reboul, 2013).
2.3.1 Vitamin A supplementation in the world

Vitamin supplements are defined as vitamins which are needed in very little amounts and are sold with specific health claims for specific physiological processes. Vitamin supplements have been used for medical reasons and to address deficiencies in the population, thus reducing the incidence of deficiency diseases. Vitamin A has the following functions in the human body: vision, immunity, fetal development, and antioxidant activity. Millions of pregnant women and almost 200 million children between the ages of one and five years in Africa and South-East Asia suffer from vitamin A deficiency. Infants and children have bigger vitamin A requirements to aid rapid growth and to assist them to combat infections (WHO, 2011). Figure 2.4 shows the current status of Vitamin A supplementations using UNICEF data.

![Figure 2.4: Vitamin A supplementation status (UNICEF, 2015)](image)

2.3.1.1 Sub-Saharan Africa

Sub-Saharan Africa has responded to its high Vitamin A deficiency burden by implementing vitamin A supplementation programmes. Figure 2.4 shows that 73% of a
vulnerable group of women and children in Sub-Saharan Africa suffer from vitamin A deficiency and this is backed by studies which show that 41 of the 45 countries give supplementary Vitamin A to all children aged 6–59 months. Many countries including South Africa have implemented largely wide-reaching vitamin A supplementation programmes; although there is some evidence that in some countries the administration of these programmes is not without disruption. Food-based strategies have been introduced in most Sub-Saharan African countries to complement the supplementation efforts of the government. However, three countries, Botswana, Cape Verde and South Africa, have also targeted efforts for vitamin A supplementation. Mauritius relies on a food-based strategy and under this programme, they have exceeded 70% regional coverage every year except 2003 (UNICEF, 2007).

2.3.1.2 East Asia and The Pacific

In countries such as Indonesia, the Philippines, Viet Nam, which are priority countries of the East Asia and Pacific region, vitamin A supplementation has been carried out for decades. However, Malaysia relies only on food-based strategies. Vitamin A-fortified food products are offered in Malaysia and the Philippines, with particular progress towards fortification to the Democratic People’s Republic of Korea, Indonesia, Thailand and Viet Nam. (UNICEF, 2015).

2.3.1.3 South Asia

Studies show that all eight countries in this region have national vitamin A supplementation programmes, although the age groups targeted for vitamin A supplementation vary in both India and Sri Lanka. While regional coverage remains relatively low, the increase in coverage from 35 percent to 62 percent from 1999–2004 translates into an additional 16 million children reached with at least one high dose. South Asia is also progressing in the scale-up of fortification of ghee and other oils (UNICEF, 2015).
2.3.1.4 Middle East and North Africa (MENA)

The MENA region has a different kind of supplementation approach; they have an expanded programme on Immunisation (EPI) with an added long-term focus on food fortification. Supplements are distributed with the measles vaccine especially in countries facing emergencies and, as part of food aid, oils fortified with vitamins A and D are distributed, helping to meet the needs of high-risk groups (UNICEF, 2007).

2.3.1.5 Central and Eastern Europe/Commonwealth of Independent States (CEE/CIS)

Vitamin A deficiency has been identified as a public health problem in CEE/CIS, and vitamin A supplements are given to children in early infancy from 0-6 months. Vitamin A supplementation programmes were launched in Uzbekistan in 2002, followed by Azerbaijan, Kyrgyzstan and Tajikistan in 2004. Food fortification and other short-term supplementation strategies have also been adopted (UNICEF, 2007).

2.3.1.6 United States of America and The Caribbean

Vitamin A supplementation initiatives in the United States of America and The Caribbean are carried out primarily through routine EPI contacts. However, supplementation is not widely used as their food industry is well developed and centralised, making large-scale food fortification a feasible strategy. Guatemala, Honduras, and Nicaragua fortify their sugar with vitamin A and other countries are planning to follow suit (ACC/SCN, 2000). The major cause of vitamin A deficiency among millions of Africans is limited access to fruits and vegetables, which are rich sources of provitamin A products because they are often not accessible or are available seasonally, with restriction (Girum, 2013). Vitamin A deficiency is the leading cause of preventable blindness, and increased susceptibility to infection and subsequent death in children (Combs, 2012). It is estimated that 250,000-500,000 children develop blindness every year due to the consequence of vitamin A
deficiency and that half the number of these die within 1 year of losing their eyesight (Buah, 2016).

The World Health Organization’s identified vitamin A as an important public health problem in eight out of nine South African provinces (WHO, 2011). The South African Department of Health implemented vitamin A supplementation (DOH), although its implementation is regarded as a temporary deficiency control measure, with the debatable capacity to be a sustainable public health intervention for child–survival. (D.O.H, 2002). The indicator in Table 2.4 refers to the percentage of South African children aged 1-9 years who have marginal or inadequate vitamin A status i.e. with serum retinol below 20ug/dL. Children are only considered to have severe vitamin A deficiency if their serum retinol levels are significantly low (<10ug/dL).
Table 2.3: The proportion of children affected by vitamin A deficiency, 2005

<table>
<thead>
<tr>
<th>Province</th>
<th>Inadequate vitamin A status (%)</th>
<th>Vitamin A deficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Cape</td>
<td>64.2</td>
<td>8.2</td>
</tr>
<tr>
<td>Free State</td>
<td>61.7</td>
<td>11.3</td>
</tr>
<tr>
<td>Gauteng</td>
<td>65.2</td>
<td>11.2</td>
</tr>
<tr>
<td>KwaZulu-Natal</td>
<td>88.9</td>
<td>44.7</td>
</tr>
<tr>
<td>Limpopo</td>
<td>75.7</td>
<td>12.5</td>
</tr>
<tr>
<td>Mpumalanga</td>
<td>52.1</td>
<td>4.2</td>
</tr>
<tr>
<td>North West</td>
<td>49.6</td>
<td>5.8</td>
</tr>
<tr>
<td>Northern Cape</td>
<td>23</td>
<td>3.8</td>
</tr>
<tr>
<td>Western Cape</td>
<td>43.5</td>
<td>2.3</td>
</tr>
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<td>South Africa</td>
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The above indicators showed KwaZulu-Natal had the highest percentage of children aged (1) to nine (9) years old who suffered from vitamin A deficiency. Provincial officials could implement a strategy (supplementation, fortification, dietary diversification) to increase the consumption of plant-based carotenoids, thus reducing the prevalence of vitamin A deficiency. There is evidence of maize biofortification interventions being implemented in Africa (Nestel et al., 2006; Tanumihardjo et al., 2008), but provitamin A biofortified maize product reports are not well documented. Thus far, these interventions have achieved little success in reducing vitamin A deficiency, particularly amongst the rural poor (Bruins, 2013).
2.4 Vitamin A supplementation advantages and benefits, disadvantages and recommendations

2.4.1 Advantages and benefits

The advantages of using Vitamin A supplements as a strategy are that, first, they are relatively affordable when they are delivered to the community through health departments. The use of vitamin A supplements boosts the immune system and increases morbidity in children and women of reproductive age. Vitamin A supplementation helps in preventing and combating vitamin A deficiency. Vitamin A is an important micronutrient that helps in immunity, vision, anti-oxidant, cell differentiation, protein synthesis, growth and human development. If coverage is adequate, it could have a high impact.

2.4.2 Disadvantages

Vitamin A supplementation is associated with the risk of exposure to very high levels of the vitamin, which is poisonous in high concentrations. Distance, limited availability and access to transport, and the caregiver’s lack of information on vitamin A drops are some of the reasons why poor rural children have less access to Vitamin A supplements. Time and effort are absorbed in accessing healthcare facilities. In other areas, there is no access to healthcare facilities. The rural poor communities are unable to bring their children to clinics and hospitals. Thus, when such activities are implemented some communities receive poor coverage.
2.4.3 Recommendations for vitamin A supplementation

The following recommendations have been made to improve the delivery of vitamin A supplementation: (i) that precautions in universal distribution programmes should be observed in all care centres; (ii) that large-scale vitamin A distribution programmes be implemented; (iii) that health workers participating in the vitamin A supplementation programme receive specific training; (iv) that regular health services are provided to individuals in the specified age group; (v) that vitamin A supplementation programmes be implemented only in vitamin A deficient areas (Kapil, 2013; Demissie, 2010; WHO, 2014).

2.5 Food fortifications

Food and Nutrition insecurity remains a challenge in South Africa and the rest of the world, especially developing countries. Women and children are usually more vulnerable to food and nutrition security than men and are more likely to suffer from malnutrition, including hidden hunger. Interventions such as fortification, which enhances the nutritional content of staple foods with inadequate nutritional value, have been proposed. Fortification is defined as the process of adding vitamins and minerals to food for the purpose of increasing the complete nutritional content (Wesley and Ranum, 2004). Food fortification may be perceived as a cost-effective way of improving individual micronutrient consumption in communities. Foods that can be fortified with vitamins are cereals, millie flour, sugar, oil, and margarine (Dary and Mora, 2002). Attempts to fortify other foods, for example, whole-wheat grain, tea, instant noodles, fish sauce, yoghurt, and salt have been made. However technological matters have prevented large-scale application of these efforts (Dary and Mora, 2002).

2.5.1 Advantages

Fortified foods are generally acceptable. They require minimum changes in food habits. They have guaranteed sustainability. The delivery systems of fortified foods are already
in place. They are readily available where existing food supplies and limited access fail to deliver sufficient levels of the particular nutrients in the diet. They are safe to eat because effective food controls quality and consumer protection measures are in place (Samaniego-Vaesken; et al., 2012; Berner, 2014).

2.5.2 Disadvantages

Modern technology can only fortify certain food types. Insufficient scientific knowledge regarding nutrient interaction limits some food fortification. Fortified foods are not affordable, not free, and are not easily accessible, especially in remote areas.

2.5.3 Recommendations

Food fortification is recommended for most vitamin A deficiency affected populations especially in populations having micronutrient deficiencies. Training skills for fortification expertise are required. Food fortification support programmes are advisable. It is recommended that fortified foods should be included in food aid. Consumer education is important for nutritional knowledge.

2.6 Food diversification

According to Maunder et al. (2001), diet diversification is one of the main techniques promoted internationally for the enhancement of micronutrient intake status particularly in malnourished individuals. Dietary diversification describes nutrient sufficiency and diet diversity, which are two of the main constituents of diet quality. There is evidence that that growing fruits and vegetables in home gardens balances dietary diversification for long-term results to achieve better health. Dietary diversification should ideally guarantee that an individual has steady access to food naturally rich in vitamin A. Dietary diversification can be done in several ways, for example, feeding programmes, and training on how to grow plants rich in vitamin A including innovative tactics for home
gardening, methods of cooking and crop storage. Diversified farming is recommended as it allows populations to eat a wider variety of foods. However there are some advantages and disadvantages that are indicated in.

### 2.6.1 Advantages

Foods containing vitamin A are available and affordable in the market. Households in vitamin A deficient communities can be provided with productive resources to facilitate the production of fruits, vegetables, and crops which can ultimately provide adequate quantities of carotene, ION, vitamin C and thiamine. It is possible to diversify one’s diet by including the large variety of already available fresh fruits and vegetables (Padulosi, et al., 2016).

### 2.6.2 Disadvantages

Fresh fruits and vegetables are expensive, thus the cost of consuming a diverse diet is usually too high for poor households. The local markets from which poor households access their food may not have the capacity to guarantee adequate supply. Climate variability can cause great shortages and increased prices.

### 2.6.3 Recommendations

#### 2.7 The importance of maize biofortification

Maize was selected for biofortification to address vitamin A deficiency mainly in Sub-Saharan African countries because it is a leading staple in this region. Biofortification is a new approach of breeding higher ranks of micronutrients straight into staple food yields crops using the best traditional breeding practices and modern biotechnology (Nestel et al., 2006; HarvestPlus, 2010; Hefferon, K. L. 2015).
Biofortification is also defined as the process by which the nutritional quality of food crops is made better through agronomic practices, conventional plant breeding, or modern biotechnology (Hefferon, 2015). Biofortification differs from conventional fortification in that biofortification aims to increase nutrient levels in crops during plant growth rather than through physical means during processing of the crops. Biofortification may, therefore, offer a way to reach populations where supplementation and conventional fortification activities may be problematic to apply and/or are restricted.

Maize as a highly preferred food crop in Africa was selected for biofortification to improve its provitamin A content (Gannon et al., 2014). Biofortification of maize could have a positive impact as a solution for vitamin A deficiency. Biofortification is regarded as important in reaching the Millennium development goals four and five of reducing the under-five years old child mortality ratio by two-thirds and the maternal mortality ratio by three-quarters between the years 1990 and 2015 (WHO, 2011). Biofortification was further approved as an additional technology and method to improve nutritional status, which is a key element of child mortalities in the current programme of the sustainable developmental goals.

Biofortified foods are important in carotenoids Carotenoids are defined as a group of 700 lipophilic yellow, orange, and red pigments mainly produced by photosynthetic organisms as well as by particular fungi and bacteria (Britton, 1995a; Khoo et al., 2011). The provitamin A biofortification process results in maize becoming yellow or orange in colour due to the availability of carotenoids. Cultivated maize varieties contain very low levels of provitamin A carotenoids varying from only 0.5 to 1.5 µg g⁻¹. Maize improvement programmes at IITA and other CGIAR centres have been trying to enhance the provitamin A content of maize grain to at least the level of 15 µg g⁻¹. This target was set by the HarvestPlus programme human nutrition experts as an initial minimum level to make a satisfactory impact on the health conditions of those affected by vitamin A deficiency and maize reliant communities (Simpungwe et al., 2017).
Carotenoids are huge (40C) organic molecules that naturally occur in plants. They are responsible largely for the yellow-orange colour of plant organs, especially fruits and roots. There are two main classes of carotenoids, carotenes, and xanthophylls. Over 600 isomers of carotenoids exist. Carotenoids perform a diversity of purposes in plants including operating as antioxidants, photoprotectants, accessory pigments for light harvesting, and substrates for production of volatile compounds in flowers, fruit, and seed (Goff and Klee, 2006; Moise et al., 2014). The most significant and best-defined role of carotenoids in animals is as a dietary source of provitamin A, which is a precursor of vitamin A, an essential nutrient for animals, including humans. Of the approximately 50 carotenoids that have vitamin A activity, only three - α-carotene, β-carotene and β-cryptoxanthin - are found in food in nutritionally significant quantities. Amongst these three carotenoids, β-carotene exhibits the greatest vitamin A activity (Grune et al., 2010).

Provitamin A carotenoids can be changed by oxidative cleavage in the body to retinol, or vitamin A, which is stored in the liver (Stahl and Sies, 2005; Combs, 2012). As stated previously, vitamin A performs several physiological roles in the human body, including immune function and production of various retinoic acid hormones, and vision. The other important functions of carotenoids in humans are that they are antioxidants (Jerome-Morais et al., 2011., Young and Lowe, 2018). As an example, specific isomers of the non-provitamin A carotenoids, lutein and zeaxanthin, are present at high levels in the fovea of the eye where they are associated with the prevention of age-related muscular degeneration (Krinsky et al., 2003; Abdel-Aal et al., 2013), a primary cause of permanent blindness in elderly populations of Western societies (Friedman et al., 2004). There are several advantages, disadvantages and recommendations of biofortification highlighted below.

2.7.1 Advantages

Biofortification is a relatively cheap method of breeding crops traditionally. Biofortification has the potential to boost farm productivity in developing countries. A biofortified crop
system is extremely sustainable. Biofortification offers a means of reaching starving populations in relatively remote rural areas.

### 2.7.2 Disadvantages

It is likely that biofortified foods will be less acceptable to consumers because yellow maize has been perceived negatively and labeled as ‘food for drought’, ‘food for the poor’ and ‘animal feed’. In some cases, the nutrients would not be acceptable to the human system. Biofortification requires a special technique in producing nutrients in some crops.

### 2.7.3 Recommendations

There is a need for more research to be conducted to improve the nutrient quality of crops, which also deliver high yields and good agronomic performance (Bouis, 2017). There is a need to re-analyse gender acceptability of bio-fortified crops, as male and female farmers may have different perceptions. Nutrition campaigns are required to provide information on biofortification. It is important to market the biofortified products for generating income. There is a need to evaluate sensory properties of biofortified foods for their acceptability (Lagerkvist, 2016).

### 2.8 Sensory evaluation of food products

Sensory evaluation is one of the scientifically recognised approaches to evaluating sensory quality attributes of food products as perceived by consumers. Its principles have their origin in physiology and psychology. “Sensory evaluation is defined as a scientific discipline used to evoke, measure, quantify, analyze and interpret responses to those characteristics of foods and materials as they are observed by the sensory sight, smell, taste, touch and hearing” (Stone and Sidel, 1993). The five senses, i.e. taste, smell, sight,
touch, and hearing are useful for gathering information about food especially during its consumption. Each phase in this definition has a specific significance, obligation or implication.

To evoke reactions needs specific, rigorous research methods and It involves an understanding of physiology, anatomy, biochemistry, psychology, genetics (e.g. taste or odour blindness for certain substances), the necessities for and influence of the test procedures and the test environment (Ackbalari, 2014).

First, to measure reactions requires measuring instruments that are qualitative or quantitative in nature to control human reaction to one or more variables in a product or material. It demands knowledge concerning measuring instruments and their application, statistics, computer science, research methodologies/protocols, the effect of the test environment, requirements for tests, test facilities and more (Singh-Ackbarali and Maharaj, 2014):

Second, to analyse reactions needs the application of the correct statistical software, test statistics, and computer literacy, as well as knowledge of physiology, psychology, and behavioural science, and further, the knowledge to evaluate qualitative and quantitative results.

Third, to interpret reactions, needs knowledge of statistics, food science, computer software, chemistry, biochemistry, physics, and gastronomy. It requires the ability to write thorough and detailed executive summaries. It entails good presentation skills and the skill to advise courses of action grounded in the facts, without being prescriptive. Perception through the senses generally requires knowledge of physiology and psychology. It also needs information regarding the physiology of the eyes, ears, tongue, mouth, fingers, and nose (Singh-Ackbarali and Maharaj, 2014).
2.8.1 Acceptance tests

The other way of getting a human response to products is giving options of liking or acceptability. These tests are usually referred to as acceptance tests and are best done with a large group of respondents because of the subjective nature of the responses. (Singh-Ackbarali, 2014) The general population can vary greatly in product preferences, so it is important to use respondents who are representative of the target market. Non-users could easily offer different results that would misinform product decisions. In acceptance tests, validity is the primary issue as it is predictive of marketplace success (Singh-Ackbarali, 2015).

Data from sensory experiments have offered a greater appreciation for their sensory properties, such as taste, texture, appearance and aroma and this greater appreciation, in turn, has had a major influence on test techniques and on the measurement of human responses to stimuli. The body of knowledge on sensory evaluation began with the physiology of the senses and the behavioural aspects of the perceptual process (McCrickerd, K. et al., 2016).

2.8.2 Consumer perceptions of foods

The perception of sensory attributes is important and contributes to the acceptance or rejection of food by consumers. It may be described as the evaluated adequacy of the product in terms of its set of required eating quality characteristics such as appearance, taste, aroma, and texture (Nordtest, 2002). Individuals are exposed to hundreds of food products, but they select only those products which fulfil their current dietary needs, a possibly informed by previous sensory experiences. Previous experience with a food product and the consumer’s motives contribute to the selection of food (Krondl and Coleman, 1988; Sema, 2013), and interpretation which is influenced by certain expectations around a food product being presented (Bell and Meiselman, 1995). Consumers automatically fill in the missing information to conclude what the food product
was supposed to fulfil (Schiffman and Kanuk, 1991). However, the previous experience could be a disadvantage, especially when certain products, for example, yellow maize, have a stigma associated with them despite being of a superior quality. The quality of food products is based on attributes such as colour, flavour, texture, and aroma (Singh-Ackbarali and Maharaj, 2014).

2.8.3 Perceived quality attributes

Perceived quality is classified under three categories: (i) the cue acquisition and categorisation; (ii) quality attribute belief formation; and (iii) the integration of quality attribute beliefs (Lazarova, 2010). For each of these three categories involvement, prior experience with the product, level of education, perceived-quality risk, and quality consciousness, influence quality perception processes, (Lazarova, 2010).

2.8.4 Acquisition and categorisation

Acquisition and categorisation are based on consumer involvement and prior experience. Oriade (2013) states that consumers are influenced by what they perceive to be important or of value; what they know, how the food product would contribute in the consumer well-being (credibility), availability and intensity of previous experiences to judge the credence attributes. The extent of consumer involvement with particular food products affects their motivation to process information; highly-involved consumers tend to be more critical. Additionally, people with more prior knowledge about a product will process quality-related information at a deeper, more abstract, and more elaborate level. Knowledgeable consumers could be more inquisitive than the less knowledgeable consumers (Fang, 2008).
2.8.5 Quality attributes belief formation

The consumer’s level of education plays an important role in information processing. Individuals with less education tend to be less competent in information processing and subsequently use less information in decision-making processes. Thus, many studies identify education level as a critical factor, especially when dealing with the adoption of innovation and technology. It is also argued that when quality risk is perceived, consumers use one or a few cues in the quality judgments; those that experience high risk use fewer quality cues in the quality perception process than consumer experiencing low risk (Veale, 2007).

2.8.6 Quality consciousness

This is a psychological process determined by the cognition and emotional effects and predisposition to respond in a consistent way to quality-related aspects, which is organised through learning and influences behaviour. It serves as a motivational factor to reflect certain behaviour. Quality consciousness is organised through learning from previous experiences and from information acquired from external sources. This component affects the judgment or assessment of what is under scrutiny (Bandura, 1999). Situational factors such as the purpose for which the product is purchased, physical surroundings, social surroundings, and time pressure are influential in determining quality.

2.9 Consumer perceptions and the acceptability of provitamin A biofortified maize and its products

Perception is a process through which an individual recognises, selects, organises and interprets any input (stimuli) to any of/or a combination of the five senses (sight, smell, taste, touch and hearing) into a meaningful and coherent picture of the situation (Bagozzi
et al., 2002; Foxall and Goldsmith, 1994; Schiffman and Kanuk, 2010). There are different types of stimuli; physical stimuli are provided by external sources.

Brand loyalty studies have revealed that it is usual for researchers to focus on consumer perceptions and acceptability, emphasising the utilitarian food attributes and experience at the expense of consumer satisfaction. Nadzri (2016) defines experiences as conceptualised sensations, feelings, cognitions, and behavioural responses that are triggered by stimuli that the food represents. On the other hand, consumer satisfaction is regarded as a positive affective reaction based on prior experience (Schwarz, 2011). The relationship experiences and consumer expectations are based on what the consumer wants. These wants indirectly influence preferences consequently, and simultaneously engineer consumer perceptions as consumers use these activities as a point of reference used to reframe their views.

Since the introduction of yellow maize, literature has shown that most consumers would rather consume white maize. This dislike of yellow maize is as a result of it being introduced to African communities in response to famine or drought, with it being regarded as animal feed and its perceived inferior taste (HarvestPlus, 2010). Thus, it is likely that these negative perceptions may limit the consumption of biofortified yellow maize. Khumalo (2008) reported that the aroma and colour of yellow maize meal with fibres were less acceptable to his selected population group. The latest studies conducted in South Africa in the KwaZulu-Natal province show that demographic factors such as age seem to be the major problem. The black African female caregivers perceived the provitamin A biofortified maize as an animal feed or food for the poor (Govender, 2014).

Studies on the consumer attitudes towards yellow maize have shown that it has a positive reception in some communities, although this is linked to specific food products. Female caregivers of infants in rural KwaZulu-Natal found the soft porridge made from biofortified maize to be as acceptable as its white maize equivalent. There may be the potential to use provitamin A-biofortified maize as a complementary food item, contributing to the
alleviation of vitamin A deficiency in infants (Govender, 2014). Meernakshi et al. (2010) suggested that the negative perception of yellow maize does not affect the liking of orange maize. Meenakshi (2010) highlighted the fact that products made from yellow maize are different and much more favoured than those from white maize because of their pleasurable taste and good-looking colour.

2.10 Interventions to change consumer perceptions: persuasive communication

Persuasive communication is a process that involves changing behaviour through a persuasive message that influences both cognitive and affective elements, Bagozzi et al., 2002). The impact of persuasive communication is affected by how involved the person is with the message (Bagozzi et al., 2002). The persuasive communication approach is one of the social approaches that are used to influence and change people’s perceptions and attitudes (Kolanisi, 2010), through two important roles, namely, transactional and responsive effects. A transactional role means that there is a mutual exchange of information between the message sender and the receiver. In contrast, a responsive role focuses more on the receiver. It also involves the ability of the receiver to perceive and interpret the message and thus make rational decisions and evaluations which are then reflected in attitude change. The persuasive theory assumes that beliefs and attitudes are influenced by consumer perceptions. Therefore, for the message to be persuasive enough the source should be trustworthy and credible. Flynn (2016) argues that if the consumer is highly involved with the message then an individual believes in the message with less time and energy to actively oppose it.

Food and nutrition education consists of a variety of educational strategies that can be implemented at different levels, and which aim to help people to make lasting changes in their diets and eating behaviours. Nutrition education does not only include learning about food and nutrients, but learning what to do and how to act in the process to improve nutrition. The nutrition education and consumer awareness team provide technical support to countries to develop policies and programmes to increase public awareness
of the importance of eating well, foster food environments that enable healthy food choices, and build the capacities of individuals and institutions to adopt food and nutrition practices that promote good health (FAO, 2017).

The promotion of nutritionally adequate diets is imperative because of the steadily increasing under-nutrition, vitamin and mineral deficiencies, obesity and diet-related chronic diseases in developing countries (Mesgarani and Shafiee, 2016) and it is led by international NGOs e.g. FAO, Harvest-plus and UNICEF. Regardless of food availability, it is essential that individuals know how best to make use of their resources to guarantee nutritional well-being. To be adequately nourished, individuals need to have access to adequate and good quality food. This can be achieved when they know the components of a good diet for health, and have the skills and motivation to make good food choices. The perceptions of consumers are likely to change in response to training, when these skills are taught, practiced, and rewarded over time. It has been shown that a series of classes is more likely to result in positive change to reinforce the message than a one-time session. Starr, L. (2017). The expected behaviour change must be realistic, and this can only be achieved when participants, with the educators’ assistance, set very specific targets that can be achieved over a realistic time frame.

There are various methods or techniques that could be used to optimise the opportunities to learn through instruction and practice in a class environment, for example written work, discussions, presentation, role-playing, storytelling and singing (Dunlosky, 2013). Kauppi (2015) shows that for the design of a successful behaviour change campaign, the designer and facilitator of the process need to understand the primary goal of the campaign and apply the principles that underlie successful behaviour change. Below are various basic principles that are viewed as key lessons for designing a successful nutrition awareness campaign:

- It should be well-designed and consistent nutrition education; aiming at changing specific practices is the key.
For behaviour change to occur, a programme participant must recognise that a particular change is essential to his or her well-being; be physically and emotionally ready to institute a change; and perhaps, most important, really believe he or she is capable of changing.

It is very important to acknowledge that people are at various points of readiness with regard to any behaviour change.

Participants should be empowered to act as experts who can share ideas and help others in problem-solving challenges.

Messages should be tailored to fit the motivational orientations of different groups of recipients.

Low levels of formal education are not an impediment to the effectiveness of the programme as long as the appropriate learning tools are in place.

New knowledge creates new experiences, and beliefs consequently develop an opportunity for new behaviours. However, this is not always the case, as a number of researchers and practitioners have noted the “KAP-GAP” representing the gap between knowledge (K) and attitude (A) which is influenced by the consumer perceptions actual practices (P) (Kolanisi, 2010; Mberia and Mukulu, 2011). Patt and Bowman (2008) state that despite anything else, for a change in behaviour to occur, a conducive and supportive environment should be created. Flynn (2016) concurs with this notion and further remarks: ‘No matter how well presented a message may be, if the receiver actively resists the message, the desired change in attitude or behaviour will not be seen. Resistance is the devotion of cognitive resources toward processes that oppose the message’.

In this study, the concept of persuasive communication, and interfacing transformative learning and indigenous learning techniques were used to raise participant’s awareness of the nutritional benefits of provitamin A biofortified maize. These techniques are reviewed in detail below.
2.11 Interfacing Transformative Learning and Indigenous Learning techniques

Transformative learning (Mezirow, 2012; Kolanisi, 2010; Taylor and Cranton, 2013) is the process of effecting change in a frame of reference. According to Mezirow (2012), “…meaning structures are understood and developed through reflection” and that “reflection involves a critique of assumptions to determine whether the belief, often acquired through cultural assimilation in childhood, remains functional for us as adults”. As argued by Khabanyane et al. (2014) this type of learning is because of the fact that knowledge and behaviour change are obtained through instrumental, communicative and emancipatory learning processes.

Instrumental learning focuses on learning through task-oriented problem solving, while communicative learning involves how individuals communicate affections. ‘Emancipatory’ carries the notion that everyone has the potential to overcome their limitations and transform their lives. It builds upon the true nature of adult learning, which is based on inbuilt logic, reality, and recognising the purpose in the process of learning.

The emancipatory learning process transforms the student’s frames of reference through critical reflection of assumptions, validating contested beliefs and perceptions through discourse, taking action on one’s reflective insight, and critically assessing it. As explained by Schlitz et al. (2010) transformation does not only focus on learning but has both personal developmental and social aspects.

On the other hand, the Integrated Knowledge Systems (IKS-based learning process) evolves from the pedagogy that listens to what others have to say (Carm, 2014). IKS is viewed as a transformative, encouraging creativity and innovation. As opposed to other western-based knowledge, it is expressive-based, subjective and has potential to explain complex social interventions (Obel-Lawson, 2006; Mann, 2011; Carm, 2014).

Communities are recognised as experts who are knowledgeable about their own situation, thus the learning processes are flexible and unstructured to allow deeper
extraction of data. It should be noted that these processes are influenced by the contribution of participants. According to McNamara (2005), it is crucial for people to give their own meaning of things rather than the researcher creating meaning on their behalf. Kaya (2014) further maintains this statement by stating that listening and learning from communities provides a better understanding of the local context and gives insights on the kind of challenges, how the society interacts, what needs to be done and whether it could satisfy their needs and expectations.

IKS is characterised as experiential knowledge generated from local knowledge, an orally transmitted process through demonstrations, and is a consequence of life realities (Ogbebor, 2011). In this study, oral tradition and visual demonstration learning processes were used. These processes included poetry, praise songs, parables and scenarios, songs and spiritually derived language through ululations.
2.12 References


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Okweche, S. I., Umoetok, S. B. A. and Osai Ephraim O. (2013). Effects of Synthetic (Carbofuran) and non Synthetic insecticides on Maize Growth and Yield in Stem Borers Infested Zones of Cross River State, Nigeria. *Journal of Biology, Agriculture and Healthcare*, 3: 1


Singh-Ackbarali, D. and Maharaj, R. (2014). Sensory Evaluation as a Tool in Determining Acceptability of Innovative Products Developed by Undergraduate Students in Food Science and Technology at the University of Trinidad and Tobago. *Journal of Curriculum and Teaching, 3* : 1

Sema, P. (2013). Do social media affect consumer decision-making? Johnson and Wales University, Providence, RI.

Singh-Ackbarali, D. (2014). Sensory Evaluation as a Tool in Determining Acceptability of Innovative Products Developed by Undergraduate Students in Food Science and Technology at The University of Trinidad and Tobago. *Journal of Curriculum and Teaching, 3:1*


Singh-Ackbarali, D. and Maharaj, R. (2014). Sensory Evaluation as a Tool in Determining Acceptability of Innovative Products Developed by Undergraduate Students in Food Science and Technology at The University of Trinidad and Tobago. *Journal of Curriculum and Teaching*, 3: 1


3.1 Introduction

This chapter gives the detailed description and background of the study area in accordance with consumers' acceptability and perception of the provitamin A biofortified maize varieties. The ethical clearance to conduct research was obtained from the UKZN Humanities and social sciences Research Ethics Committee. The reference for the ethical clearance is HSS / 0748 / 011D. An overview of the research methodology for each objective is presented. A combination of qualitative and quantitative research methods was adopted in this study due to the complexity of the study, as it explores the perceptions, acceptability, and intervention strategies regarding provitamin A biofortified maize products, i.e. phuthu and jeqe. Thus, the use of one perspective to investigate the problem would not provide a holistic understanding. Therefore, in this study both Induction and Deduction research approaches were integrated, a combination which is commonly referred to as the abductive research approach. The primary purpose of this study was to provide apply a systematic scientific process in order to gain logic, reasoning and an innovative component to ensure that all people at all times have food and nutrition security through the consumption and enjoyment of socially acceptable foods for a healthy and active life.

The inductive approach was adopted for this study to assess the sensory characteristics of the biofortified maize-based dishes. The hypothesis was that smallholder farmers who produce white maize have negative attitudes towards provitamin A biofortified maize. The deductive approach was used to collect data on consumer perceptions and change of perceptions using the integration of transformative learning and Indigenous Knowledge Systems methods.
3.2 Description of the study area

uMhlathuze Local Municipality is an administrative area in the King Cetshwayo District Municipality of KwaZulu-Natal in South Africa. The municipality is named after the Mhlathuze River. uMhlathuze municipality is located on the north-eastern coast of KwaZulu Natal (KZN), covering 796 km². This study was conducted in two communities, Ongoye (KwaMkhwanazi) and KwaMbonambi. KwaMbonambi has a population of 127,000, while Ongoye (Mkhwanazi) has 22,758 inhabitants. The uMhlathuze Municipality is surrounded by four district municipalities which are, UMkhanyakude District Municipality, Zululand District Municipality, UmZinyathi District Municipality, and ILembe. There are six local municipalities i.e. uMhlathuze Local Municipality, UMlalazi Local Municipality, Nkandla Local Municipality, Mthonjaneni Local Municipality, Ntambanana Local Municipality and Mbonambi Local Municipality in the King Cetshwayo District Municipality. The major towns in the King Cetshwayo District Municipality are Richards Bay, Empangeni, Eshowe, Melmoth, Mthunzini, Gingindlovu, KwaMbonambi, Buchannan and Nkandla, which are shown in Figure 3.1.
The households in Empangeni (KwaDlangezwa) and KwaMbonambi are classified as agricultural because of their geographical location. However, the agricultural environment in these communities is slowly deteriorating due to climate change variation, threatening local food and nutrition security. Despite this challenge, agriculture is still regarded as the main contributor to the household food and nutrition security in Northern KwaZulu-Natal. Maize is the most common crop in this region; it is a staple in South African diets, with an average daily intake of 300 g or more per capita (Grain SA; 2014). White grain maize is the most popular planted variety for human consumption while the yellow maize is planted mainly for livestock, especially chicken production.
The municipality is an attractive location for industries and mines, as there are significant natural mineral resources and the necessary socio-economic services and facilities. Regardless of these abundant opportunities for socio-economic development and poverty alleviation, the municipality has unsustainable developmental practices. The municipal population is projected as 349 576 allocated uniformly between rural and urban areas. Currently, 40% of the population is unemployed, partly due to low levels of skills development and literacy. The literacy levels of the community and skills are inadequate to foster enterprise growth and job creation, thus there are high levels of income poverty. The municipality is identified as one of the poverty node areas in KwaZulu-Natal. The majority of people in the community depend on grants offered by the government.

There is a high incidence of urban migration, which has resulted in the rural population being either elderly or very young. Furthermore, this migration has put a strain on urban infrastructure, resulting in the development of settlements that are more informal, overcrowded schools, and ill health. Households in the municipality have limited access to basic household and community services such as water, electricity, sanitation, waste removal and social amenities that are required to meet their basic needs. There is a complex challenge in the management of water supply and demand, thus household and agricultural water needs are not met.

Food and nutrition insecurity remains a challenge especially amongst the rural poor communities, a situation that is aggravated by the high frequency of droughts and water shortages in the municipality. Women and children belonging to female-headed households are more vulnerable to food and nutrition insecurity. Maternal, infant and child mortality rates are a concern as they are increasing rather than decreasing. (Figure 3.1) shows the map of uThungulu District Municipality demarcation.

Furthermore, there is a high incidence of HIV/AIDS and the number of infected and affected individuals continues to increase at rates above the national average and affects communities negatively. There is a high rate of non-communicable diseases such as hypertension, sugar diabetes, cholesterol, heart disease, asthma, stroke, and cancer.
Food and nutrition insecurity is a challenge in the country and the rest of the world, especially developing countries. Women and children are usually more vulnerable than men because they are more exposed to malnutrition in the form of nutrition deficiencies, including hidden hunger. Hidden hunger, as explained in chapter 2, is a silent killer which is a challenge going beyond the Millennium Developmental Goals (MDGs). This requires attention, as the Sustainable Developmental Goals also targets the reduction of the Food and Nutrition by 2050; therefore staple foods that provide inadequate nutritional value should be enhanced in order to reduce nutrient deficiencies.

Harvestplus (2014) has recommended the biofortification of staples as a solution. Biofortification of maize with vitamin A results in a yellow-orange colour due to carotenoids. In most countries, yellow maize is not accepted or consumed as food for humans but used as feed for livestock. In some countries that have been exposed to droughts, yellow maize was used as first aid. Thus, consumers withhold certain perceptions about yellow maize as food for human consumption (see chapter 2 for further details).

### 3.3 Product selection

Although yellow maize is generally less popular and acceptable as food for humans, Govender (2014) and Pillay (2014) show that jeqe made with yellow maize was both popular and accepted. To determine which maize food products were to be used in this study, popular yellow maize food products were profiled and foods that were consumed by all members of the households, especially children, were given priority. A Rural Rapid Appraisal exercise revealed that few dishes and beverages used yellow maize as the main ingredient. Only jeqe (maize bread) and African beer were popular, as opposed to the use of white maize which prepared soft porridge, stiff porridge, crumbled porridge (phuthu) and amahewu. Jeqe was also chosen because in South Africa bread is the second staple food consumed, especially in households with children. In addition, jeqe
can be eaten with amasi or isishebo made from vegetables (imifino), or meat (inyama). As seen in the food basket of most South Africans, flour is the most purchased commodity to bake home bread, therefore this indirectly excludes the households that rely on homemade bread from consuming the fortified bread that can be purchased from shops. It is for this primary reason that this study selected homemade bread (jeqe) as one of the food products to be assessed for acceptability.

In KwaZulu-Natal province, phuthu is an alternative to rice; it can be consumed with isishebo (gravy, stews, and curries) and or with vegetables. The other way of eating phuthu is with amasi (sour milk), mainly during summer. In poor households, it may be eaten dry or with water or tea. The difference between the phuthu eaten with isishebo and the phuthu with sour milk is in the preparation of these dishes. Phuthu eaten with isishebo and jeqe are the most consumed foods in isiZulu households; therefore, these foods were selected as the dishes which were to be prepared using biofortified yellow maize. Phuthu is consumed by all household members and can be eaten as the main meal or as a snack, depending on the method of preparation and how it is served. Local recipes were adopted and used to prepare the foods (see chapter 4 for recipes).

The sensory characteristic properties of both jeqe and phuthu were then assessed in this study using both descriptive and sensory evaluation. Additionally, the effect of the nutrition campaign was evaluated to assess the consumer perception change towards the biofortified yellow maize-based dishes. This study carries an assumption that consumer perceptions, the acceptability of the dishes understudy, and consumer willingness to prepare and consume the dishes could be the contributors towards enhanced food and nutrition status especially the rural poor communities (Figure 3.2).
Figure 3.2: The conceptual framework for consumer acceptability of biofortified yellow maize.
3.4 Overview of the research methodology

As shown in Figure 3.2 and Table 3.1, there are three objectives explored in this study and each objective was investigated using a specific research approach. Table 3.1 shows the overview of the methodologies followed for each objective, including the sampling size. Further details of the methodologies are discussed in the appropriate research chapters, which are presented in Chapters four to six.

3.5 Validity and trustworthiness

In this study, Rapid Rural Appraisal was used as a tool to gain insight and broader understanding of the population under study. It was useful in establishing the description of the smallholder farmers, the crops they were planting and how they consumed maize. A combination of research methods was used in this study for triangulation purposes (Table 3.1).

The sensory evaluation activities were used to determine how sensory properties and consumer acceptability complemented each other. Focus group discussions justified certain opinions and consumer preferences whilst they were also valuable for ensuring that the interpretation of the indigenous methods had credibility and transferability. The field workers were trained for three days on how to conduct sensory evaluation activities and on questionnaire administration. An expert in focus group discussion who speaks the local language facilitated the various group discussions, enhancing the dependability of the study. Moreover, the pictorial hedonic scale, focus group interview guide, sensory attribute scale and a questionnaire (before and after) were used to maintain conformability.
### Table 3.2: Research methodology overview

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Data collected</th>
<th>Data collection tool</th>
<th>Techniques tests</th>
<th>Data analysis</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>To investigate the perceptions and acceptability of sensory properties of provitamin A biofortified <em>phuthu</em> and jeqe by smallholder farmers in Empangeni, KZN.</td>
<td>Profiling yellow maize-based dishes and demonstrations for recipe development Consumer perceptions of provitamin A <em>phuthu</em> and <em>jeqe</em>. Sensory acceptability of provitamin A <em>phuthu</em> and <em>jeqe</em>.</td>
<td>Key informant interviews Focus groups Pictorial Hedonic scale Untrained sensory panellists Tape recorder Note taking</td>
<td>Rapid Rural Appraisal Untrained Sensory evaluation panellists</td>
<td>Demonstrations Content Analysis (SPSS)Statistical Package for Social Sciences version 22 Fisher’s T-test</td>
<td>68</td>
</tr>
<tr>
<td>To characterise sensory properties of provitamin A biofortified <em>phuthu</em> using a trained consumer panel.</td>
<td>14 Sensory attributes of provitamin A biofortified maize <em>phuthu</em>. Sensory components of three provitamins A maize varieties (Synthetic 6PVAH 124-143, 7PVAH 144-167, 8PVAH 168-190) and (CC3) white maize control.</td>
<td>Trained sensory panelists Note taking</td>
<td>Pre-screening and screening technique Open discussions Descriptive tests Discrimination tests</td>
<td>One – way ANOVA (Analysis of Variance) PCA (Principle component analysis) Comparison of multiple means using Fisher’s LSD (Least Significance Test) test</td>
<td>11</td>
</tr>
<tr>
<td>To evaluate consumer perceptions and acceptability of provitamin A biofortified maize prior to and after provitamin A awareness campaign using both modern and indigenous learning methods.</td>
<td>Songs Praises Poems Scenarios Parables</td>
<td>Focus groups Key informant Questionnaires Interviews</td>
<td>Multi-stakeholder workshop Persuasive communication Abduction approach resulting from the integration of transformative and IKS learning processes. Presentations</td>
<td>Content analysis T-test Oral assessment Evaluation</td>
<td>21</td>
</tr>
</tbody>
</table>
3.6 Summary

The study was done to explore the perceptions, acceptability, and intervention strategies regarding provitamin A biofortified maize benefits for certain products, i.e. *phuthu* and *jeqe*. A combination of qualitative and quantitative research methods was adopted in this study. Inductive and deductive research approaches were integrated to assess the sensory characteristics of the biofortified maize-based dishes, with the hypothesis that smallholder farmers who are maize producers of white maize could have negative attitudes towards provitamin A biofortified maize. Focus groups, sensory evaluation and nutrition campaign workshops observing some phenomenon such as consumer perceptions and change of perceptions using the integration of transformative learning and Indigenous Knowledge Systems methods were employed.
3.7 References


CHAPTER FOUR: SMALLHOLDER FARMERS’ PERCEPTIONS AND SENSORY ACCEPTABILITY OF PROVITAMIN A BIOFORTIFIED MAIZE FOOD PRODUCTS IN EMPANGENI, KWAZULU-NATAL PROVINCE, SOUTH AFRICA

Abstract

A study was conducted to investigate consumers’ perceptions and the acceptability of yellow provitamin A-biofortified maize (PABM) when presented in different types of traditional maize foods. It was thought that the use of PABM for making maize-based foods, such as phuthu and jeqe, which are popular in KwaZulu-Natal, could motivate consumers to use PABM as a food source. An untrained panel of 68 regular maize consumers participated in the current study. Sensory evaluation and focus group discussions were used to collect data. Findings revealed that white phuthu was more acceptable than yellow phuthu, whereas yellow jeqe was more acceptable than white jeqe. The findings indicate that PABM can be acceptable to consumers if it is presented in a food type that has appealing qualities. In the current study, jeqe was found to be a suitable food type.

Key Words: Perceptions, Acceptability, Pro-vitamin A biofortified maize, Phuthu, Jeqe
4.1 Introduction

The availability and consumption of vitamin A-rich foods can contribute to minimising and preventing diseases that are associated with vitamin A deficiency (VAD), and thereby contribute to the reduction of hunger and malnutrition. Globally, two billion people suffer from hunger and undernourishment, and 265 million of these people are from Africa (FAO, IFAD and WFP, 2015). Micronutrient deficiency is a silent threat to food and nutrition security. VAD has been reported to be mainly threatening the health and well-being of most African rural households (FAO, 2003).

Vitamin A is essential for immunity, vision, protection against oxidation, cell differentiation, protein synthesis, growth and development (Arigony et al., 2013; Barber et al., 2014; Doldo et al., 2015). The limited access to vitamin A-rich food sources, such as animal products, fruits and green vegetables has been identified as the major cause of VAD among millions of African rural households (Abrha, 2016). Vitamin A-rich foods are often not easily accessible due to several factors, including cost, seasonality and perishability of the food crop.

In Africa, most staple foods, such as white maize, rice, and wheat are mainly made up of starch, with a small percentage of micronutrients. Evidence shows that white maize is ranked the second most produced crop following cassava in Africa (Blancquaert, 2014; Wirtz, 2014). Maize is the most preferred staple food for more than 1.2 billion people in sub-Saharan Africa and Latin America (Olaniyan, 2015). In some countries such as Tanzania, meals made from white maize are consumed three times per day, almost seven days per week (Mboya et al., 2011). In sub-Saharan Africa, people consume white maize as opposed to yellow maize. The preference for meals made from white maize in Africa implies that white maize plays an important role in influencing the nutrition security of people in the continent. Moreover, the deficiency of vitamin A in white maize raises nutritional and health concerns. This widespread consumption of maize-based foods in Africa has been associated with the occurrence of hidden hunger in rural households (Argyropoulou, 2016).
Many strategies, such as food fortification, supplementation and dietary diversification have been implemented in an attempt to combat hidden hunger in sub-Saharan Africa. However, high levels of vitamin A deficiency still persist, threatening household food and nutrition security (Nair, 2015). Biofortification, a new approach to developing (largely by conventional breeding) varieties of staples with high levels of micronutrients has been introduced (Bouis et al., 2011). Maize, as a leading crop in Africa, has been identified for biofortification with provitamin A (Pillay et al., 2011; Tumuhimbise et al., 2013). Unfortunately, provitamin A-biofortified maize possesses unfamiliar sensory properties, including a yellow/orange colour and strong flavour and aroma, which are mainly due to carotenoid pigments, including provitamin A pigments (Talsma, 2013). African consumers have shown a preference for white maize, which is perceived to have better sensorial acceptability than yellow maize due to the unfamiliar sensory attributes of the yellow maize (Muzingi, 2010; Pillay et al., 2011). Further, there are reports of negative perceptions of yellow maize, for instance, that it is food for the poor, food for use in times of disaster such as drought or famine, as well as livestock feed (Ranum, 2013).

4.1.1 Vitamin A deficiency (VAD) and consumer acceptance of provitamin A-biofortified maize in South Africa

Vitamin A deficiency (VAD) is acknowledged as one of the most significant health conditions among children (Abrha, 2016). The Human Sciences Research Council’s (HSRC) South Africa 2014 report showed that 43.6% and 13.3% of South African children under the age of five years and reproductive women, respectively, were affected by VAD. The worst affected provinces were Limpopo, KwaZulu-Natal, Mpumalanga, North West and the Eastern Cape (Hall et al., 2016). These provinces were also identified as poverty nodes.

The acceptance of provitamin A maize foods was shown to vary with consumer age in studies conducted in KwaZulu-Natal, South Africa. Younger consumers showed no preference between provitamin A and white maize-based foods, whilst older consumers seemed to prefer white maize-based foods (Pillay et al., 2011; Govender, 2014). The
sensory attributes such as colour and taste of PABM foods were of concern. In the present study, the biofortification of maize was considered necessary for improving its vitamin A content to a satisfactory level. However, based on previous reports, there were also concerns about its acceptability. It is hypothesised that the current level of provitamin A biofortified yellow maize acceptance could be changing as customers become more aware of the benefits of vitamin A. Thus, the aim of the current study was to assess consumer perceptions and the acceptability of selected PABM-based food products.

In KwaZulu-Natal, South Africa, the traditional food products phuthu (crumbled porridge) and jeqe (steam bread) are widely consumed. It was, therefore, hypothesised that the use of biofortified maize for making these food products could increase the acceptance of PABM and its use in meal preparation.

4.1.2 Specific objectives

1. To investigate and compare consumers’ perceptions and the acceptability of phuthu made from white maize and biofortified maize.
2. To investigate and compare consumers’ perceptions and the acceptability of a traditional steamed maize bread known in isiZulu as jeqe made from white and biofortified maize.

4.1.3 Description of the study area

The study was conducted in KwaDlangezwa (Ongoye) and KwaMbonambi in KwaZulu-Natal, a province of South Africa. KwaDlangezwa is located close to the University of Zululand and is situated in King Cetshwayo district municipality. KwaMbonambi is a village, 29 km North-East of Empangeni and 30 km North of Richards Bay.
4.2 Research methodology

A combination of research methods using sensory evaluation and focus group discussions were used to investigate participants’ perceptions and the acceptability of traditional foods, namely *phuthu* and *jeqe*, made with PABM compared with their counterparts (references/controls), i.e. *phuthu* and *jeqe* made with white maize. A total of 68 panelists (34 males and 34 females) participated in the sensory evaluation of the PABM-based foods. The acceptability of the PABM-based foods under study was evaluated using a 5-point pictorial (Figure 4.1). Four sensory attributes, namely, colour, texture, aroma and taste were used to further investigate the acceptability of the PABM-based foods.

![Figure 4.1: Pictorial smiley faces used for sensory evaluation](image)

The sensory evaluation panellists were recruited based on gender, age (between 18 and 85 years), being involved in maize production, and being a regular maize consumer. The participants were seated back to back and about an arm’s length from each other. Randomised 3 digit numbers obtained from the Table of Random Numbers were used to blind label the food samples. Five field workers were trained to serve the food products to the panellists. The *phuthu* samples were served first and *jeqe* samples were served later. The serving order was from left to right. The panellists were provided with water to rinse the mouth before and after testing each sample.

An expert facilitated focus group discussions and was assisted by a note taker, who documented the proceedings and recorded them using a tape recorder. The discussion probed whether the experiences, beliefs and opinions of the participants influenced their perceptions of PABM-based foods. They also explored whether the acceptability of PABM-based foods was influenced by age and gender. The focus group discussions
lasted for about an hour. The discussions were later transcribed (verbatim) and themes were identified.

4.2.1 Maize grain sampling

Two varieties of maize, CC3 (white in colour), and 8PVAH–168-190, provitamin A-biofortified maize, (yellow in colour) were planted and harvested at Ukulinga research farm, University of KwaZulu-Natal Pietermaritzburg, and Makhathini research station, Jozini, KwaZulu-Natal, respectively.

4.2.2 Materials and method used to prepare white and yellow phuthu

The two food types, phuthu and jeqe, were prepared according to standardised Zulu recipes. The following recipe was used to prepare phuthu:

First, 500 ml of water was measured in a measuring jug, the water was transferred to a saucepan, 5 ml of salt was added to the water and this water and salt mixture was boiled at a high temperature. Second, 375 g (2.5 cups) of maize flour was added to the boiling salty water. Third, the mixture was covered and cooked for three minutes at high temperature, after which it was stirred continuously for another three minutes, then covered again. The temperature was adjusted from a high temperature to a low temperature setting. The phuthu was left to cook for a total cooking time of 15 minutes, with occasional stirring.

4.2.3 Materials and methods for preparation of white and yellow jeqe

To prepare jeqe, first, 250 g of maize flour, 250 g of wheat flour, 10 g of instant dry yeast, 5 g of salt and 10 g of sugar were measured accurately then mixed together. Second, after thoroughly mixing the dry ingredients, 300 ml of lukewarm water was added to the dry ingredients. The mixture was kneaded to form a dough. Third, the dough was covered with a lid and put in a temperature controlled environment where the temperature was
maintained at 30°C and left for 20 minutes to rise (ferment). After 20 minutes, the risen dough was kneaded gently and was left to rise at 30°C for another 15-20 minutes. Then the risen dough was poured into a greased enamel bowl. Finally, the enamel bowl was placed into a half-filled pot of boiling water and steamed for an hour.

4.2.4 Data analysis

Data were analysed using the Statistical Package for Social Science (SPSS) version 22, and the t-test was performed to compare mean acceptability ratings for white and yellow phuthu, and white and yellow jeqe. Content analysis was done to identify themes, patterns and concepts.

4.3 Results

Participants’ age and the acceptability of white and yellow phuthu

The largest age group was that of participants aged 50-59 years, who were 30.9% of the participants, whereas the smallest group was that of participants aged 18-20, who accounted for only 1.5% of the participants (as shown in Table 4.1).

Table 4.1: Participants by age groups

<table>
<thead>
<tr>
<th>Age group</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 -20 years</td>
<td>1.5</td>
</tr>
<tr>
<td>21 – 29 years</td>
<td>13.2</td>
</tr>
<tr>
<td>30 – 39 years</td>
<td>22.1</td>
</tr>
<tr>
<td>40 – 49 years</td>
<td>16.2</td>
</tr>
<tr>
<td>50 – 59 years</td>
<td>30.9</td>
</tr>
<tr>
<td>60 – 69 years</td>
<td>11.8</td>
</tr>
<tr>
<td>70 – 79 years</td>
<td>2.9</td>
</tr>
<tr>
<td>80 – 89 years</td>
<td>1.5</td>
</tr>
</tbody>
</table>
Table 4.2 shows the results of sensory evaluation of the PABM samples. 25% of the participants aged between 50-59 years rated white *phuthu* very good and 2.9% good (Table 4.2). Further, 13.2% of the participants of the same age group rated yellow *phuthu* very good and 10.3% rated it good. The lowest ratings of the yellow *phuthu* were obtained from participants aged 18-20 years. In general, for both types of yellow maize foods (yellow *phuthu* and yellow *jeqe*) slightly higher ratings were obtained from the participants aged 50-59 years.

**Table 4.2: The acceptability of white and yellow *phuthu* according to age of the consumers (n =68)**

<table>
<thead>
<tr>
<th>Age</th>
<th>WHITE PHUTHU</th>
<th>BIOFORTIFIED PHUTHU</th>
<th>YELLOW PHUTHU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>Very Bad</em> (%)</td>
<td><em>Bad</em> (%)</td>
<td><em>Not sure</em> (%)</td>
</tr>
<tr>
<td>18-20</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>21-29</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>30-39</td>
<td>2.9</td>
<td>1.5</td>
<td>0.0</td>
</tr>
<tr>
<td>40-49</td>
<td>0.0</td>
<td>0.0</td>
<td>2.9</td>
</tr>
<tr>
<td>50-59</td>
<td>1.5</td>
<td>1.5</td>
<td>0.0</td>
</tr>
<tr>
<td>60-69</td>
<td>1.5</td>
<td>1.5</td>
<td>0.0</td>
</tr>
<tr>
<td>70-79</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>80-89</td>
<td>1.5</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>7.4</td>
<td>4.5</td>
<td>2.9</td>
</tr>
</tbody>
</table>

*Key: very bad =1; bad=2; not sure=3; good=4; very good=5*

Table 4.3 shows that 35.3% of the participants aged 30-59 years rated biofortified yellow maize *jeqe* very good, whilst 20.6% of the participants of the same age rated white maize *jeqe* very good.
Table 4. 3: The acceptability of white and yellow jeqe according to consumer age (n = 68)

<table>
<thead>
<tr>
<th>Age Groups</th>
<th>WHITE PHUTHU</th>
<th>BIOFORTIFIED YELLOW PHUTHU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very (%)</td>
<td>Bad (%)</td>
</tr>
<tr>
<td></td>
<td>Neutral (%)</td>
<td>Good (%)</td>
</tr>
<tr>
<td></td>
<td>Very (%)</td>
<td>Bad (%)</td>
</tr>
<tr>
<td></td>
<td>Neutral (%)</td>
<td>Good (%)</td>
</tr>
<tr>
<td>18-20</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>21-29</td>
<td>2.9</td>
<td>5.9</td>
</tr>
<tr>
<td></td>
<td>2.9</td>
<td>2.9</td>
</tr>
<tr>
<td>30-39</td>
<td>2.9</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>7.4</td>
<td>7.4</td>
</tr>
<tr>
<td>40-49</td>
<td>1.5</td>
<td>5.9</td>
</tr>
<tr>
<td></td>
<td>4.4</td>
<td>2.9</td>
</tr>
<tr>
<td>50-59</td>
<td>2.9</td>
<td>5.9</td>
</tr>
<tr>
<td></td>
<td>8.8</td>
<td>10.3</td>
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<tr>
<td>60-69</td>
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<tr>
<td></td>
<td>1.5</td>
<td>2.9</td>
</tr>
<tr>
<td>70-79</td>
<td>0.0</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>0.0</td>
<td>1.5</td>
</tr>
<tr>
<td>80-89</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>0.0</td>
<td>1.5</td>
</tr>
<tr>
<td>TOTAL</td>
<td>11.7</td>
<td>10.3</td>
</tr>
<tr>
<td></td>
<td>23.6</td>
<td>26.4</td>
</tr>
<tr>
<td></td>
<td>26.4</td>
<td>28.1</td>
</tr>
<tr>
<td></td>
<td>13.2</td>
<td>8.8</td>
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<tr>
<td></td>
<td>13.2</td>
<td>31.0</td>
</tr>
<tr>
<td></td>
<td>13.2</td>
<td>47.1</td>
</tr>
</tbody>
</table>

*Key: very bad = 1; bad = 2; not sure = 3; good = 4; very good = 5

There was no statistically significant association between the overall acceptability of yellow jeqe and age of the consumer as well as between the overall acceptability of yellow phuthu and age of the consumer, suggesting that the age of the consumer cannot be used to predict the acceptability of yellow maize foods.

4.3.1 A Comparative consumer acceptability of white and biofortified yellow phuthu

The consumer acceptability test of phuthu in terms of the sensory attributes evaluated, excluding overall acceptability, revealed that white phuthu had higher ratings than biofortified yellow phuthu (Table 4.4). The taste and texture of white phuthu were rated higher compared to its appearance and aroma. White phuthu was rated much higher for all the sensory attributes evaluated compared to biofortified yellow phuthu. For the
biofortified yellow *phuthu*, aroma and appearance had higher ratings compared to taste and texture.

Table 4.4: Sensory attribute (excluding overall acceptability) acceptability ratings of acceptability of white and biofortified yellow *phuthu* (n = 68)

<table>
<thead>
<tr>
<th>Rating</th>
<th>Aroma</th>
<th>Appearance</th>
<th>Texture</th>
<th>Flavour</th>
<th>Aroma</th>
<th>Appearance</th>
<th>Texture</th>
<th>Flavour</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.9</td>
<td>5.9</td>
<td>4.4</td>
<td>8.8</td>
<td>14.7</td>
<td>10.3</td>
<td>14.7</td>
<td>10.3</td>
</tr>
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<td>2</td>
<td>4.4</td>
<td>2.9</td>
<td>4.4</td>
<td>1.5</td>
<td>11.8</td>
<td>8.8</td>
<td>10.3</td>
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<td>3</td>
<td>16.2</td>
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<td>8.8</td>
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<td>14.7</td>
<td>18.2</td>
<td>13.2</td>
<td>14.7</td>
</tr>
<tr>
<td>4</td>
<td>30.9</td>
<td>26.5</td>
<td>26.5</td>
<td>26.5</td>
<td>35.3</td>
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<td>5</td>
<td>45.6</td>
<td>52.9</td>
<td>55.9</td>
<td>60.3</td>
<td>23.5</td>
<td>35.3</td>
<td>33.8</td>
<td>32.4</td>
</tr>
</tbody>
</table>

*Rating: 1=very bad; 2=bad; 3=not sure; 4=good; 5=very good*

Table 4.4 shows the overall acceptability of white *phuthu* and Biofortified yellow *phuthu* samples. Most participants (85.3%) rated the overall acceptability of white *phuthu* at 4 or above, as opposed to only 63.2% who gave biofortified yellow *phuthu*. As predicted by the literature, white phuthu had higher overall ratings, with 70% of the participants giving it a score of 5 (i.e. “very good”) (Table 4.5). Similarly, only 38.2% of the participants felt that the biofortified yellow *phuthu* was very good and gave it a score of 5.

4. 5: Overall acceptability of white and biofortified yellow phuthu (n = 68)

<table>
<thead>
<tr>
<th>Type of phuthu</th>
<th>White Phuthu Respondents (%)</th>
<th>Biofortified Yellow Phuthu Respondents (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>11.8</td>
<td>16.2</td>
</tr>
<tr>
<td>2</td>
<td>2.9</td>
<td>10.3</td>
</tr>
<tr>
<td>3</td>
<td>0.0</td>
<td>7.4</td>
</tr>
<tr>
<td>4</td>
<td>14.7</td>
<td>27.9</td>
</tr>
<tr>
<td>5</td>
<td>70.6</td>
<td>38.2</td>
</tr>
</tbody>
</table>

Ratings: 1=very bad; 2=bad; 3=not sure; 4=good; 5=very good
4.3.2 A Comparison of the acceptability of white jeqe and yellow jeqe

Yellow jeqe received better ratings than white jeqe, with 70.6% of the panellists giving it scores of 4 or more, while white jeqe only received a score of 4 or more from 58.8% of the panellists. Table 4.6 gives a more detailed look at the levels of acceptability of the different samples. Yellow jeqe received a more favourable reception than yellow phuthu.

Table 4.6: Overall acceptability of white and yellow jeqe (n = 68)

<table>
<thead>
<tr>
<th>Ratings</th>
<th>White steamed Bread (jeqe) Respondents (%)</th>
<th>Biofortified Yellow steamed Bread (jeqe) Respondents (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13.2</td>
<td>17.6</td>
</tr>
<tr>
<td>2</td>
<td>7.4</td>
<td>4.4</td>
</tr>
<tr>
<td>3</td>
<td>20.6</td>
<td>7.4</td>
</tr>
<tr>
<td>4</td>
<td>29.4</td>
<td>26.5</td>
</tr>
<tr>
<td>5</td>
<td>29.4</td>
<td>44.1</td>
</tr>
</tbody>
</table>

Ratings: 1= very bad; 2= bad; 3= not sure; 4= good; 5= very good

These findings show that the majority of the panellists liked yellow jeqe more than white jeqe. Table 4.7 shows yellow jeqe had higher ratings than white jeqe for three of the four attributes under evaluation, i.e. appearance, texture and flavour.
Table 4. 7: Sensory attribute (excluding overall acceptability) ratings for the acceptability of white and yellow Jeqe (n= 68)

<table>
<thead>
<tr>
<th></th>
<th>Panellists who found white Jeqe acceptable</th>
<th>Panellists who found biofortified yellow Jeqe acceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aroma (%)</td>
<td>Appearance (%)</td>
</tr>
<tr>
<td></td>
<td>6.0</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>13.4</td>
<td>13.4</td>
</tr>
<tr>
<td></td>
<td>19.4</td>
<td>16.4</td>
</tr>
<tr>
<td></td>
<td>37.3</td>
<td>35.8</td>
</tr>
<tr>
<td></td>
<td>23.9</td>
<td>29.9</td>
</tr>
</tbody>
</table>

Table 4.8 shows that there was a linkage between the sex of the panellists and their preferences. The female panellists had higher mean ratings (4.53) for the taste of white phuthu than for the other sensory attributes (excluding overall acceptability) evaluated.

Table 4. 8: A comparison of the mean ratings for the acceptability of sensory attributes (excluding overall acceptability) of white phuthu between males and females (n=68)

<table>
<thead>
<tr>
<th></th>
<th>Mean rating</th>
<th>Mean difference</th>
<th>Standard Deviation</th>
<th>Mean Difference</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aroma acceptability</td>
<td>Male</td>
<td>4.12</td>
<td>0.088</td>
<td>1.122</td>
<td>0.088</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>4.03</td>
<td>-0.265</td>
<td>1.000</td>
<td>0.277</td>
</tr>
<tr>
<td>Appearance acceptability</td>
<td>Male</td>
<td>4.03</td>
<td>-0.265</td>
<td>1.314</td>
<td>0.277</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>4.29</td>
<td>0.938</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texture acceptability</td>
<td>Male</td>
<td>4.12</td>
<td>-0.206</td>
<td>1.320</td>
<td>0.272</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>4.32</td>
<td>0.878</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taste acceptability</td>
<td>Male</td>
<td>4.03</td>
<td>-0.500</td>
<td>1.381</td>
<td>0.285</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>4.53</td>
<td>0.929</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NS = Not significant (p>0.05)
The sensory attributes of white *phuthu* rated the lowest by the female panellists was aroma. The male panellists gave the same scores for aroma and texture of white *phuthu*; however, their ratings for these sensory attributes were slightly higher than the ratings they gave for the appearance and taste of the white *phuthu*, which had identical scores. Overall, there was no statistically significant difference in the mean ratings ($\alpha>0.05$) for the acceptability of white *phuthu* between males and females.

The t-tests revealed that the female panellists' mean rating (3.91) for the appearance of yellow *phuthu* was higher than the mean ratings for the other sensory attributes (excluding overall acceptability) (Table 4.9). These panellists gave higher ratings for the appearance, texture and taste of yellow *phuthu* compared to the ratings given for the same sensory attributes by the males. However, there was no statistically significant difference in the mean ratings ($p>0.05$) for the sensory attribute acceptability of yellow *phuthu* between males and females.

**Table 4.9: A comparison of the mean ratings for the acceptability of sensory attributes (excluding overall acceptability) of yellow phuthu between males and females (n=68)**

<table>
<thead>
<tr>
<th></th>
<th>Mean rating</th>
<th>Standard Deviation</th>
<th>Mean Difference</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aroma perception</td>
<td>Male</td>
<td>3.29</td>
<td>1.548</td>
<td>-0.176</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>3.47</td>
<td>1.134</td>
<td></td>
</tr>
<tr>
<td>Appearance</td>
<td>Male</td>
<td>3.56</td>
<td>1.440</td>
<td>-0.353</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>3.91</td>
<td>1.164</td>
<td></td>
</tr>
<tr>
<td>Texture perception</td>
<td>Male</td>
<td>3.41</td>
<td>1.219</td>
<td>-0.294</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>3.71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taste perception</td>
<td>Male</td>
<td>3.29</td>
<td>1.250</td>
<td>-0.500</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>3.79</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Sensory attribute (excluding overall acceptability) of white and yellow jeqe according to consumer gender. The t-test showed that the female panellists gave a mean rating of 3.88 for the sensory attribute ‘appearance of white jeqe’, a rating which was higher than the mean ratings for the other sensory attributes (excluding overall acceptability), as shown in Table 4.10. The male panellists gave texture and taste of white jeqe identical scores for the mean ratings (3.56). However, this was lower than the mean ratings for the other sensory attributes of white jeqe. The female panellists gave the appearance the highest mean rating (3.53), while the taste of white jeqe received the lowest mean rating (3.29). Overall, there was no statistically significant difference in the mean ratings (p>0.05) for the acceptance of white jeqe between males and females.

Table 4.10: A comparison of the mean ratings for the acceptability of sensory attributes (excluding overall acceptability) of white jeqe between males and females (n=68)

<table>
<thead>
<tr>
<th></th>
<th>Mean ratings</th>
<th>Standard Deviation</th>
<th>Mean Difference</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aroma acceptability</td>
<td>Male 3.743</td>
<td>1.355</td>
<td>0.324</td>
<td>0.260</td>
</tr>
<tr>
<td></td>
<td>Female 0.41</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appearance acceptability</td>
<td>Male 3.88</td>
<td>1.175</td>
<td>0.353</td>
<td>0.283</td>
</tr>
<tr>
<td></td>
<td>Female 3.53</td>
<td>1.161</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texture acceptability</td>
<td>Male 3.56</td>
<td>1.501</td>
<td>0.235</td>
<td>0.467</td>
</tr>
<tr>
<td></td>
<td>Female 3.32</td>
<td>1.121</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taste acceptability</td>
<td>Male 3.56</td>
<td>1.460</td>
<td>0.265</td>
<td>0.420</td>
</tr>
<tr>
<td></td>
<td>Female 3.29</td>
<td>1.219</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The t-test indicated that the female panellists liked the texture and appearance (mean rating: 4.18) of yellow jeqe more than its other sensory attributes; the taste of the yellow jeqe was also rated favourably (mean rating: 4.09) (Table 4.11). The male panellists rated aroma and texture acceptability of yellow jeqe lower than the other sensory attributes.
evaluated. Overall, for all the sensory attributes evaluated, there was a statistically significant difference in the acceptability of yellow jeqe to females and males.

Table 4.11: A comparison of the mean ratings for the acceptability of sensory attributes (excluding overall acceptability) of yellow jeqe between males and females (n=68)

<table>
<thead>
<tr>
<th></th>
<th>Mean rating</th>
<th>Standard Deviation</th>
<th>Mean Difference</th>
<th>t value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aroma acceptability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>3.21</td>
<td>1.343</td>
<td>-0.676</td>
<td>2.169</td>
<td>0.034*</td>
</tr>
<tr>
<td>Female</td>
<td>3.88</td>
<td>1.225</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appearance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>3.44</td>
<td>1.418</td>
<td>-0.735</td>
<td>2.293</td>
<td>0.025*</td>
</tr>
<tr>
<td>Female</td>
<td>4.18</td>
<td>1.218</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texture acceptability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>3.21</td>
<td>1.533</td>
<td>-0.971</td>
<td>2.987</td>
<td>0.004**</td>
</tr>
<tr>
<td>Female</td>
<td>4.18</td>
<td>1.114</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taste acceptability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>3.32</td>
<td>1.552</td>
<td>-0.765</td>
<td>2.280</td>
<td>0.026*</td>
</tr>
<tr>
<td>Female</td>
<td>4.09</td>
<td>1.190</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**= Significant at 0.01 level; *= Significant at 0.05 level

4.3.3 Findings obtained from focus group discussions

With regard to PABM yellow jeqe, participants had the following to say:

1. It looks like a cake
2. It is attractive you can even eat it without any spread or gravy
3. Children would love this one

With regard to the PABM yellow phuthu, participants had the following to say:

1. I do not need to colour my food anymore
2. This could be good for Sunday lunches
3. This cannot be eaten with fermented milk but will be very good with vegetables
4. This is phuthu for vegetables
In addition, participants had the following views with regard to white *phuthu*:

1. It is our staple food
2. It is available throughout all seasons
3. Can be consumed by all family members
4. Can be used for lunch as well as dinner
5. It can be complemented by stew, fresh milk or fermented milk

These findings suggest that sensory attributes are not the only determinants of food preferences and choices that lead to the acceptability of the food. Other factors such as previous experience and socialisation of the consumer can be predetermining factors that frame the acceptability elements, such as the reason for consumption (is it for pleasure, nutritional purposes or otherwise?), and food type (e.g. is the food for special occasions or for normal routine?).

### 4.4 Discussion

The main finding of the current study is that the food type or form in which it is presented to the consumer influences how biofortified yellow maize is perceived. The yellow colour seems to have no effect on the overall acceptability of the yellow maize products as long as the other key sensory attributes, including taste, are acceptable. This research, therefore, has revealed that the trend about the dislike of yellow maize by consumers is changing.

These findings highlight the complexity of food consumption as mentioned by several consumer behaviour researchers. Psychological factors, including the learning experience as well as the aspects of why people consume food, especially the pleasure components, are often overlooked (Vabo and Hansen, 2014). As revealed in the focus group discussions white ‘*phuthu*’ was a staple food for most households. It was an all-season food consumed by all household members and consumed at both lunch and dinner. The *phuthu* was usually complemented by a stew, locally known as *isishebo*, fresh
milk, and fermented milk (locally known as amasi) and or vegetables (known as imifino in isiZulu). Fermented milk is often readily available and affordable for most rural people in South Africa. White phuthu therefore offers consumers an affordable option in terms of the types of foods that complement it. On the other hand, colour influenced the acceptability of yellow phuthu. It was mentioned that the yellow phuthu would be preferred only if served with stew and/or vegetables. Vegetables that are consumed together with phuthu are usually prepared using spices and/or adding ground peanuts to them; thus this option is more expensive than amasi. The high cost ofisishebo for yellow phuthu would naturally lead to the preference of white phuthu over the yellow alternative.

The taste, appearance, aroma and texture of the samples determined the acceptability of the provitamin A-biofortified maize jeqe and phuthu. Food form is largely determined by the recipes (formulation) and preparation method, which are known to contribute highly to the sensory properties of food. In this study, it appears that recipes (formulation) and preparation method for the two food forms, jeqe and phuthu, significantly influenced the sensory properties of the two food forms, especially their taste, appearance, aroma and texture. The yellow colour of Jeqe made from biofortified yellow maize was regarded as attractive, yet none of the participants regarded the colour of yellow phuthu as attractive. The latter suggests that the presence of underlying appearance attributes apart from the colour of the foods played a role in influencing participants’ sensory perceptions of yellow jeqe and phuthu. Participants in focus group discussions also mentioned that yellow jeqe looked like a cake. This may be another factor that enhanced the attractiveness of yellow jege as compared to yellow phuthu, which is in the form of crumbs. According to Costell (2010), other than organoleptic properties, there are various factors that influence consumer food preferences, including past experiences, and socio-cultural and environmental factors. These factors play a role prior to tasting the food, thus they can predetermine and create consumer expectations of food types. In the current study, the texture of the yellow maize was found to be another critical factor. As indicated earlier, phuthu is expected to be in the form of crumbs and hence appear crumbly. This texture is particularly important if the phuthu is intended to be eaten with milk. It appears that the yellow phuthu of the current study did not seem crumbly enough for eating with milk. This suggestion is supported by the fact that during focus group discussions, the participants
stated that the yellow *phuthu* would be acceptable to them if accompanied by a relish (*isishebo*). They mentioned that if they used the yellow *phuthu* they would use it as an alternative to yellow rice (turmeric or curry powder dyed rice). The yellow rice is usually prepared for special occasions. Thus, in agreement with Costell *et al.* (2010), food familiarity, perceptions, beliefs, opinions and expectations (e.g. expected pleasure and fitness for use in a common recipe) played an important role in the degree of acceptance of PVAB yellow maize-based foods.

Although there were some differences between the levels of acceptability of the investigated maize-based foods between different age groups, the lack of statistically significant association observed between the overall acceptability of the yellow and white *phuthu* and *jeqe* imply that age was not an important influencing factor regarding the acceptability of the indicated maize-based foods. The maize-based foods investigated had higher scores from the 50-59-year-old participants. Pillay *et al.*, (2011) and Govender *et al.* (2014) reported that the acceptability of provitamin A-biofortified maize (PABM) was influenced by the age of the consumer and food form. Regarding food form, the findings of this study concur with the findings of these authors. However, the findings of the current study differ with those of Pillay *et al.*, (2011) and Govender *et al.* (2014) with respect to the influence of consumer age on the acceptability of PABM. In this study the older group accepted the PABM dishes as much as they were accepted by the younger generation, indicating that age had no influence on the acceptability of PABM. The statistically significant differences in the acceptability of yellow *jeqe* to females and males indicate that gender has an influence on the acceptability of some food forms of the PABM. However, the underlying factors that caused the females to like yellow *jeqe* more than the males were not investigated.

### 4.5 Conclusion

The current study has shown that provitamin A biofortified maize can be acceptable to consumers if it is prepared in forms that have appealing sensory properties and meet consumer expectations e.g. past experiences, and psychological and socio-cultural factors. Certain forms could be made using provitamin A biofortified yellow maize and be
more acceptable compared to their white maize counterparts; in the current study, yellow jeqe was found to be one such food form. Further work on recipe development is needed to establish a variety of food forms in which PABM is acceptable to consumers, and thus facilitate the adoption and utilisation of PABM for addressing vitamin A deficiency (VAD) among VAD-vulnerable communities.

4.6 Recommendations

It is recommended that the biofortification of maize and the use of biofortified yellow maize foods should be encouraged for the alleviation of vitamin A deficiency. In addition, good recipes that enhance taste and texture of yellow maize foods should be made available to maize consumers.
4.7 References


CHAPTER FIVE: DESCRIPTIVE SENSORY ANALYSIS OF PROVITAMIN A-
BIOFORTIFIED (YELLOW) MAIZE PHUTHU (CRUMBELED PORRIDGE)

Abstract

This study was conducted to characterize the sensory properties of phuthu made from three varieties of provitamin A biofortified maize hybrids (PVAH), namely: synthetic 6PVAH 124-143, 7PVAH 144-167 and 8PVAH 144-167 in comparison to phuthu made from white maize -control sample. Four major sensory properties namely appearance, aroma, texture and flavor under 12 attributes, namely: yellow colour, rough appearance, the presence of white specks (white specks), dry appearance, cooked maize aroma, cooked maize flavour, crumbliness, chewiness, roughness, stickiness, malleability and the presence in the mouth of residual particles after having swallowed the phuthu (residue). Intensities were ranked and scores characterized the sensory properties of the food samples investigated. This investigation was done using 11 trained panellists. ANOVA, Fisher’s Least Significant Difference test (LSD) and Principle Component Analysis (PCA) were conducted to evaluate and identify variations between provitamin A biofortified maize phuthu based on their sensory attribute loadings. Findings show that seven of the attributes detected in provitamin A bio-fortified maize phuthu had the typical characteristics of white maize phuthu. Yet, noticeable attributes such as yellow colour, white specks, cooked maize aroma, cooked maize flavour, and stickiness were not of typical white phuthu characteristics. Another distinct attribute that distinguished yellow phuthu from white phuthu samples were stickiness and less malleability. Stickiness could be due to the presence of carotenoid pigments in the yellow maize. Malleability affects the chewiness and crumbliness, more so the cooked maize aroma and cooked maize flavour were reported to be low in the yellow phuthu samples. It is concluded that it is necessary to reduce the intensity of the stickiness of yellow maize phuthu to enhance its acceptability.

Keywords: Sensory properties, Provitamin A biofortified maize, Phuthu, Trained panellist, ANOVA
5.1 Introduction

In chapter four findings revealed that white phuthu was more acceptable to smallholder farmers than provitamin A biofortified (yellow) maize. It was not clear why the yellow phuthu was less acceptable. It was shown that yellow jeqe and the control white jeqe share similar levels of consumer acceptability, suggesting that yellow maize could substitute white maize when making jeqe. However, yellow phuthu was less acceptable compared to its white phuthu counterpart. Because white phuthu is more popular and widely consumed than jeqe in KwaZulu-Natal, phuthu would be the more effective food form for delivering provitamin A to target populations in KwaZulu-Natal compared to jeqe. Therefore, it is important to identify and characterise the sensory properties of yellow phuthu in an attempt to improve its acceptability.

A single food product such as maize can be made into different traditional forms such as maize-based fermented drink (amaheu), soft porridge (idokwe), stiff porridge (pap) and crumbled porridge (phuthu). The chemical and physical composition of food contributes to sensory attributes such as aroma, appearance, texture and taste/flavour (Clark, 1998; Cardello, 1994; Shepherd, 1988). Maize-based food forms have specific sensory attributes that give each food its unique character through its preparation and this is how consumers can immediately identify, describe and accept it or not. Each ethnic group in South Africa prepares a maize-based food in the form of stiff porridge or crumbled porridge. The BaPedi people in Limpopo prepare and mostly consume stiff porridge called bogobe, whilst the Ngunis such as Zulus and Xhosas prepare and consume crumbled porridge: the Zulu people in KwaZulu Natal call it phuthu and the Xhosa people in the Eastern Cape call it umphokoqo.

Awobusuyi (2016) conducted a study on consumer acceptance of provitamin A biofortified maize amahewu1 in KwaZulu-Natal and found that it was more acceptable than the white amahewu sample. Pillay et al. (2014) did a study on provitamin A biofortified maize (yellow) soft porridge, and found that its smoothness, glossiness and runniness

1 Amahewu is a South African traditional fermented maize beverage with a watery consistency with a smooth and soothing mouth feel.
contributed to its acceptability by consumers. A study by Govender et al. (2014) among female infant caregivers in rural KwaZulu-Natal concurred with the findings. Ruwaida (2016) conducted a consumer acceptability test of phuthu where she served it with chicken stew (isishebo); the provitamin A biofortified maize phuthu was acceptable. Unlike Ruwaida (2016), the phuthu sampled in chapter four was not served with isishebo and this could have decreased its acceptability ratings as it is probable that the stew masked the taste and other sensory attributes of the sample.

Although certain provitamin A biofortified maize food forms could be acceptable, there are other foods that consumers are particularly observant of (Biswa, 2015). Biswa (2015) established that provitamin A biofortified stiff porridge was less acceptable compared to white stiff porridge partly due to the yellow colour, strong aroma and other attributes not typically found in white maize, such as stickiness, bitter aftertaste and margarine-like flavour. Since yellow maize acceptance is linked to food forms, it is likely that different methods of preparation resulted in different sensory profiles in the respective food forms (Pillay et al., 2011). Each of the indicated maize food forms has distinct characteristics and sensory attributes, which will contribute to its sensory acceptability.

Although it was established that panellists preferred white phuthu to yellow phuthu in Chapter 4, the reasons for this could not be established. Characterising the attributes of yellow phuthu could contribute to improving its consumer acceptability. Data on the sensory attributes of yellow phuthu could be used to modify its preparation, for example, if sensory attributes that are not typically found in white maize were detected in the yellow phuthu, ingredients that would reduce their intensities could be determined and applied. The aim of the research described in this chapter was to determine the sensory profile of yellow maize phuthu compared to its white counterpart, to highlight the intensity of the attributes that are not popular in white phuthu, and to discuss their potential to influence the acceptability of yellow phuthu.
5.2 Research methodology

5.2.1 Maize Grain

Three varieties of provitamin A bio-fortified (yellow) maize (Synthetic 6PVAH-124-143; Synthetic 7PVAH-144-167; Synthetic 8PVAH-168-190) and CC3 white maize (control) were planted and harvested at Makhathini research station, at Jozini in KwaZulu-Natal and at the University of KwaZulu-Natal (Ukulunga research farm), Pietermaritzburg in KwaZulu-Natal. Grain from each of the maize varieties was harvested and milled into maize meal with a roller mill.

5.2.2 Preparation of phuthu

The three yellow maize varieties described in section 5.2.1 were used to prepare yellow phuthu samples and the white maize variety to prepare white phuthu (control). The phuthu was prepared following a Zulu traditional recipe of making phuthu lwesishebo (crumbled porridge eaten with stew). This was basic phuthu consumed almost daily as compared to ‘phuthu lwamasi’ (crumbled porridge eaten with sour milk). The phuthu was made at the University of Zululand, Consumer Sciences food laboratory, KwaZulu-Natal. Sample testing for sensory characteristics was done in an area isolated from the cooking area to prevent diffusion of smells. Cooking was done according to the Zulu recipe which is given below.

5.2.3 Phuthu recipe

Four cups of provitamin A biofortified (yellow) maize meal, 1/8 measuring spoon salt and 1 litre of water were used to prepare provitamin A biofortified maize meal phuthu. First, the water was boiled at a high temperature. Second, 4 cups of provitamin A biofortified
maize were poured in the boiling water and covered until all the water was absorbed by the maize meal. Third, the temperature was reduced to low heat. Fourth, the mixture was stirred with a wooden spoon to mix well and covered with a lid to simmer for 5 minutes. It was then stirred 4 times after every 5 minutes and cooked for a duration of 20 minutes. The *phuthu* was served warm. The same recipe was used to prepare white *phuthu*.

### 5.2.4 Descriptive sensory analysis

Eleven trained panellists were used for the descriptive sensory evaluation. The trained panellists evaluated 12 sensory attributes of the four maize varieties mentioned in section (Table 5.1). The ages of the panellist range between 18 and 30 years. The panellists (UNIZULU undergraduate and postgraduate students) were recruited on the basis of being primary consumers of *phuthu* and being involved in maize production. They were recruited from various UNIZULU departments, pre-screened and screened for participation. A pre-screening was done to test the panellists’ ability to use the five basic senses. The panellists were trained by a sensory evaluation expert for two weeks. They were then given a questionnaire for discriminative and descriptive tests. The training included orientation on the principles of sensory evaluation as well as the test objective. It also included a review of *phuthu* samples based on systematic language development and generation of references as well as the establishment of appropriate intensity scales specific to the products under investigation. A list of descriptive terms generated by the panellists characterised the products in terms of appearance, aroma, flavour and texture. The operational definitions of each sensory term and the reference material, reference standard and appropriate intensity scales were formulated and agreed on and are highlighted in Figure 5.1 and Table 5.1. The panellists were asked to complete an evaluation chart that contained definitions and references.

A focus group discussion was conducted under the supervision of a moderator to determine the attributes that characterised the *phuthu* samples and decide on the descriptors.
The characterization of sensory attributes of the PABMP under study was evaluated using a scale ranging from 0-10 (Figure 5.1).

0 = Extremely bad, 5 = Average, 10 = Extremely good

Figure 5.1: A sensory attribute scale of PVABMP ranging from 0-10.
Table 5. 1: General sensory descriptors for provitamin A biofortified maize phuthu

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Definition</th>
<th>Score (0 – 10)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Appearance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yellow colour</td>
<td>The intensity of yellow colour of <em>phuthu</em></td>
<td>Light yellow = 2&lt;br&gt;Very yellow = 10</td>
<td>Butter&lt;br&gt;Egg yolk</td>
</tr>
<tr>
<td>Rough</td>
<td>The degree of roughness perceived on the surface of <em>phuthu</em></td>
<td>Not rough/smooth = 0&lt;br&gt;very rough = 10</td>
<td>Butter surface&lt;br&gt;Broken maize (grits)</td>
</tr>
<tr>
<td>White specks</td>
<td>The presence of white specks in <em>phuthu</em></td>
<td>No specks= 0&lt;br&gt;Many white specks = 10</td>
<td>Coconut in yellow flour</td>
</tr>
<tr>
<td>Dry</td>
<td>The dryness of the <em>phuthu</em></td>
<td>Moist = 0&lt;br&gt;Very dry = 10</td>
<td>Yellow maize paste (20% solid)&lt;br&gt;Yellow maize flour</td>
</tr>
<tr>
<td><strong>Aroma</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooked maize aroma</td>
<td>The degree of cooked maize aroma</td>
<td>Not intense = 0&lt;br&gt;Very intense = 10</td>
<td>Yellow maize porridge (40% solid)</td>
</tr>
<tr>
<td><strong>Flavour</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooked maize flavour</td>
<td>The intensity of cooked maize flavour of <em>phuthu</em></td>
<td>Not intense= 0&lt;br&gt;Very intense= 10</td>
<td>25% maize porridge</td>
</tr>
<tr>
<td><strong>Texture</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crumbliness</td>
<td>The force required to crumble <em>phuthu</em> at 1st chew in the mouth</td>
<td>No force=0&lt;br&gt;Most force= 10</td>
<td>Rusks</td>
</tr>
<tr>
<td>Chewiness</td>
<td>The force required to chew <em>phuthu</em> until swallowed</td>
<td>No effort= 0&lt;br&gt;Most effort= 10</td>
<td>Rusks</td>
</tr>
<tr>
<td>Roughness</td>
<td>The degree of rough particles perceived while eating <em>phuthu</em></td>
<td>Not rough= 0&lt;br&gt;Very rough = 10</td>
<td>All bran flakes</td>
</tr>
<tr>
<td>Stickiness</td>
<td>The extent to which the <em>phuthu</em> adheres to the hand</td>
<td>Not sticky = 0&lt;br&gt;Very sticky=10</td>
<td>Honey</td>
</tr>
<tr>
<td>Malleability</td>
<td>The ease of malleability of the <em>phuthu</em></td>
<td>Not easy (Very difficult) = 0&lt;br&gt;Very easy = 10</td>
<td>Yellow maize flour&lt;br&gt;25% yellow maize porridge</td>
</tr>
<tr>
<td>Residual (residues)</td>
<td>The number of particles left in the mouth after swallowing the <em>phuthu</em></td>
<td>No particles= 0&lt;br&gt;Many particles= 10</td>
<td>All bran flakes</td>
</tr>
</tbody>
</table>
5.2.5 Sample labelling and serving order

The sensory analysis took place in individual booths, in a room equipped with air conditioning and lights. Randomised 3 digit numbers obtained from the Table of Random Numbers were used for labelling the serving containers with *phuthu* samples. Three varieties of provitamin A biofortified *phuthu* samples and white *phuthu* control samples were served to each panellist for evaluation purposes. Panellists were provided with a glass of clean water for rinsing their mouths after each test. In addition, serviettes, as well as disposable teaspoons for the sensory test were provided. The serving order of all the samples was done from left to right. The panellists ate the *phuthu* in the traditional way, using a tablespoon without any relish and the responses were immediately entered into the individual questionnaires provided to each panellist. Panellists were required to evaluate each sample twice before making their judgement. The former and the latter were done to ensure validity and reliability of the findings.

5.2.6 Statistical analysis

The sensory profiling and consumer acceptability data were analysed using analysis of variance (ANOVA). Comparison of multiple means was performed using Fisher’s Least Significant Difference test (LSD) (p< 0.05). Furthermore, the descriptive sensory data were subjected to Principal Component Analysis (PCA) to evaluate and identify variations between provitamin A biofortified maize *phuthu* based on their sensory attribute loadings.

5.3 Results and discussion

The sensory attributes of the biofortified maize *phuthu* as described by the trained panel are presented in Table 5.2.
Table 5.2: Sensory attributes of biofortified maize *phuthu* as described by the trained panel.

<table>
<thead>
<tr>
<th>ATTRIBUTE</th>
<th>STANDARD WHITE MAIZE</th>
<th>7PVAH (168-190)</th>
<th>6PVAH (124-143)</th>
<th>8PVAH (144-167)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellowness</td>
<td>1.00 ± 0.25</td>
<td>5.25 ± 0.35</td>
<td>4.99 ± 0.36</td>
<td>4.99 ± 0.30</td>
</tr>
<tr>
<td>Rough appearance</td>
<td>6.73 ± 0.21</td>
<td>4.84 ± 0.33</td>
<td>5.20 ± 0.38</td>
<td>4.81 ± 0.44</td>
</tr>
<tr>
<td>White specks</td>
<td>2.59 ± 0.25</td>
<td>2.17 ± 0.45</td>
<td>1.70 ± 0.36</td>
<td>1.41 ± 0.36</td>
</tr>
<tr>
<td>Dry appearance</td>
<td>7.36 ± 0.35</td>
<td>5.27 ± 0.33</td>
<td>5.20 ± 0.40</td>
<td>5.11 ± 0.37</td>
</tr>
<tr>
<td>Cooked maize aroma</td>
<td>9.45 ± 0.20</td>
<td>4.50 ± 0.51</td>
<td>4.24 ± 0.54</td>
<td>4.02 ± 0.53</td>
</tr>
<tr>
<td>Cooke maize flavour</td>
<td>9.18 ± 0.30</td>
<td>4.38 ± 0.52</td>
<td>3.96 ± 0.52</td>
<td>3.98 ± 0.52</td>
</tr>
<tr>
<td>Crumbliness</td>
<td>7.86 ± 0.36</td>
<td>2.38 ± 0.31</td>
<td>2.37 ± 0.32</td>
<td>2.39 ± 0.32</td>
</tr>
<tr>
<td>Chewiness</td>
<td>8.32 ± 0.30</td>
<td>2.67 ± 0.35</td>
<td>2.61 ± 0.34</td>
<td>2.51 ± 0.34</td>
</tr>
<tr>
<td>Roughness</td>
<td>8.18 ± 0.33</td>
<td>3.81 ± 0.39</td>
<td>3.61 ± 0.35</td>
<td>3.52 ± 0.45</td>
</tr>
<tr>
<td>Malleability</td>
<td>10.00 ± 0.00</td>
<td>5.67 ± 0.72</td>
<td>5.88 ± 0.64</td>
<td>5.59 ± 0.66</td>
</tr>
<tr>
<td>Residue</td>
<td>1.81 ± 0.21</td>
<td>3.43 ± 0.34</td>
<td>3.39 ± 0.42</td>
<td>3.41 ± 0.40</td>
</tr>
<tr>
<td>Stickiness</td>
<td>0.00 ± 0.00</td>
<td>0.52 ± 0.27</td>
<td>0.76 ± 0.32</td>
<td>1.20 ± 0.50</td>
</tr>
</tbody>
</table>

Mean values followed by different superscript letters in the same row are significantly different (p<0.05) according to LSD test.

The principal component analysis (PCA) was performed on the 13 sensory attributes of three (3) biofortified maize *phuthu* and a standard white maize *phuthu*. Three (3) principal components (PCs) were obtained (Table 5.3, Fig. 5.2). By PCA. The *phuthu* samples were also separated based on their sensory attributes. The first two principal components, PC1 and PC2 explained 94.92% and 4.64% of the total variance, respectively.

The standard white maize *phuthu* was loaded on PC1 and is strongly correlated with nine (9) sensory attributes. This means cooked maize flavour and aroma, rough and dry appearance, roughness, chewiness, crumbliness, and malleability strongly characterise standard white maize *phuthu*. The presence of white specks in standard white maize *phuthu* significantly reduced its stickiness. The second principal component (PC2) is
strongly associated with 6PVAH, 7PVAH and 8PVAH *phuthu*. These *phuthu* samples were characterised by a strong yellow appearance and more particles left in the mouth after swallowing (residual).

**Table 5.3: Correlation between sensory attributes and principal components**

<table>
<thead>
<tr>
<th>Sensory attributes</th>
<th>PC1</th>
<th>PC2</th>
<th>PC3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellowness</td>
<td>-0.987</td>
<td>0.161</td>
<td>0.000</td>
</tr>
<tr>
<td>Rough appearance</td>
<td>0.981</td>
<td>-0.102</td>
<td>0.168</td>
</tr>
<tr>
<td>White specks</td>
<td>0.856</td>
<td>0.511</td>
<td>-0.075</td>
</tr>
<tr>
<td>Dry appearance</td>
<td>0.999</td>
<td>-0.048</td>
<td>-0.021</td>
</tr>
<tr>
<td>Cooked maize aroma</td>
<td>0.999</td>
<td>-0.033</td>
<td>-0.028</td>
</tr>
<tr>
<td>Cooke maize flavour</td>
<td>0.997</td>
<td>-0.042</td>
<td>-0.065</td>
</tr>
<tr>
<td>Crumbliness</td>
<td>0.994</td>
<td>-0.109</td>
<td>-0.030</td>
</tr>
<tr>
<td>Chewiness</td>
<td>0.996</td>
<td>-0.085</td>
<td>-0.023</td>
</tr>
<tr>
<td>Roughness</td>
<td>0.998</td>
<td>-0.055</td>
<td>-0.037</td>
</tr>
<tr>
<td>ility</td>
<td>0.995</td>
<td>-0.095</td>
<td>0.028</td>
</tr>
<tr>
<td>Residue</td>
<td>-0.993</td>
<td>0.119</td>
<td>0.011</td>
</tr>
<tr>
<td>Stickiness</td>
<td>-0.884</td>
<td>-0.457</td>
<td>-0.098</td>
</tr>
</tbody>
</table>
Figure 5.2: Biplot of principal component (PC) 1 versus PC2 loadings of biofortified maize *phuthu* and standard white maize *phuthu*

The results of the sensory acceptability test of the *phuthu* samples reported in the previous chapter (Chapter 4) are presented again as Table 5.4 in order to relate the sensory profiles of the *phuthu* samples in Table 5.2 and 5.3 with their sensory acceptability. As was stated in chapter 4 as well as is indicated in Table 5.4, there was no significant difference in the acceptability of white maize *phuthu* and yellow maize *phuthu* (p>0.05).
Table 5.4: Sensory acceptability of provitamin A biofortified maize phuthu (From Chapter 4)

<table>
<thead>
<tr>
<th>Sensory attribute</th>
<th>Mean ± SE</th>
<th>White maize</th>
<th>Yellow maize</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aroma</td>
<td>3.70 ± 0.15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.81 ± 0.15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.632</td>
<td></td>
</tr>
<tr>
<td>Appearance</td>
<td>3.96 ± 0.14&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.94 ± 0.16&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.911</td>
<td></td>
</tr>
<tr>
<td>Texture</td>
<td>3.91 ± 0.15&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.90 ± 0.17&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.992</td>
<td></td>
</tr>
<tr>
<td>Taste/ flavour</td>
<td>3.91 ± 0.15&lt;sup&gt;d&lt;/sup&gt;</td>
<td>3.90 ± 0.17&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.992</td>
<td></td>
</tr>
<tr>
<td>Overall Acceptability</td>
<td>3.97 ± 0.17&lt;sup&gt;e&lt;/sup&gt;</td>
<td>4.02 ± 0.17&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.858</td>
<td></td>
</tr>
</tbody>
</table>

Means marked with different letters in the same row are significantly different (P<0.05), according to the t-test.

Stickiness was common to all yellow phuthu samples, whereas the same attribute was very low in white maize (5.5). Possibly, the stickiness of the yellow maize phuthu samples contributed to the lower acceptability of yellow phuthu compared to the white alternative (Table 5.4). This is supported by Beswa (2015) who proposed that the stickiness in the yellow maize could be due to the presence of carotenoid pigments. Reducing the stickiness of yellow maize phuthu could enhance its acceptability. This could be achieved by modifying the phuthu recipe, potentially by adding ingredients that reduce the stickiness, adding vegetables, or adding more maize flour during cooking - as was done in Ruwaida (2016) study.

Other differences were observed between the white phuthu sample and the yellow phuthu samples. First, white phuthu was more malleable than all three yellow phuthu samples, implying that its malleability is a key sensory attribute. Therefore, the lower malleability of the yellow phuthu samples could have contributed to their lower acceptability. It is possible that the stickiness discussed above could lower malleability of the yellow phuthu.
Table 5.5: Principal component analysis results

<table>
<thead>
<tr>
<th>Component</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chewiness</td>
<td>0.881</td>
<td>0.096</td>
<td>0.308</td>
<td>0.033</td>
</tr>
<tr>
<td>Crumbliness</td>
<td>0.873</td>
<td>0.33</td>
<td>-0.014</td>
<td>-0.027</td>
</tr>
<tr>
<td>Roughness</td>
<td>0.785</td>
<td>0.136</td>
<td>-0.164</td>
<td>-0.188</td>
</tr>
<tr>
<td>White specks</td>
<td>0.748</td>
<td>0.377</td>
<td>-0.26</td>
<td>0.131</td>
</tr>
<tr>
<td>Residue</td>
<td>0.709</td>
<td>-0.276</td>
<td>-0.001</td>
<td>0.142</td>
</tr>
<tr>
<td>Cooked maize flavour</td>
<td>0.286</td>
<td>0.829</td>
<td>-0.179</td>
<td>-0.125</td>
</tr>
<tr>
<td>Dry appearance</td>
<td>0.110</td>
<td>-0.053</td>
<td>0.914</td>
<td>0.166</td>
</tr>
<tr>
<td>Rough appearance</td>
<td>-0.063</td>
<td>0.068</td>
<td>0.867</td>
<td>0.328</td>
</tr>
<tr>
<td>Malleability</td>
<td>-0.49</td>
<td>0.324</td>
<td>0.551</td>
<td>-0.058</td>
</tr>
<tr>
<td>Cooked Maize aroma</td>
<td>0.054</td>
<td>0.393</td>
<td>-0.015</td>
<td>0.828</td>
</tr>
<tr>
<td>Yellowness</td>
<td>-0.146</td>
<td>-0.053</td>
<td>-0.223</td>
<td>-0.720</td>
</tr>
<tr>
<td>Stickiness</td>
<td>-0.326</td>
<td>-0.065</td>
<td>0.401</td>
<td>0.670</td>
</tr>
</tbody>
</table>

Second, the yellow phuthu was less crumbly, chewy and rough compared to the white phuthu. These also seem to be partly due to the stickiness of the phuthu. Chewiness and crumbliness are also key sensory attributes of phuthu. The low intensity of these attributes in the yellow phuthu samples could have also lowered its acceptability compared to white phuthu. Again, the results highlight the need to modify the recipe for yellow maize phuthu to improve its acceptability. Third, the intensity of the cooked aroma was much lower in the yellow phuthu samples than in the white phuthu. The cooked maize aroma is also a key sensory attribute for phuthu, therefore its low intensity in yellow maize phuthu is likely to have contributed to its lower acceptability. Finally, the intensity of the yellow in the white phuthu was very low; however, the result in Chapter 4 shows that the yellow colour did not reduce the consumer acceptability of yellow phuthu.

Interestingly, some unique sensory properties found in another popular maize food (stiff porridge) were not detected in phuthu. These included the bitter aftertaste and margarine-
like flavour (Biswa, 2015). These findings indicate that the sensory properties of yellow maize vary with food forms. This seems to affirm the previous findings that consumer acceptability of provitamin A maize varies depending on the food (Pillay et al., 2011). Therefore, there is an opportunity to improve consumer acceptability of provitamin A maize through food form selection and recipe modification and development.

5.4 Conclusions and recommendations

The yellow phuthu samples were characterised by their much lower intensity of chewiness, crumbliness, roughness, white specks and less malleability, and much higher intensity of yellowness and stickiness compared to the control. Stickiness could be due to the presence of carotenoid pigments in the yellow maize. It was therefore concluded that it is necessary to reduce the intensity of the stickiness of yellow maize phuthu to enhance its acceptability. Recipe modification is recommended for improving the acceptability of yellow phuthu. This includes adding other ingredients as suggested earlier, and changing the ratio of water to dry ingredients to make it stiffer and hence improve texture attributes such as malleability and chewiness.
5.5 References


Abstract

There is a tendency to rely on mainly Western methods of learning to assess knowledge, perceptions and attitude change, especially regarding awareness, education and training programmes. Indigenous methods of transferring knowledge/information and assessing behaviour after knowledge transfer have not been well documented. This was a study conducted to explore the integration of indigenous and Western methods of learning in awareness campaigns. A sample of 21 kwaDlangezwa smallholder farmers was selected to participate in a three-day awareness campaign workshop on provitamin A-biofortified maize (PABM). The farmers represented a consumer population with negative perceptions towards PABM, especially with reference to its colour. The two learning methods, Western (transformative learning) and indigenous learning were integrated with the intention of generating farmer awareness towards the benefits of adopting, cultivating and utilising PABM for improved food and nutrition security. In this regard, the adopted teaching and learning processes (systematic instructions, demonstrations and debates) were inclined towards Western learning methods, whereas the assessment process was inclined towards indigenous learning processes, such as the composition of songs, singing praises, poems, scenarios and parables. The results demonstrated that smallholder farmers had improved knowledge, transformed perceptions and showed a willingness to adopt, cultivate and utilise PABM. Integration of the two learning methods proved to be effective, because the farmers showed that, even though the PABM was not purely natural, they accepted that they needed to prioritise the nutritional value more than the yield potential and naturalness. Furthermore, they indicated enthusiasm for cultivating PABM after undergoing the awareness campaign.

Keywords: consumers, learning, traditional, transformative, provitamin A biofortified maize.
6.1 Introduction and background

Indigenous knowledge (IK) is defined as a science that is user-derived, based on a myriad of traditional and local knowledge factors that are unique to a given culture (Maila and Loubser, 2003). Yet, most often IK is not recognised as true science. This difference between Western knowledge (science) and IK continues to be a challenge because it is assumed that IK is inferior to other knowledge systems. As a result, Indigenous Knowledge Systems (IKS) and their learning processes are usually not integrated into development programmes, awareness campaigns and behaviour change programmes. Education and campaigns are regarded as effective interventions to engineer and alter a person’s behaviour (perceptions and attitudes). Yet several studies have reported on the failure of education and awareness campaigns intended to change behaviour (Taylor and Russo, 2002; Verplanken and Wood, 2006; Ogden et al., 2007). Regarding education, Knowles et al., (1998) remark that the most overlooked mistake leading to failure is that education programmes and learning processes are usually interpreted as being synonymous processes meaning that they are perceived to carry the same meaning and purpose. It is also often overlooked that knowledge and skill learning can be less complex when compared to changing behaviours such as perceptions. This is because the participants should be able to challenge their assumptions and to re-evaluate their ideas. Unfortunately, not all learning processes provide such an opportunity.

Most campaigns fail to change perceptions because they only focus on informing people rather than focusing on how the information/ knowledge has been received and if the knowledge has managed to reframe one’s mindset (Mann, 2011). Thus, defining the meaning, purpose and how these interventions function when planning to change behaviours, including perceptions, is important. Education campaigns focus more on the design of the programme itself and how it can impact change and not on the process of behaviour change. For education to result in effective behaviour change it should also include learning processes and techniques. An awareness campaign is an organised, purposeful effort to relay the message, reframe and defy negative perceptions that create change, and is guided by thoughtful planning (Mann, 2011; WHO, 2012). Both education
and campaigns result in improved participant knowledge when assessed, but often this knowledge does not translate to change or intention to change (Kolanisi et al., 2010).

Although there has been an observable shift over the years, most nutrition education interventions and awareness campaign are still inclined towards cognitive development, without considering the social settings and ways of life, which usually influence behaviour (Obel-Lawson, 2006; Mann, 2011; WHO, 2012). Perceptions are triggers of attitude formation; marketers, thus, rely more on perceptions than knowledge (Schiffman and Kanuk, 2004). There are two processes that are identified as leading to attitudes: judgemental and concern processes (Schiffman and Kanuk, 2004). The judgemental process is based on perceived quality and performance of the product, such as a new maize (PABM) variety, in this instance. This is associated with satisfaction if the product performs according to what is expected (Collado, et al., 2012). The concern or the so-called ‘wondering about’ process depends on information and experiences held by the consumer. It activates preferences, but if the consumers do not have enough information, knowledge, or experience about the object, they tend to be tense, distrustful, insecure and uncertain.

In the literature, three fundamental influencers of perception development and change are mentioned, namely needs, motivation and culture. Needs are defined as basics that are necessary to sustain life and are linked to the context of one’s life (Du Plessis and Rousseau, 2003). In terms of Maslow’s hierarchy of needs, the satisfaction of human needs leads to enhancement of quality of life, which could also be referred to as development. It involves the ability of an individual to improve his or her life through proper management of resources (Kulkarni, 2013). Needs are complex in nature and can be classified as intuitive, implicit or explicit. Intuitive needs are more concerned with desires, wants and previous experiences. It is a psychological process of constructing an image of what ought to be. An implicit need is embedded in one’s own values and in what is being offered- that is, they are based on the attributes of the service. Explicit needs are overt, as they are more focused on benefits and involve comparing the attributes of the service with the actual benefit it brings. All three types of needs influence the perceptions that originate from previous experience, which is ‘what ought to be’.
The second influencer is ‘motivation’, which is an internal factor that compels action (behaviour). It is the ability of an individual to comprehend and interpret information, as well as his or her ability to make effective use of opportunities (Crano and Prislin, 2008). According to the Motivation Opportunity Determinants (MODE) model developed by Fazio in 1990, one’s state of mind determines whether one is able to cognitively engage with the message, one’s motivation and the opportunities available (Bardi et al., 2003). This suggests that when both motivation and opportunity are high, intended behaviour can result in a positive change. Baron and Bryne (2003) reason that, even if there is a high motivation, if consumers are unable to utilise the available resources, then opportunities are minimised and motivation can be negatively affected.

The third perception influencer is culture. This influencer is usually omitted or under considered when designing education programmes and campaigns. It is, however, a very strong persuasive factor (Kaya, 2014). The study conducted by Nakashima (2010) proposed a framework on the importance of integrating IK with agricultural-based development interventions to facilitate ownership and sustainability. Cultural systems are the contextual basis of reframing used by societies. Therefore, to enhance motivation and to create opportunities, cultural context should be considered in order to stimulate and ensure a match between the cognitive, affective and behavioural components for change to happen. Since 1978, when IKS was recognised in education by the United Nations Educational, Scientific and Cultural Organization (UNESCO), it has been gradually integrated into education. However, in many African countries, though African situations, experiences and challenges dominated the research and developmental programmes (Nakashima, 2010).

Integrating IKS into education and awareness interventions increases their potential to be easily adopted and owned to ensure sustainability (WIPO, 2006). A study conducted in Kenya by Obel-Lawson (2006) integrated several communication channels, including IKS; it showed positive results in informing and changing consumers’ behaviour (perceptions and attitudes) towards the consumption of leafy vegetables. Most studies conducted on a similar subject agree that the integration of IK in any education or
awareness campaign motivates the participants to further engage and be involved in the message being conveyed, or with the information being disseminated. Secondly, it offers liberty to the communities to choose how they would like to be involved in the learning process. This boosts their self-esteem and brings pride. Thirdly, it is transformative and makes communities own the empowerment process. It provides opportunities and space for critical thinking. Fourthly, it offers a chance to communities to construct knowledge that is reflective of their own realities. Ryan and Abbots (2001) argue that ‘learning is not only a result of individual learning but involves interactions between all living things’. As stated by Roth (2004), it is also about ‘the art factual components of a community of participants’.

There is little documentation concerning the integration and synergy between IKS and Western learning processes. This study shows how IK-based learning processes, such as the composition of songs, singing praises, poems, scenarios and parables complemented the Western learning process, referred to as transformative learning, used in giving systematic instructions, demonstrations and conducting debates, in influencing smallholder farmers’ ‘perceptions towards PABM.

6.2 Research methodology

According to the literature, PABM has received less acceptability due to its colour. This is related to the yellow-orange maize that is associated with food aid, poverty, livestock, drought and inferior taste (Pillay et al., 2011). Therefore, a preliminary study was conducted to identify and assess the perceptions held by smallholder farmers in KwaDlangezwa. Out of three groups surveyed for perceptions, one group was identified as possessing negative perceptions towards yellow-orange maize. This is the group that was selected to undergo a three-day awareness campaign workshop on PABM. It was important in this study to implement an awareness campaign with this group to enhance the adoption of PABM because this maize is drought-resistant, nutritious and can contribute towards improved food and nutrition security.
6.2.1 Sampling method

Purposive sampling was used to select 21 smallholder farmers from kwaDlangezwa to participate in a three-day awareness campaign concerning PABM. They were mostly subsistence farmers who produced maize and used it for household consumption. Most participants (55%) were female and their ages ranged from 23 to 60 years.

6.2.2 Research design

A phenomenological research design, mainly focussing on descriptive phenomenology, was adopted in this study. As stated by Padilla-Diaz (2015), this approach is about obtaining people’s experiences and understanding their perspective of how they view and/or respond to certain things. It is about interpreting and giving meaning to a phenomenon experienced and perceived by the people being studied. This was achieved through the integration of the transformative learning approach with IK learning methods. Transformative learning was mainly used as a teaching and learning process (systematic instructions, demonstrations and debates). The IK learning methods (composition of songs, singing poems of praise, scenarios and parables) were also used for teaching and learning but were found to be mainly inclined towards assessment processes.

6.2.3 Transformative learning processes

Transformative learning is defined as a conscious action because it allows the accuracy of perception, avoidance of premature cognitive commitment, flexibility, innovation and leadership ability (Timmons and Alur, 2004). The learning is self-directed and therefore not rigidly defined, as learners are expected to deal with real-life challenges, think in complex ways, challenge their own views, and think beyond their experiences. As stated by Mezirow (2004), the transformative learning process is based on changing behaviour through the transformation of perspectives and the identification of assumptions. Perspectives are viewed as having the power to construct and shape thoughts, beliefs
and feelings about how things are done. The transformation of one’s perspective occurs when an individual opens themselves to other peoples’ worlds and begins to understand their expectations and beliefs. Expectations are powerful in influencing experiences, perceptions and behaviour. This is justified because human beings have expectations based on prior experience and socialisation.

Furthermore, transformative learning is based on the constructivist theory of adult learning and development (Dirkx, 1998). This means that the learning process begins with one’s experiences to guide the future. When the individual opens their perspectives to others, then learning begins. The learning process activates a review of the problem, transforms perspectives, improves meaning through participation and knowledge acquisition and helps the modification of perceptions (Cranton, 2002; Mezirow, 2000). In transformative learning, knowledge is more than just an intellectual process or acquisition of knowledge. The individual internalises the information and gains a deeper understanding, leading to perspective change. Transformative learning categorises knowledge into three, namely instrumental, communicative and emancipatory. Instrumental knowledge is the verification of beliefs. Communicative knowledge deals with interacting with others to find a common understanding of a subject. Emancipatory knowledge is self-knowledge that occurs through self-reflection; it involves a process of critical analysis (Cranton, 2002; Mezirow, 2004). The three knowledge categories complement conscientisation. Conscientisation is a process through which an individual develops the ability to critically analyse and ask questions, and thus take action to change. Such a process occurs when there is an opportunity for dialogue.

6.2.4 Indigenous Knowledge Systems and/ or processes

Several researchers agree that IKS-based learning processes evolve from the pedagogy that listens to what others have to say (Kaya, 2014). Learning from communities provides a better understanding of the local context and gives insight into their challenges, societal interaction, and what needs to be done; and it could satisfy their needs and expectations. IKS is viewed as being transformative, encouraging creativity and innovation. As opposed
to other Western-based knowledge, it is expressive-based, subjective and has the potential to explain complex social interventions (Obel-Lawson, 2006; Mann, 2011). Communities are recognised as experts who are knowledgeable about their own situation. The learning processes are thus flexible and unstructured, to allow deeper extraction of data. It should be noted that these processes are influenced by the contribution of participants. According to McNamara (2005), it is crucial for people to give their own meaning of things, rather than the researcher creating meaning on their behalf.

Unfortunately, the IK learning processes in nature are less structured, with limited theory and philosophical paradigms to support and challenge Western learning processes (Kaya and Seleti, 2013; Kaya, 2014). The IKS methodology is regarded more as a biased, and less valid and valuable form of knowledge than other forms of knowledge (Ogbebor, 2011). Consequently, the IK learning processes lost value and sense of worth, and their effect was viewed as having no impact (Nkondo, 2010; Kaya, 2013). IKS is characterised as experiential knowledge generated from local knowledge; an orally transmitted process through demonstrations, and a consequence of life realities (Ogbebor, 2011). In this study, oral tradition and the visual demonstration learning process were used. These processes included poetry as a praise song, parables and scenarios, songs, and spiritually derived language through ululations (a sign of excitement and/or strong agreement). IKS is more empirical than theoretical. The African indigenous ways of ‘knowing’ are consequently not easily measurable, but the actions and behaviour reflect the effect and the impact that the learning processes and the message conveyed have enforced on an individual’s perspectives.

6.8 Research procedure

The workshop was facilitated by various experts in the field of maize production. The stakeholders who participated included smallholder farmers researchers, plant breeders, a crop scientist, a consumer scientist, a food scientist, and representatives from NGOs and a tribal authority). In this study, the nine steps of Gagne’s model were integrated with the transformative learning principles and IK. They were interpreted as shown in Table 6. 1.
6.2.5 Data analysis

The abduction approach was followed in this study to assess and analyse data resulting from the integration of transformative and IKS learning processes. This approach is referred to as pattern recognition and plausible reasoning. It aims to explore data and find a certain pattern that can be justified as new knowledge. With this process the researcher observes emerging patterns and exploits them in more than one way to get credible data. Therefore, this approach intends to investigate, scrutinise and justify the noticed patterns. The smallholder farmers’ change in perceptions was assessed observed and critically analysed using content analysis.

Descriptive statistical analysis (analysis of percentage distributions) was further used to assess and analyse the smallholder farmers’ knowledge and perceptions of PABM before and after the vitamin A awareness campaign workshop. Wilcoxon Signed Ranks Tests were conducted to compare scores before and after the provitamin A awareness campaign on all of the aspects tested. In addition, an evaluation workshop was conducted both orally and as a written assessment.
Table 6.1: Integration of transformative and IK learning and assessment processes

<table>
<thead>
<tr>
<th>Transformative learning</th>
<th>Gagne’s model integrated with IK</th>
</tr>
</thead>
</table>
| **Content**             | 1. The consumer scientist took the expert role and was the main facilitator - creating an environment for knowledge transaction and responses.  
                             2. The facilitator explained the overall purpose of the programme and discussed expected learning outcomes.  
                             3. Educational booklets written in the local language and with pictures were issued to the participants.  
                             4. The presentations by the various experts were content-based, *i.e.* the production of PABM, nutritional value and food development. |
| **Open discussions**    | 5. Even though the presenters took a leading role, the participants were included, as they were recognised and given the opportunity to be key experts about maize production and consumption. The participants were given the opportunity to present their own experiences and beliefs.  
                             6. The sessions included several teaching strategies, such as demonstrations, presentations and dialogues, to engage participants in the learning programme and to allow critical thinking.  
                             7. Each session was followed by a plenary session. The participants could relay the message in their own preferred way - *IK practices such as dance, poems, songs and ululations, scenarios and parables were allowed and appraised.*  
                             8. A transactional and responsive process allowed participants to identify their own disorienting dilemma – experts shared their knowledge but allowed the participants to contribute their knowledge and practices. |
| **Reflections**         | 9. After each session the participants reflected on the lessons learnt. This served as a two-fold process, namely a feedback platform and a focus group discussion to assess whether the participants had synthesised the knowledge gained. |

**There were three stages in this process:**
- Critical reflection - *synthesising the new information about orange-yellow PABM as a new maize variety.*
- Adjustment - *weighing options of retaining the negative perceptions (prior knowledge and experiences) towards yellow maize, since PABM resembles the same colour as the yellow maize variety associated with food aid/drought maize (referred to as maize for livestock).*
- Continued reflection - *the adoption of the maize variety based on its satisfactory agronomic traits, acceptable sensory attributes and its contribution to the food and nutrition security of the households.*
6.3 Results and discussion

6.3.1 Demographic profile of the participants

The 21 participants that attended the workshop were from the surrounding rural areas of kwaDlangezwa. They were all smallholder farmers, growers and consumers of maize. The groups consisted of 10 males and 11 females, with ages between 23 and 60 years. The participants could read and write. Most of the participants depend on small-scale farming for their household income.

Table 6.2 shows that most participants’ knowledge and understanding of white maize and vitamin A biofortified maize changed after they attended the provitamin A awareness campaign. Before the provitamin awareness campaign, 38% of the participants disagreed with the notion that white maize had more nutrients than provitamin A biofortified maize. After the provitamin awareness campaign, this proportion changed to 57%. The improved understanding was also observed in all the other aspects tested. Likewise, after the provitamin, A awareness campaign, the proportions of unsure participants decreased tremendously in all aspects tested as the participants’ knowledge of the issues improved.

However, the Wilcoxon Signed Ranks Test indicated that the differences in the participants’ scores regarding the nutrient composition of white maize relative to yellow maize, and their awareness of vitamin A deficiency as a health and economic problem before and after the workshop were not statistically significantly. The proportion of participants who agreed that they had knowledge about vitamin A biofortified maize increased from a total of 52.4% to a total of 95.2% after the vitamin A awareness campaign. The Wilcoxon Signed Ranks Test confirmed that increased scores which reflected participants’ improved knowledge of vitamin A were statistically significantly (p= 0.003.) after the campaign. These findings show that the provitamin A awareness campaign had a positive influence on enlightening participants about provitamin A biofortified maize.
Table 6.2: Participant perceptions before and after the provitamin A awareness campaign

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree (%)</th>
<th>Disagree (%)</th>
<th>Not sure (%)</th>
<th>Agree (%)</th>
<th>Strongly Agree (%)</th>
<th>Wilcoxon Signed Ranks Test results</th>
</tr>
</thead>
<tbody>
<tr>
<td>White maize has more nutrients than other foods</td>
<td>9.5</td>
<td>38.1</td>
<td>28.6</td>
<td>19.1</td>
<td>9.5</td>
<td>19</td>
</tr>
<tr>
<td>I know about vitamin A biofortification</td>
<td>14.3</td>
<td>0</td>
<td>4.8</td>
<td>0</td>
<td>28.6</td>
<td>23.8</td>
</tr>
<tr>
<td>I know about vitamin A deficiency</td>
<td>0</td>
<td>0</td>
<td>9.5</td>
<td>0</td>
<td>14.3</td>
<td>28.6</td>
</tr>
<tr>
<td>I am aware that vitamin A is a health problem</td>
<td>0</td>
<td>0</td>
<td>4.8</td>
<td>0</td>
<td>19</td>
<td>23.8</td>
</tr>
<tr>
<td>I understand that vitamin A is a health as well as an economic problem</td>
<td>9.5</td>
<td>0</td>
<td>9.5</td>
<td>0</td>
<td>9.5</td>
<td>23.8</td>
</tr>
<tr>
<td>White maize is a natural food</td>
<td>14.3</td>
<td>19.6</td>
<td>14.3</td>
<td>4.8</td>
<td>33.3</td>
<td>28.6</td>
</tr>
<tr>
<td>White maize is healthy</td>
<td>14.3</td>
<td>29.8</td>
<td>14.3</td>
<td>9.6</td>
<td>47.6</td>
<td>9.5</td>
</tr>
<tr>
<td>Yellow maize is not natural</td>
<td>52.4</td>
<td>57.1</td>
<td>9.5</td>
<td>28.6</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Maize yield consideration is more important than consideration for nutrients found in maize</td>
<td>23.8</td>
<td>42.9</td>
<td>14.3</td>
<td>28.6</td>
<td>47.6</td>
<td>9.5</td>
</tr>
</tbody>
</table>
The percentage of participants who strongly disagreed that white maize was healthy more than doubled, from 14.3% to 29.8%, whilst the percentage of participants who strongly agreed that white maize was healthy did not change (14.3%). Overall, after the vitamin A awareness campaign, the total percentage (39.4%) of participants who disagreed that white maize was healthy was higher compared to the total percentage of participants who disagreed before the campaign (28.6%). After the vitamin A awareness campaign, the total percentage of participants who disagreed that yellow maize was not natural increased from 61.9% (pre-campaign) to 85.7%. After the vitamin A awareness campaign, the total percentage of participants who agreed that yellow maize was not naturally decreased from 19.0% to 14.3%.

With the exception of the notion that yellow maize is not natural, after the provitamin A awareness campaign, the percentage of unsure participants decreased in all of the tested aspects, indicating that the knowledge gained through the campaign was effective in changing their mindset with regard to provitamin A biofortified maize. However, the Wilcoxon Signed Ranks Test confirmed that scores for the notion that white maize is a natural food and healthy and that yellow maize is not natural, before and after the provitamin A awareness campaign, were not significantly different. The Wilcoxon Signed Ranks Test indicated that scores for the notion that maize yield consideration is more important than consideration for nutrients found in maize were significantly (p=0.036) different after the provitamin A awareness campaign compared to before the campaign. In general, Tables 2 and 3 reveal that the participants’ knowledge of provitamin A biofortified maize increased significantly after the provitamin A awareness campaign, and ultimately their perceptions of provitamin A biofortified maize also changed.

6.3.2 Processes towards ‘knowing’ the effect of the learning methods

During the workshop sessions following the ‘systematic instructions’, every session was tailor-made to suit the message to be conveyed. The learning environment was created to be less intimidating to the participants, i.e. visual learning material in the local language.
was arranged, displayed and referred to during lessons. The facilitators of learning (presenters) was involved with the participants during the facilitation process, creating opportunities for them to share their own knowledge, experiences and perspectives, triggering dialogues. For example, when presenting on the nutritional benefits of PABM the participants shared their perceived realities, such as: (i) relaying stories that revealed their value for health which were associated with life expectancy; (ii) perceiving that indigenous agricultural production systems acknowledge traditional sentimental value to assure one’s identity and sense of belonging; (iii) showing concerns about IK and its systems that are slowly disappearing and being undermined thus resulting in a greater shift towards Western ways; (iv) showing concerns about the impact of climate change on lifestyle and future food systems. This provided the researcher with an in-depth insight into consumer comprehension, anxieties and intents. It also served as an indicator for the facilitator to further steer the lesson facilitation towards recipients, because there are knowledge gaps or issues of concern when an opportunity prevails immediately to redirect learning without losing the purpose of the education intervention.

Following the principles of transformative learning, during the lessons, the participants were offered opportunities to paraphrase the message. As stated by Mezirow (1998) and Franz (2007), the transformation is founded on experiencing change through new experiences that are guided by a shift in from thoughts, feelings and actions. The IKS allows innovation and creativity. Therefore the participants were not dictated to on how they should present or reflect their understanding, but rather were given freedom to paraphrase the message in whichever way or by whatever method that pleased them. As argued by several researchers who conducted studies on behaviour change, when both motivation and opportunity are high, the effect of the message to transmit into behaviour change becomes greater (Baron and Bryne, 2003; Crano and Prislin, 2008). In the present study, the participants engaged with the message through the use of their own developed parables and scenarios to reflect their knowledge and perspectives. As mentioned, through the MODE model, the participants were critically involved with the message and, in the process, motivated the change in their own perspectives. The participants did parables based on a scripture to relay the message about the importance
of wisdom in their farming. They linked the parable to a scenario which focussed more on PABM and how it could improve their well-being. This created a transactional and responsive platform for all involved.

Involving the participants in the learning and facilitation processes created an opportunity for the participants to be empowered. It offered a less intimidating environment in which they felt comfortable and confident to be themselves without trying to impress the facilitator. As suggested by McNamara (2005), it is crucial for people to give their own meaning to things, rather than the researcher creating meaning on their behalf. As pointed out by Taylor and Russo (2002), one of the causes of this resistance is the fact that the message is usually received from outside the world of the participants. IK-based learning processes allowed the participants to overcome the feeling of powerlessness and lack of self-confidence as hidden factors that had a great potential to hinder the expected change.

6.3.3 Knowing the effect of the integration of the learning methods on smallholder farmers

A song was composed by the smallholder farmers on the last day of the workshop. The song content gave an insight of how the PABM had been previously perceived and how they had changed their perceptions. The song began by telling how yellow maize was first introduced to them and why they gained negative perceptions about it. It then shifted to how they now understand PABM and how they appreciate the benefits that it brings to the well-being of their households.

The song was composed through a group discussion. This was an innovation of the participants to reflect their knowledge and perception changes. The development of the song content gave the participants an opportunity to explore and understand their own opinions, whilst offering participants a chance to challenge their own assumptions and re-evaluate their ideas. According to Mezirow (2000), this is one of the most ignored
fundamental principles required in behaviour-change processes. The content of the song, the expression of the participants when singing, and the mood set acted as indicators to gauge the change in perception. Although this method did not numerically show who and how many participants’ perspectives were changing or not yet changing, it provided an immediate analysis of whether the process was being effective or not.

Onwueke (2007) felt that a song generates experiences and gives a sense of belonging. A song can be used as an assessment tool because the tonal inflexion of the words can mean something; thus the researcher or facilitator can probe the tone inflexion presented during singing. As stated by Onwueke (2007) “A word may have one meaning if uttered at a relatively high pitch, and another meaning if uttered at a relatively low pitch, with a third and possibly a fourth meaning if uttered with either a downward or upward inflexion.” The fundamental advantage brought by the song composition and its delivery through singing was that it gave the opportunity for immediate feedback. The researcher thus probed more about the content of the song through a dialogue which led the researcher to enter the world of the participants. Consequently, certain complexities that shaped the farmers’ perceptions were identified and resolved instantly. Some of the Western methods have limitations as they do not offer the chance for feedback and/or further probing. (Onwueke, 2007).

Dancing forms were demonstrated by a few individuals during the song. These were viewed as a social commentary to show whether the rest of the group was in agreement with the message/s being transmitted through the song. This dancing was accompanied by ‘Ululation’ from the peers. Therefore the combination of dance and ululation formed a tool to gauge the acceptance of the message. One could argue that the ‘Ululation’ was done to appreciate and encourage the dancers; however, it should be noted that in this instance there was coordination between the dancers and the ululat. Thus, the tone and the pitch of ululation were in accordance with the message given through the song, which, in this case, reflected the behaviour (perceptions), cognitive development (knowledge) and emotions (satisfaction) of the participants.
6.3.4 Willingness to adopt the new intervention

After six months the smallholder farmers who participated in the workshop were revisited. They still maintained the same enthusiasm and interest shown on the last day of the workshop. It was discovered that the smallholder farmers who participated in the workshop shared with other farmers their new perspectives and willingness to produce PABM. However, the time factor as the indicator of actual behaviour change could be a challenge in IKS perception and behaviour change processes. The intention-behaviour would not be as challenging as the assessing of the actual behaviour. Nevertheless, actual behaviour poses a challenge to assess, even for Western processes, because of the complex nature of the behaviour elements such as perceptions and attitudes that are usually exposed and easily influenced by other factors that the individual is exposed to, directly or indirectly.

6.3.5 IKS and Western-based workshop evaluation

Generally, after delivering a workshop an evaluation is done. In this instance, the principle was the same, but the participants were allowed to give the evaluation textually and orally. In this regard, it showed that the participants were satisfied with the workshop (Table 6.3
Table 6.3: Workshop evaluation

<table>
<thead>
<tr>
<th>Questions</th>
<th>Percentage (%) of participants (N=21)</th>
<th>Verbatim quotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I see a great need for us to start using provitamin A maize</td>
<td>98</td>
<td>‘today’s food is unhealthy; we no longer live a longer life because of the food we eat; provitamin A is our future’</td>
</tr>
<tr>
<td>2. I have a responsibility to ensure that my family has access to nutritious foods</td>
<td>98</td>
<td>‘that is why we are farmers trying to ensure that our families are healthy’</td>
</tr>
<tr>
<td>3. As a farmer, I have a role to play in enhancing the health and nutrition of my community</td>
<td>90</td>
<td>‘the primary purpose of waking up early in the morning and go to the fields is to provide for my people and family’</td>
</tr>
<tr>
<td>3. I am ready to be a producer of provitamin A maize</td>
<td>100</td>
<td>‘Where can we get the seeds?’</td>
</tr>
<tr>
<td>4. I am satisfied with the facilitation, pitching and interaction during learning</td>
<td>96</td>
<td>‘I enjoyed myself; I did not even think of missing even a day; I was comfortable and did not feel intimidated at all; I thought universities are places for educated people only but today I have changed my mind’</td>
</tr>
<tr>
<td>5. The learning materials were at my level</td>
<td>80</td>
<td>‘Except for the font sizes here and there because of my poor eyes, all was well; at times we did not use the posters on the walls’</td>
</tr>
</tbody>
</table>

Most of the participants orally reflected on the workshop, giving statements to show their satisfaction and how much they had learnt. Some decided to present poems. Below is one of the comprehensive poems about PABM developed by one of the farmers who attended the workshop. The other participants, when the poem was being sung, contributed by ululating to confirm agreement with the points mentioned in the poem. Again, dance was another expressive form that was used to indicate satisfaction.
6.3.6 Inkondlo yesondlo sempilo eqholiwe

Mmbila obomvu buyela kubantu bemvelo yakwenu isizwe sakho siphelile izifo, insalela yakh isiphuphuma ezinqwendweni zethu sithi buyisa isithunzi sakho qholiwe, ubuyise imiphefumulo esisele nezifo, ulwazi lwakho luzosabalala izwe lonke, kuvuke abagulayo. Wena uphethe uVitamin A, uma sithola umsoco wakho siyophila isikhathi eside ngawe. Vitamin A wena uvusa amasosha omzimba, uqinise amathambo anteketeke, zonke izitho zomzimba ziyonotha ngawe. Mmbila obomvu, siyakudinga Vitamin A. Buya uzoba isibani sempilo yesizwe. Enhla nasezansi, emagumbini omhlaba, uyokwandisa nenzalo yesizukulwane sikaThixo.


6.3.7 Poem on yellow maize (summarised version)

Yellow maize the nation has suffered enough of diseases. We know that you can bring back your dignity in a fortified form so that even the sickly can be revived to life again.

Yellow maize you are rich in Vitamin A, a nutrient for longevity
A nutrient responsible for the immune system
A nutrient that strengthens weak bones so that all limbs get revived.
The sick, pregnant, the lazy will be energetic and even children will grow clever!

Yellow maize we need Vitamin A, this is the light for the health of the nation.
North, South and all maize of the world
Through you yellow maize God’s generations will prosper.

6.3.8 Poem interpretation

The first section of the poem indicates a willingness to utilise PABM and excitement about the new information that will bring value to their well-being. The second part refers to how it will be utilised and gives thanks to the researchers who developed the maize variety, people who made it easier for the science to be shared with them and how they wish the knowledge could go from generation to generation. The last section was mainly towards encouraging the other farmers to accept the PABM. It served as a way to confirm if other farmers were keen on planting PABM. This section brought in the confirmation of the audience, as louder ululation and dance were observed.

It could be reasoned that the songs of praises and the poems served as an affirmation that the message was being accepted and it could be used as an indicator to demonstrate the intention to change. When the poet recited the poem, the audience ululated when they strongly agreed and were satisfied with the message; dancing indicated satisfaction and agreement with the messages being conveyed.
6.4 Conclusion

In this study, the transformative learning process provided a systematic process for the development of examining, and questioning and revising perspectives based on prior knowledge and experience, to build new knowledge, and rebuild experiences and perspectives. The IKS-based learning processes gave power to the participants to reflect on the true meaning, understanding and interpretation of the message. It enforced their involvement, encouraged them to view and use their realities to interpret the message, and gave them ownership of the process, whilst it also empowered them in the process.

Although transformative learning acknowledges the importance of motivation and also gives participants an opportunity to explore and understand their own situation, for change to occur, it lacks ways to position them to challenge their assumptions and re-evaluate their ideas for behaviour change to translate into actual behaviour. IKS-based learning processes assure that the participants are highly motivated, creating more possibilities for sustained actual change in behaviour. The integration of the learning processes complemented each other very well, with the transformative learning process providing a systematic process (determined content), and allowing the participants to contribute to knowledge building through IK-based learning processes.

Statistical analysis of the responses of the study participants to the knowledge and perceptions questionnaires indicate that the provitamin A awareness campaign significantly changed consumer knowledge and perceptions of provitamin A-biofortified maize, especially with regard to three valuable aspects, that is, naturalness, yield and nutrition. The poem verified and further elaborated this. As opposed to other maize varieties available on the market, in the current study, the consumers showed that, although they perceived PABM as not purely natural, they accepted that they needed to prioritise the nutritional value more than the yield potential and naturalness.
6.5 References


Cranton, P. (2002). Teaching for transformation, new directions for adult and continuing education: Contemporary viewpoints on teaching adults effectively. *New Directions for Adult and Continuing Education, 93*: 63-71


CHAPTER SEVEN: SUMMARY, CONCLUSION AND RECOMMENDATIONS

7.1 Summary and Conclusion

This study was aimed at investigating the acceptability of provitamin A biofortified maize food products in the form of phuthu and jeqe. An untrained consumer panellist evaluated the acceptability of provitamin A biofortified maize-based foods (phuthu and jeqe). A complimentary follow-up investigation was conducted using a trained panel to describe the sensory attributes (characteristics) of phuthu. Provitamin A biofortified maize is a new maize type which is not yet known by consumers. Several studies conducted in several countries, including South Africa, in sub-Saharan Africa found that consumers generally had negative perceptions towards this maize due to the previous experiences they had with other yellow maize types. Therefore, an awareness campaign on provitamin A was conducted to investigate whether it could impact positively on the consumer perceptions and hence acceptance of provitamin A biofortified maize. The following specific objectives were addressed in the study:

- To investigate the perceptions and sensory acceptability of provitamin A biofortified phuthu and jeqe by smallholder farmers in Empangeni, KwaZulu-Nata (KZN).
- To characterise the sensory properties (attributes) of provitamin A biofortified phuthu by a trained consumer panel.
- To evaluate the effect of a provitamin A awareness campaign conducted by both modern and indigenous learning methods on consumer perceptions and acceptability of provitamin A biofortified maize.

Provitamin A hybrid (8PVAH; 168-190) is a new yellow maize type developed to have high provitamin A levels to address vitamin A deficiency (VAD) in target population groups, especially rural communities in sub-Saharan Africa countries, including South Africa. Carotenoids impart a unique colour (yellow/orange) and other sensory attributes, including a strong aroma, onto the provitamin A biofortified maize grain and its food products. These sensory attributes are not found in white maize and seem to significantly contribute to the lower acceptability of the biofortified maize compared to white maize.
Scientists, such as breeders, develop innovations that could be of great help in improving household food and nutrition status. However, technology and innovation on its own do not directly translate into consumer acceptability. In this study it was argued that Provitamin A hybrid (8PVAH; 168-190) could be used by rural households who mainly rely on agriculture for household food production and consumption rather than depending on retail purchases. As mentioned in the study findings, in South Africa yellow maize, which resembles the biofortified provitamin A, was introduced during several droughts. Consequently, the experiences of consuming this maize were engraved in consumers’ experiences, formulating negative perceptions. Ultimately, this led to yellow maize being regarded as animal feed rather than as food fit for human consumption.

Several yellow maize-based foods and food products received more positive reviews compared to those made by white maize, despite yellow maize’s lower acceptability. The consumption of these yellow maize-based food products varied with ethnicity, geographic location and lifestyle. In KwaZulu-Natal province phuthu and jeqe were the most popular yellow-maize food forms. It should be mentioned though, that there are two popular phuthu dishes in KwaZulu-Natal, phuthu lwamasi (crumbled porridge with sour milk) and phuthu lwesishebo (crumbled porridge eaten with relish). The two phuthus also differ in cooking preparation, which influences the texture attribute. In this study, phuthu lwesishebo was prepared using a local recipe. Phuthu and Jeqe were selected as provitamin A biofortified (8PVAH; 168-190) maize-based foods for the experimentation in this study.

The study on the acceptability of provitamin A biofortified food products in selected research areas of KwaZulu-Natal province revealed that younger consumers had more positive perceptions than older consumers. These inferences originated from the sensory evaluation of provitamin A biofortified phuthu and the jeqe meals, where sensory attributes such as taste, appearance, texture and aroma were assessed. Interestingly, in this study, colour, taste and texture contributed to the acceptability of the two provitamins A biofortified food products regardless of age and gender, although younger respondents showed a higher preference for the meals. The yellow colour of jeqe was highly
appreciated as it gave the participants the illusion of a cake. The older generation used their previous experience of yellow maize known as *Bhokide* as their point of reference, which was introduced to them as food aid during drought periods. As mentioned in Chapter 4, yellow maize is hardly available at retail grocery shops as food for human consumption and is mainly found in agricultural shops, which mainly sell, livestock feed. This pattern continues to perpetuate negative perceptions about yellow maize. However, in this study participants expressed their willingness to consume biofortified maize, especially if it was to be readily available in local grocery stores and shelved in the food section and as commercial seeds for planting.

Consumer acceptability tests revealed that yellow *phuthu* was less acceptable than yellow *jeqe*. Therefore, descriptive sensory evaluation was done to determine the sensory attributes of the yellow *phuthu* and to attempt to relate its distinct differences from white *phuthu* to its acceptability. The PABM yellow *phuthu* had similar *phuthu* characteristics as the usual white *phuthu* except that yellow *phuthu* samples had a lower intensity of chewiness, crumbliness, roughness, and white specks and were less malleable. The intensity of yellowness and stickiness in yellow *phuthu* was higher compared to the control (white *phuthu*). It was thought that the stickiness could be due to the presence of carotenoid pigments in the yellow maize. It was therefore concluded that it is necessary to reduce the intensity of the stickiness of yellow maize *phuthu* to enhance its acceptability.

As an intervention to eliminate the negative perceptions and consequent relatively lower acceptability of provitamin A biofortified maize compared to the traditional white maize (reference/control), a nutrition awareness campaign was conducted. The main participants in the campaign were older participants, who had given yellow maize very low acceptability scores. A change of attitude for the older people involved in this study was regarded as important because they are the most active in agricultural production, are the custodians of traditions, and influence what foods are consumed in households. Therefore, informing and changing their perspectives paved the way to improving willingness to consume provitamin A biofortified maize.
Transformative Learning and Indigenous Knowledge Systems Learning processes were adopted in the vitamin A awareness campaign. These two learning processes are complementary and were used to change the participants’ perception of provitamin A biofortified maize, thereby improving its acceptability. As opposed to other studies, the change in consumer perceptions, and the willingness to adapt and produce PABM was not just an intended behaviour but rather an actual and observable behaviour change. A rapid follow-up study after six months of the campaign showed that the group that had been exposed to the awareness campaign were planting and consuming provitamin A biofortified maize. This study seems first to use a combination of Transformative Learning and Indigenous Knowledge Systems Learning processes in an awareness campaign to change negative perceptions of consumers towards a food source (provitamin A biofortified maize) and thereby increase its acceptability.

### 7.2 Recommendations

The yellow colour of Provitamin A biofortified maize could be used in the manufacture of many starch-based foods, e.g. curry powder or turmeric that are naturally white but have artificial food dyes or colourants to give them their orange colour. Provitamin A biofortified maize foods could be used in its natural colour without any additives. Thus, this presents product developers with an opportunity to develop new food products based on provitamin A biofortified maize, especially to target future consumers.

Use should be made of Provitamin A biofortified maize to develop or prepare different foods based on the sensory attributes that characterise the food forms. Where white maize is substituted by Provitamin A biofortified maize in the preparation of food and undesirable sensory properties develop, it is recommended that the ratio of mealie-meal to water be modified to achieve the acceptable consistency and texture. Acceptability of food forms such as the fermented soft-porridge-based drink (*amahewu*) that are characterised by a watery attribute should be investigated.
Nutrition awareness campaigns designed to educate smallholder farmers about the importance and benefits of the biofortified maize crop could improve the acceptability and adoption of provitamin A biofortified maize. These campaigns would also accelerate the eradication of the vitamin A deficiency and improve the quality of life in the rural communities.

Provitamin A biofortified maize is not yet commercially available in South Africa, yet evidence exists that it has been commercialised in Zimbabwe and Zambia. Commercialising the maize in South Africa would ensure that it is readily available in grocery stores as an alternative to white maize food products. Most nutrition-based interventions such as vitamin A drops have been introduced in South Africa; however, results from other studies reveal that such interventions have not been successful. It is suggested that provitamin A maize could be a cost-effective intervention accessible to rural poor communities.

7.3 Further studies

1. Acceptability of provitamin A biofortified maize-based drinks
2. Investigation of the ratios of white mealie-meal and provitamin A biofortified maize mealie-meal to water
3. Market research on provitamin A biofortified maize
4. Recipe and product development of provitamin A biofortified maize
7.4 References


Cranton, P. (2002). Teaching for transformation, new directions for adult and continuing education: Contemporary viewpoints on teaching adults effectively. New Directions for Adult and Continuing Education, 93: 63-71


Girum, M. (2015). Genetic analysis of carotenoid accumulation in tropical maize inbred lines using molecular tools and field tests for accelerating the biofortification of maize
with provitamin A. National University of Ireland Galway, (PhD Thesis). College of Science, School of Natural Sciences.


INP. (2001). The national directorate: nutrition and provincial nutrition units. Integrated nutrition programme strategic plan 2001/02 to 2006/07; November 2001


Okweche, S. I., Umoetok, S. B. A. and Osai Ephraim O. (2013). Effects of Synthetic (Carbofuran) and non Synthetic insecticides on Maize Growth and Yield in Stem Borers Infested Zones of Cross River State, Nigeria. *Journal of Biology, Agriculture and Healthcare*, 3: 1


Sema, P. (2013). Do social media affect consumer decision-making? Johnson and Wales University, Providence, RI.


Singh-Ackbarali, D. (2014). Sensory Evaluation as a Tool in Determining Acceptability of Innovative Products Developed by Undergraduate Students in Food Science and Technology at The University of Trinidad and Tobago. *Journal of Curriculum and Teaching*, 3:1


Appendix A: Project information and informed consent

Good day

My name is Kate Ngwanamoelo Ndwandwe and I am working at the University of Zululand. I am doing a research project to evaluate the impact of a nutritional education programme on the acceptability of provitamin A-biofortified, orange/yellow maize varieties by small-scale farmers/consumers. The household heads of the selected area will be interviewed by means of focus groups. I need your assistance in getting the information for this research project. I will explain the project to you so that you will understand exactly what will be done, the reasons, and what will be expected of you so that you can decide if you want to participate in this project. Participation is voluntary and should you decide to participate, you may withdraw at any stage during this project.

1) WHAT IS THIS PROJECT FOR?

The purpose of the research project is;

- To characterise the sensory properties of provitamin A, biofortified yellow maize.

- To develop and implement a nutrition programme to improve consumer perceptions and acceptability of maize.

- To determine the impact of the nutrition education programme on consumer perceptions and acceptability of yellow maize.

2) WHY IS THIS PROJECT IMPORTANT?

This project is a relevant and worthwhile undertaking due to the need to promote rural agriculture, in particular home and community gardening in South Africa. Evidence exists that adequate nutrition is an underlying factor contributing to public health problems and social challenges in the world today (Vorster et al. 1999). Therefore, a better
understanding of the determinants and changes in dietary patterns and nutrient intake during the demographic transition in developing countries and how these changes or the nutrition transition influence health outcomes, could lead to more appropriate and relevant policies, strategies and intervention programmes to protect and promote health, and to prevent and control diseases (Vorster et al., 1999).

3) PROCEDURE

The project will take place over a period of two weeks. The researcher and research assistants will request you to attend focus groups that will be held and answer questions on behalf of the families. We will characterise the sensory properties of provitamin A, biofortified yellow maize by doing a sensory evaluation. After sensory evaluation, we will develop and implement a nutrition education programme to improve consumer perceptions and acceptability of the yellow/orange maize. We will also determine the impact of nutrition education programme on consumer perceptions and acceptability of yellow maize.

4) WHAT ARE THE BENEFITS FOR YOU?

- Healthy and nutritional status indicators for you, family and community. You will receive feedback.

- The information collected will be analysed and the results will be made available to the participants on request. The information will be used for publication in scientific journals and will also be presented at scientific conferences. No results will be published in magazines or local newspapers.

5) WHAT DO WE EXPECT FROM YOU?

- You will be asked to sign a consent form.

- We will ask you a number of questions regarding your health, age, income, family, and smoking and drinking habits.

- Then you will receive a reference number for the project.
Participation

If you have any questions about the project, please do not hesitate to ask me or my moderator at any time.

Thank you,

PhD Student (Project Leader)

Tel:

E-mail address:

6) **INFORMED CONSENT**

I, the undersigned,…………………………………………………………………………………………………………………………………………………………………………………………

[ID…………………………………..] participant.

From this postal address………………………

……………………………………Code…………………………………………………………………………………………………………………………………………………………………………………………

I have read the details of the project, or have listened to the oral explanation thereof, and declare that I understand it. I have had the opportunity to discuss relevant aspects with the researcher and declare that I voluntarily participate in the project. I hereby give consent to participate in the project.

I hereby indemnify the University of KwaZulu-Natal (UKZN), or any employee of the UKZN, against any liability that may originate during my participation in this research project. I further undertake that I will not claim against the UKZN or any UKZN employee any personal disadvantages that participants may suffer as a result of this research.

**Signature of participants**

…………………………………………..
Signed at ……………………………on……………………….Month…………………

Witnesses

Name………………………………………………Name …………………………………

Signature ……………………………………Signature……………………………….

Signed at……………………………………..Signed at………………………………

Address of the parent/guardian………………………………………………………………

………………………………………………………………………………………………

Contact telephone number………………………………………………………………

Consent Form

Sensory evaluation panel of Phuthu porridge made from provitamin A biofortified orange/yellow maize

I, the undersigned, ________________________________ (Full Name)

Participant, student number ___________________, Tel: ____________________,

have been fully informed of:

• The purpose of this study,

• That my participation is voluntary,

• That I can withdraw at any time,

• That participation will cost me nothing, and

• That all information given will be kept confidential.

I agree to:
Sensorially test the Phutu porridge and answer a questionnaire.

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

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

_________________________________  __________________________________
(Participant’s signature or mark) (Witness)

Signed at: __________________________ on _____/_______/2012

Consent Form

Sensory evaluation panel of Phuthu/Jeqe made from provitamin A bio-fortified (orange/yellow) maize

I, the undersigned, ________________________________ (Full Name) participant, student number ___________________, Tel: __________________,

have been fully informed of:

• The purpose of this study,

• That my participation is voluntary,

• That I can withdraw at any time,

• That participation will cost me nothing, and

• That all information given will be kept confidential.
I agree to:

Sensorially test the Phutu/Jeqe porridge and answer a questionnaire.

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

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

_________________________  __________________________
(Participants signature or mark)   (Witness)

Signed at: __________________________ on _____/_______/2013

Research requirements

The followings must be prepared and be available during the research process

<table>
<thead>
<tr>
<th>Stationary</th>
<th>Equipment</th>
<th>Food</th>
<th>Forms</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research files</td>
<td>10 Knives</td>
<td>Juice, assorted</td>
<td>Demography questionnaires</td>
<td>Tape recorder and cassettes</td>
</tr>
<tr>
<td>Pens</td>
<td>Paper plates</td>
<td>Bread</td>
<td>Consent forms</td>
<td>Testing booths</td>
</tr>
<tr>
<td>Pencils</td>
<td>Paper serviettes</td>
<td>Bread spread</td>
<td></td>
<td>Venue</td>
</tr>
<tr>
<td>Exam pads</td>
<td>Small bowls</td>
<td>Yellow/Orange maize seeds</td>
<td>Camera</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
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<td>---------------------------</td>
<td>--------</td>
<td></td>
</tr>
<tr>
<td>Calculator</td>
<td>Measuring spoons</td>
<td>Cake flour</td>
<td>Remuneration</td>
<td></td>
</tr>
<tr>
<td>Pair of scissors</td>
<td>Mixing bowl</td>
<td>Baking powder</td>
<td>Salt</td>
<td></td>
</tr>
<tr>
<td>Measuring jug</td>
<td>Sugar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cup</td>
<td>Yeast</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaspoon</td>
<td>Water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tablespoon</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sieve</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pot</td>
<td>Sunlight</td>
<td>Dishwasher</td>
<td>Dish drier</td>
<td>Metal wrack</td>
</tr>
<tr>
<td>--------------</td>
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</tr>
<tr>
<td></td>
<td>liquid</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

| Wooden spoon | Glass           | Fork           |               |              |
Appendix B: Instruction manual for sensory evaluation

IMPORTANT: DO NOT START TESTING THE SAMPLES BEFORE YOU HAVE READ AND UNDERSTOOD THE FOLLOWING INSTRUCTIONS

9.1. Important information

What the researcher and moderator will do.

At the beginning:

- Explain the routine for the day
- Register the subject on the attendance register as being present
- Complete the demography form
- Ensure that the consent form is in the file and completed

At the end

- Collect the completed forms from the participants
- Sign the participant out on the register
- Hand out a sandwich with a glass of fruit juice to each participant
- Give a participant remuneration if available

APPENDIX D: SOCIO-DEMOGRAPHIC QUESTIONNAIRE

This questionnaire covers certain aspects of your life, and your family life including work and personal details, health and illness, and lifestyle and social life that is relevant to health.
**Personal information:**

<table>
<thead>
<tr>
<th>Education level of household head (Tick one only)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Primary school Std 6-8</td>
<td>Std 9-10</td>
<td>Tertiary education</td>
<td>Don't know</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mother’s employment status (Tick one only)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housewife by choice</td>
<td>Unemployed</td>
<td>Self employed</td>
<td>Wage earner</td>
<td>Other, specify:</td>
<td>Don’t know</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Education level of breadwinner (Tick one only)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Primary school Std 6-8</td>
<td>Std 9-10</td>
<td>Tertiary education</td>
<td>Don’t know</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Father’s employment status</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Tick one only)</td>
<td>Unemployed</td>
<td>Self-employed</td>
<td>Wage earner</td>
<td>Retired by choice</td>
<td>Other, specify:</td>
<td>Not applicable e.g. dead</td>
</tr>
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<td>--------------------------</td>
</tr>
<tr>
<td>1 person</td>
<td>2 persons</td>
<td>3-4 persons</td>
<td>5-6 persons</td>
<td>More than 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 persons</td>
<td></td>
<td>3-4 persons</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 persons</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household income per month (including wages, rent, sales of veggies, etc, state grant)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Tick one only)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>None</td>
<td>R100-R500</td>
<td>R5000-R1000</td>
<td>R1000-R3000</td>
<td>R3000-R5000</td>
<td>Over R5000</td>
<td>Don't know</td>
</tr>
</tbody>
</table>

185
Is this usual income of the household?  
(Tick one only)  
<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

If no, what other income is available, specify

Is this more or less the income that you had over the past six months?  
(Tick one only)  
<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

How much money does household on food spend weekly?  
(Tick one only)  
<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>R0 - R50</td>
<td>R50 - R100</td>
<td>R100 - R150</td>
<td>R150 - R200</td>
<td>R200 - R250</td>
<td>R250 - R300</td>
<td>R300 - R350</td>
<td>R350 - R400</td>
<td>R400 - R450</td>
<td>R450 - R500</td>
</tr>
</tbody>
</table>
## Marital status (tick one only)

<table>
<thead>
<tr>
<th></th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unmarried</td>
<td>Married</td>
<td>Divorced</td>
<td>Separated</td>
<td>Widowed</td>
<td>Living together</td>
<td>Traditional marriage</td>
<td>Other, specify</td>
</tr>
</tbody>
</table>

## Now decide on the following:

### Type of dwelling

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Brick, concrete</td>
<td>Plastic</td>
<td>Tin</td>
<td>Plank, wood</td>
<td>Other, specify:</td>
</tr>
</tbody>
</table>

### Number of people sleeping in the house for at least 4 nights per week?

### Number of rooms in house (excluding bathroom, toilet, kitchen, if separate)

### Number of people per living/sleeping room (tick one)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-2 persons</td>
<td>3-4 persons</td>
<td>More than 4</td>
</tr>
</tbody>
</table>
10.2.1. Do you ever eat the following foods rich in vitamin A?

<table>
<thead>
<tr>
<th>FOOD</th>
<th>DESCRIPTION</th>
<th>AMOUNT</th>
<th>TIME EATEN</th>
<th>CODE AMOUNT/DAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liver</td>
<td></td>
<td></td>
<td>Per Day</td>
<td>Per Week</td>
</tr>
<tr>
<td>Paprika</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red pepper</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cayenne pepper</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chili powder</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweet potatoes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carrots</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SENSORY EVALUATION

Introduction

We are recruiting respondents that are willing to participate in tasting/sensory evaluation of maize porridge. Sensory evaluation will involve initial training of panellists followed by the product evaluation. We would require 3 hours of your time every day from Monday the 2nd July 2012 to Friday, 6th July 2012.

1. Would you like to participate?

Yes: continue with Interview

No: close and terminate the interview
Interviewer: I would like to ask a few questions to determine whether you are part of the group of people our client is interested in.

2. **In what year were you born/ How old are you**: (younger than 18, close and terminate):

3. **Do you consume maize porridge**
   - **Yes**: continue with Interview
   - **No**: close and terminate the interview

4. **On average how often do you consume maize porridge?**
   - **Almost every day**: Continue with interview
   - **At least once a week**: Continue with interview
At least once every two weeks | Continue with interview  
---|---  
At least once a month | Close and terminate the interview  
Less than once a month | Close and terminate the interview

5. Can you please describe how a stiff maize porridge smells or looks like.  

6. Do you have any food allergy  

| Yes | Close and terminate the interview  
|---|---  
| No | Continue with interview  

7. Can you read and write English  

| Yes | Continue with interview  
|---|---  
| NO | Close and terminate the interview  

8. Are you available to participate in the Training and evaluation sessions?  

<table>
<thead>
<tr>
<th>Days</th>
<th>Periods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday -Saturday</td>
<td>11h -12.30 and 13h - 14.30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Days</th>
<th>Periods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Yes for days and periods: continue with Interview
9. **Qualitative phase specification (Check by the interviewer)**

<table>
<thead>
<tr>
<th>Recruitment specification and demographics</th>
<th>Check</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender: Max 50 % Males- Would expect more females 70: 30 Females: males</td>
<td></td>
</tr>
<tr>
<td>Must be over the age of 18</td>
<td></td>
</tr>
<tr>
<td>Must be a South Africa citizen</td>
<td></td>
</tr>
<tr>
<td>Must be a regular consumer of maize porridge (at least once/twice a week)</td>
<td></td>
</tr>
<tr>
<td>Must have no food allergies or intolerance (Self-report)</td>
<td></td>
</tr>
<tr>
<td>Must be able to read and write English</td>
<td></td>
</tr>
<tr>
<td>Good health (self-report)</td>
<td></td>
</tr>
<tr>
<td>Non- smoking</td>
<td></td>
</tr>
</tbody>
</table>

I, ........................................................................................................, (respondent name) have agreed to participate in the sensory evaluation process.

Signature ..................................................  Date: ......................................

**IMPORTANT**: DO NOT START TESTING THE SAMPLES BEFORE YOU HAVE READ AND UNDERSTOOD THE FOLLOWING INSTRUCTIONS
Instructions will be given verbally and in a written form.

12.1. Working stations for sensory evaluation tests

All working stations should have the following:

a) Glass of water  Pencil

b) Serviette  Pen

c) Product  Rubber

d) Spoon  Piece of paper

e) Fork  Bread

<table>
<thead>
<tr>
<th>Workstation</th>
<th>Product Number</th>
<th>Product Name</th>
<th>Participant Name</th>
<th>Signature</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Three</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Four</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Five</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Six</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seven</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eight</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ten</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Presented to you are a series of samples with variable colour intensity. Rate these samples by the order of increasing colour intensity, starting from left to right.

Sample No.

1. ______________

2. ______________

3  ______________

4. ______________

5  ______________

6  ______________

7  ______________

After sensory evaluation participants will receive some refreshments as well as remuneration.

12.2. IMPORTANT INFORMATION

The leader of this project is Mrs N.K Nd wandwe and the moderator is (………). In order to ensure accurate and reliable data, the project leaders will supervise the data collection process and cross-check some of the information they have obtained.

All the basic questions must be asked in the same way. Should questions be translated, please ensure that the meaning of the question is not changed by the way the question is rephrased. The project leaders will be available for assistance at all times during the trial.
THANK YOU FOR YOUR COOPERATION AND PATIENCE

GOODBYE!

Lexicon for maize (Phuthu)

<table>
<thead>
<tr>
<th>Appearance</th>
<th>Definition</th>
<th>References</th>
<th>Score 0 - 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow</td>
<td>The intensity of yellow colour of <em>phuthu</em></td>
<td>Butter, Egg yolk</td>
<td>Light yellow = 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Very yellow = 10</td>
</tr>
<tr>
<td>Rough</td>
<td>The degree of roughness perceived on the surface of <em>phuthu</em></td>
<td>Butter surface,</td>
<td>Not rough/smooth =</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Broken maize (grits)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>very rough = 10</td>
</tr>
<tr>
<td>White specks</td>
<td>The presence of white specks in <em>phuthu</em></td>
<td>Yellow flour,</td>
<td>No specs= 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coconut in yellow flour</td>
<td>Many white particles= 10</td>
</tr>
<tr>
<td>Dry</td>
<td>The dryness of <em>phuthu</em></td>
<td>Yellow maize paste (20% solid), Yellow maize flour</td>
<td>Moist = 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Very =dry</td>
</tr>
<tr>
<td>Aroma</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall aroma of phutu</td>
<td>The intensity of the overall aroma of <em>phuthu</em></td>
<td></td>
<td>Not intense = 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Very intense = 10</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Scale</td>
<td>Notes</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>--------------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td><strong>Cooked maize aroma</strong></td>
<td>The degree of cooked maize aroma</td>
<td>25% maize porridge</td>
<td>Not intense = 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Very intense = 10</td>
</tr>
<tr>
<td><strong>Flavour</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Overall Flavour</strong></td>
<td>Intensity of the overall flavour of <em>phuthu</em></td>
<td></td>
<td>Not intense = 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Very intense = 10</td>
</tr>
<tr>
<td><strong>Cooked maize flavour</strong></td>
<td>The intensity of cooked maize flavour of <em>phuthu</em></td>
<td>25% maize porridge</td>
<td>Not intense = 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Very intense = 10</td>
</tr>
<tr>
<td><strong>Residues</strong></td>
<td>The number of particles left in the mouth after swallowing <em>phuthu</em></td>
<td>All bran flakes</td>
<td>No particles = 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Many particles = 10</td>
</tr>
<tr>
<td><strong>Texture</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Crumbliness</strong></td>
<td>The force required to crumble <em>phuthu</em> at 1st bite in the mouth</td>
<td>Maize puffs Rusks</td>
<td>No force = 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>More force = 10</td>
</tr>
<tr>
<td><strong>Chewiness</strong></td>
<td>The force required to chew <em>phuthu</em> until swallowed</td>
<td>Rusks</td>
<td>No effort = 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>More effort = 10</td>
</tr>
<tr>
<td><strong>Roughness</strong></td>
<td>The degree of rough particles perceived while eating <em>phuthu</em></td>
<td>All bran flakes</td>
<td>Not rough = 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Very rough = 10</td>
</tr>
</tbody>
</table>
| Stickiness | The extent to which phuthu adheres | 25% cooked starch gel | Not sticky= 0
|            | 100%                                | Very sticky=10        |
| Mouldiness | The ease of moulding *phuthu*       | 25% maize porridge, yellow maize flour | Very easy= 0
|            |                                     | Not easy (Very difficult)= 10 |
15h30p.m -16h00p.m: Reflection session

**26 November 2014**

08h00a.m: - Tea

9h00a.m – 10h30a.m: Maize biofortification – Denise Mncwango

10h30a.m – 11h30a.m: Group discussion

11h30.00a.m – 12h00p.m: Reflection session

12h00p.m – 13h00p.m: Lunch

13h00p.m – 14h30p.m: Scenario – Vitamin A –Unathi Kolanisi and Nozipho Zungu

14h30p.m – 15h00p.m: Group Discussion

15h00pm – 15h15pm: Tea

15h15p.m – 15h45pm: Reflections

**27 November 2014**

08h00a.m: - Tea

9h00a.m – 10h30a.m: South African Food Based Dietary Guidelines (SAFBDG)

10h30a.m – 11h30a.m: Food safety – Nozipho Zungu

11h30.00a.m – 12h00p.m: Post- knowledge questionnaire

12h00p.m -13h00p.m: Workshop evaluation and reflection session

13h00p.m – 14h00p.m: Lunch

14h00p.m – 16h00p.m: Award ceremony (Dr Siwela and Dr Selepe to lead)
Appendix D: Teaching material for educating communities about provitamin A biofortified maize

**PRO-VITAMIN A BIOFORTIFIED MAIZE**

1. kernels
2. diagram of plant
3. image of field
4. image of corn meal
1. WHAT IS FOOD?

- An item that enters the body’s systems and tissues to build, repair and maintain life (Wilson et al., 2009)
- Human survival depends on getting food.
Plants are primary sources of food through the process of photosynthesis. Animals are secondary sources of food for humans.
HOW DOES FOOD RELATE TO NUTRITION?

CHEMICAL COMPOUND + AGRICULTURE = FOOD

NUTRIENTS

DIET

IMPORTANCE OF FOOD
WHAT IS FOOD SECURITY?
• 2001/2 World Food Summit: “Food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

WHAT IS FOOD AND NUTRITION SECURITY?
• Food and nutrition security policy, (2013) defines it as “access to and control over the physical, social and economic means to ensure sufficient, safe and nutritious food at all times, for all South Africans, in order to meet the dietary requirements for a healthy life”.

In the South African constitution it is stated that every South African citizen has a right to sufficient food and water; and social security (du Toit, 2011).
Food and nutrition security is about:
- Where do you get food?
- How much food?
- What kind of food?
- Who should get food?
- When is food available?
- How do you acquire and obtain food?
What happens when there is food and nutrition insecurity?

MALNUTRITION occurs!!

Adapted from UNICEF 1990
Signs of malnutrition
What is the role of agriculture?

The agricultural sector must now pay attention to the quality of food that is being produced and delivered rather than on quantity alone because different people in the society have different nutritional needs according to their health status.

WAY FORWARD

Fortification (nutritional value is added to a processed food product)

- Selective
- Costly

Therefore, not effective and sustainable

- Remote rural areas usually have less access to fortified foods
- Low socio-economic status compromises the acquisition of biofortified foods

Biofortification (the process of adding nutritional value to a crop)

- Rural-based sustainable intervention
- Complements fortification & supplements
- Time & cost effective - can take place on the farmers’ fields
- Targets staple foods
- Drought and disease resistant
- Comparable yields as non-biofortified crops
## Uses of biofortification in other countries

<table>
<thead>
<tr>
<th>Schedule of product release. Crop</th>
<th>Nutrient</th>
<th>Countries of first release</th>
<th>Agronomic trait</th>
<th>Release year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweetpotato</td>
<td>Pro-vitamin A</td>
<td>Uganda, Mozambique</td>
<td>Disease resistance, Drought tolerance, acid soil tolerance</td>
<td>2007</td>
</tr>
<tr>
<td>Bean</td>
<td>Iron, Zinc</td>
<td>Rwanda, DR Congo</td>
<td>Virus resistance, Heat and drought tolerance</td>
<td>2010</td>
</tr>
<tr>
<td>Pearl Millet</td>
<td>Iron, Zinc</td>
<td>India</td>
<td>Mildew resistance, Drought tolerance</td>
<td>2011</td>
</tr>
<tr>
<td>Cassava</td>
<td>Pro-vitamin A</td>
<td>Nigeria, DR Congo</td>
<td>Disease resistance</td>
<td>2011-12</td>
</tr>
<tr>
<td><strong>Maize</strong></td>
<td><strong>Pro-vitamin A</strong></td>
<td><strong>Zambia</strong></td>
<td><strong>Disease resistance, Drought tolerance</strong></td>
<td><strong>2011-12</strong></td>
</tr>
<tr>
<td>Rice</td>
<td>Zinc, Iron</td>
<td>Bangladesh, India</td>
<td>Disease and pest resistance, cold and submergence tolerance</td>
<td>2012-13</td>
</tr>
<tr>
<td>Wheat</td>
<td>Zinc, Iron</td>
<td>India, Pakistan</td>
<td>Disease resistance, Lodging</td>
<td>2012-2013</td>
</tr>
<tr>
<td>Studies</td>
<td>Findings</td>
<td>References</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>-------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acceptability of Provitamin A biofortified</td>
<td>• Acceptance varied with consumer demographic profiles — younger consumers accepted Provit A the same as white maize whilst older seemed to prefered white maize</td>
<td>Pillay et al (2011)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acceptability of Provitamin A biofortified dishes/beverages</td>
<td>• Acceptance of Provit A varied food type – an opportunity to increase acceptance through recipe development</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Phuthu more acceptable than samp and thin porridge</td>
<td>Pillay et al (2011)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Provit A biofortified stiff porridge was as acceptable as white maize</td>
<td>Daniso et al (2012)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Acceptability of corn bread as corresponding to the white corn bread</td>
<td>Ndwandwe (2012)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Acceptability of roasted fresh Provit A maize was more acceptable than white</td>
<td>Owabe (2013)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Boiled fresh Provit A maize was as acceptable as the corresponding white products</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Provit A weaning foods as acceptable as correspond weaning foods by care givers</td>
<td>Govender et al (2013)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Pop corn Provit A biofortified maize highly acceptable to consumers</td>
<td>Jele et al (2014)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Amahewu Provitamin A biofortified maize was as acceptable as white maize</td>
<td>Aurobussuy (2014)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The role of vitamin A in health

Roles of vitamin A in human

• Essential component of metabolism - normal body function
• Involved in immune function
• Maintains cell growth
• Needed for the visual cycle
• Regulates the expression of various genes and reproduction
SOURCES OF VITAMIN A

CARROT

SWEET POTATOES

SPINACH

BUTTERNUT

YELLOW MAIZE

MANGOES
10 STEPS TO FOOD SAFETY

1. Food must be stored at the proper temperature at all times.
2. Wash raw fruits and vegetables thoroughly before preparation/use.
3. Avoid reheating food many times as heat increases growth of micro-organisms, reheat left over food once only.
4. Dishcloths, kitchen towels to be sanitized at all times.
5. Wash your hands thoroughly before preparing food and after.
6. Store raw food separately from cooked food, food to be covered at all times.
7. Food preparation areas, equipment, utensils, crockery to be cleaned thoroughly before using.
8. Wooden utensils such as chopping boards not to be used except the rolling pin.
9. Left over food should not be stored in the cold room for more than a day.
10. Protect food from insects, rodents, and other animals by ensuring that pest control is practiced every six weeks.
SOUTH AFRICAN FOOD BASED DIETARY GUIDELINES

1. Enjoy a variety of foods
2. Be active
3. Make starchy foods the bases of most meal
4. Eat dry beans, peas, lentils and soya regularly
5. Chicken, fish, meat or eggs can be eaten daily
6. Drink lots of clean, safe water
7. Eat plenty of vegetables and fruit everyday
8. Eat fats sparingly
9. Use salt sparingly
10. If you drink alcohol, drink sensibly
11. Use foods and drinks containing sugar sparingly, and not between meals
Biofortification for Sustainable Food and Nutrition Security

Dr Unathi Kolanisi (Food Security)
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Dr Muthulisi Siwela (Dietetics & Human Nutrition)
siwelam@ukzn.ac.za
Mrs Kate Ndwanwe
INFORMATION DAY 14th AUGUST 2014: EJOZINI SMALLHOLDER FARMERS
Global Estimates of Malnourishment

Agriculture has been largely successful in meeting the energy needs of the world.

Table 1: Global estimates of malnourishment (Hunger) 1960-2013 (Source: HLPE, 2012 and FAO, 2014)

<table>
<thead>
<tr>
<th>Period</th>
<th>No of malnourished (million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1969-71</td>
<td>875</td>
</tr>
<tr>
<td>1979-81</td>
<td>850</td>
</tr>
<tr>
<td>1990-92</td>
<td>848</td>
</tr>
<tr>
<td>1995-97</td>
<td>792</td>
</tr>
<tr>
<td>2000-02</td>
<td>836</td>
</tr>
<tr>
<td>2006-08</td>
<td>850</td>
</tr>
<tr>
<td>2009</td>
<td>1023*</td>
</tr>
<tr>
<td>2010</td>
<td>925*</td>
</tr>
<tr>
<td>2011-2013</td>
<td>842*</td>
</tr>
</tbody>
</table>
Hidden Hunger in Africa

- Micronutrient deficiencies is silent disease across Africa causing:
  - Immature deaths
  - Disabilities (*birth defects, permanent physical & mental impairment*)
  - Reduced work capacity
  - Potential to reduce the gross domestic product (GDP)

- 11 countries in Africa are still iodine deficient
- 20% of maternal mortality is due to iron deficiency
- Vitamin A deficiency is responsible for 40-50% of under-five mortality and morbidity
Food is a human right

- Food and Nutrition Justice - Access to good nutritious food is a fundamental human right which, when denied, is a denial of natural justice (Kremer, 2013)

- The body requires over 40 essential nutrients (vitamins, minerals, amino acids, protein and carbohydrates) to function properly.
## Biofortification to date

<table>
<thead>
<tr>
<th>Schedule of product release, Crop</th>
<th>Nutrient</th>
<th>Countries of first release</th>
<th>Agronomic trait</th>
<th>Release year</th>
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<tr>
<td>Sweetpotato</td>
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<td>Virus resistance, Heat and drought tolerance</td>
<td>2010</td>
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<td>Disease resistance, Drought tolerance</td>
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Multi-Sectoral Holistic Approach

Biofortification is a pro-poor & cost effective intervention that requires:

- Farmers & Consumers
- Soil scientists
- Plant breeders/agronomists
- Food scientists
- Biotechnologists
- Human nutritionists & Health practitioners
- Economists
- Extension officers
- Policy-makers
- Consumer scientists
- Food security experts
- and other relevant stakeholders

• Food security is complex, thus it requires a multi-disciplinary approach.
Vitamin A

• Vitamin A is a fat soluble vitamin.
• Preformed forms (retinoids)- animal products
• Precursor forms (provitamin A carotenoids)- from plants
• Provitamin A carotenoids- α-carotene, β-carotene and β-cryptoxanthin
## Pre and post assessment Questionnaire

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## Sources of Vitamin A

*Table 4: Selected Food Sources of Vitamin A*

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<th>mcg RAE per serving</th>
<th>IU per serving DV*</th>
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<td>28,058 561</td>
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<tr>
<td>Beef liver, pan fried, 3 ounces</td>
<td>6,582</td>
<td>22,175 444</td>
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<tr>
<td>Spinach, frozen, boiled, ½ cup</td>
<td>573</td>
<td>11,458 229</td>
</tr>
<tr>
<td>Carrots, raw, ½ cup</td>
<td>459</td>
<td>9,189 184</td>
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<tr>
<td>Pumpkin pie, commercially prepared, 1 piece</td>
<td>488</td>
<td>3,743 249</td>
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<tr>
<td>Peppers, sweet, red, raw, ½ cup</td>
<td>117</td>
<td>2,332 47</td>
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<tr>
<td>Mangos, raw, 1 whole</td>
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<tr>
<td>Black-eyed peas (cowpeas), boiled, 1 cup</td>
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<tr>
<td>Apricots, dried, sulfured, 10 halves</td>
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<td>1,261 25</td>
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<tr>
<td>Broccoli, boiled, ½ cup</td>
<td>60</td>
<td>1,208 24</td>
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<td>Ready-to-eat cereal, fortified with 10% of the DV for vitamin A, ½–1 cup (more heavily fortified cereals might provide more of the DV)</td>
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<tr>
<td>Milk, fat-free or skim, with added vitamin A and vitamin D, 1 cup</td>
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<td>500 10</td>
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<td>Baked beans, canned, plain or vegetarian, 1 cup</td>
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<td>Egg, hard boiled, 1 large</td>
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<td>Salmon, sockeye, cooked, 3 ounces</td>
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<td>Yogurt, plain, low fat, 1 cup</td>
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<tr>
<td>Tuna, light, canned in oil, drained solids, 3 ounces</td>
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<td>Chicken, breast meat and skin, roasted, ½ breast</td>
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# Sources of Vitamin A

<table>
<thead>
<tr>
<th>Food</th>
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<th>Percent serving DV*</th>
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<td>Ready-to-eat cereal, fortified with 10% of the DV for vitamin A, ½–1 cup</td>
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<td>Chicken, breast meat and skin, roasted, ½ breast</td>
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The role of vitamin A in health

Role of vitamin A in human

• Essential component of metabolism- normal body function
• Involved in immune function
• Maintains cell growth
• Needed for the visual cycle
• Regulates the expression of various genes and reproduction

Sources of vitamin A

• Preformed types: retinol (alcohol), retinal (aldehyde), retinoic acid (acid)
• Found in animal foods: including liver, fish, fish oils, fortified milk and eggs
• Provitamin A types: α-carotene, β-carotene and β-cryptoxanthin
• Found in plant foods: mainly dark green and yellow-orange vegetables and fruits
• Including carrots, spinach, sweet potatoes, broccoli, mangoes, peaches, apricots
Vitamin A deficiency status in Africa

- In Africa, more than 80% of dietary intakes of vitamin A are from plant sources.
- Populations in which the diets are of low quality due to lack of animal foods are more likely to have sub clinical deficiency of vitamin A (serum retinol < 0.7 μmol/l).
- The risk of vitamin A deficiency disorders is greatly increased with low intake of vitamin A during periods such as infancy, childhood, pregnancy and lactation, when requirement for the vitamin increases (WHO 2009).

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Vitamin A deficiency (VAD) in SA

- In SA-major public health problem
  - SAVACG STUDY (1994)
    - 1 in 3 children
  - NFCS-fortification baseline (2005)
    - 2 in 3 children
  - Very recently in 2012 by HSRC: HSRC report (2014)
    - 43.6% and 13.3% of South African children under the age of five years and reproductive women were affected by VAD, respectively.

- Groups at risk
  - Poor and older adults - Alcoholism and liver disorders
  - Severe fat malabsorption - Coeliac disease
  - Chronic diarrhoea - Pancreatic insufficiency
  - Crohn’s disease - Cystic fibrosis
  - AIDS - Premature infants
Appendix E: Pre/post - focus group discussion guide

Warm up questions

1. What thoughts come to your mind when talking about maize?
   a. What nutrients do you expect from maize?
   b. Are there any major differences between yellow and white maize?
   c. 
   d. What food preparation methods do you know for preparing different types of maize?
   e. Production management of different types of maize

Main questions

2. What is the most important thing that comes to mind when choosing any food for purchasing and consumption? *(Rank according to the order of importance)*

3. What is your sensory evaluation of the uphuthu and or cornbread? *(describe the taste, aroma, colour, texture and acceptability)*

4. Do you think biofortified maize is the food for the future?

5. Would you plant and or buy biofortified maize?

6. What food dishes is yellow maize used in/with?

7. What are the benefits of using bio-fortified yellow maize?
Pictorial Smiley Faces

Very bad (1)  Bad (2)  Not sure (3)  Good (4)  Very good (5)

A sensory attribute scale of PVABMP ranging from 0-10.

0 = Extremely bad, 5 = Average, 10 = Extremely good
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