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

NGWANAMOELO KATE NDWANDWE

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Pietermaritzburg

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

Signed: Ndw.N K Date: 14/03/2018

Ngwanamoelo Kate Ndwandwe (Candidate)

Signed: UKolanisi Date: 14/03/2018

Prof Unathi Kolanisi (Supervisor)

Signed: MSiwela Date: 14/03/2018

Prof Muthulisi Siwela (Co-Supervisor)

Signed: Date: 10/04/2018

Dr Rose Mboya (Co-Supervisor)

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.

Signed: Ndw.N K Date: 14/03/2018

Ngwanamoelo Kate Ndwandwe (candidate)

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DEDICATION

This thesis is dedicated to my mother, the late Sarah Mphahlele Lekganyane and my father, the late Masenko Phineus Lekganyane for their love and support. I am also dedicating it to the late Mosebjwadi (Grandmother) and the late Sedupa (Grandfather) Lekganyane, the late Princess Hunadi (Grandmother) and the late Prince Mokgubi Mphahlele (Grandfather). This work is also dedicated to my brothers and sisters for motivating me to study further. Finally, this work is dedicated to my lovely husband Prof Muzi Ndwandwe and our wonderful children Nonjabulo, Nhlakanipho and Matsimela who suffered the discomfort of less attention and love from me for the duration of this study.

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
UNICEF: United Nations International Children's Emergency Fund
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, 2005). 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 biorfortified 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.

1.6.14. **Provitamin A:** a carotenoid that exhibits vitamin A activity (Reboul, 2013).

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

Akhtar, S., Ahmed, A., Randhawa, M. A., Atukorala, S., Arlappa, N. and Ismail, T. Z. (2013). Prevalence of vitamin A deficiency in South Asia: causes, outcomes, and possible remedies. *Journal of Health Population and Nutrition,* 31(4): 413-423

Arigony, A. L. V., de Oliveira, I. M., Machado, M., Bergter, L. and Henriques, P. J. (2013). The influence of micronutrients in cell culture: A reflection on viability and genomic stability. *BioMedical Research International,* 22 Article ID 597282.

Awobusuyi, T. D. (2015). Quality and storage stability of provitamin A biofortified amahewu, a non-alcoholic cereal beverage. Master's degree thesis (Applied Durban University of Technology, Durban, South Africa.

Bailey, R. L., West, K. P and Black, R. E. (2015). The epidemiology of global micronutrient deficiencies. *Annals of Nutrition and Metabolism*, 66 (2): 22-33

Birol, E., Meenakshi, J. V. and Oparinde, A. (2015). Developing country consumers' acceptance of biofortified foods: a synthesis. *Journal of Food Security*, 7: 555

Bouis, H. E., Hotz, C., McClafferty, B., Meenakshi, J. V. and Pfeiffer, W. H. (2011). "Biofortification: A new tool to reduce micronutrient malnutrition." *Food and Nutrition Bulletin,* 32 (1): 31S-40S

Bruins, M. J., Kupka, R., Zimmermann, M. B., Lietz, G., Engle-Stone, R. S. and Kraemer, K. (2016). Maximizing the benefits and minimizing the risks of intervention programs to address micronutrient malnutrition: symposium report. *Journal of Maternal Nutrition*, 12(4): 940-948

Caballero, B. (2003). Original communication, fortification, supplementation, and nutrient balance. *European Journal of Clinical Nutrition*, 57(1): 76-78

Campos-Bowers, M. H. and Wittenmyer, B. F. (2007). Biofortification in China: policy and practice. *Journal of Health Research Policy and Systems*, 5:10

Castenmiller, J. J. M. and West, C. E. (1998). Bioavailability and bioconversion of carotenoids. *Journal of* Annual. Review of Nutrition, 18: 19-38

Cazzonelli, C .I. (2011). Carotenoids in nature: insights from plants and beyond Functional. *Journal of functional Plant Biology*, 38: 833-847

Chen, W. and Chen, G. (2014). The roles of vitamin A in the regulation of carbohydrate, lipid, and protein metabolism. *Journal of Clinical Medicine,* 3(2): 453-479

Christopher, C. I. (2011). Carotenoids in nature: insights from plants and beyond functional. *Journal of Functional Plant Biology,* 38: 833-847

Chumngoen, W. and Tan F. J. (2015). Relationships between descriptive sensory attributes and physicochemical analysis of broiler and Taiwan native chicken breast meat. *Journal of Animal Science.* 28(7): 1028-37

DAFF. (2014). The national policy on food and nutrition security. Pretoria: Government of South Africa.

Darmon, N. and Drewnowski, Adam. (2008). Does social class predict diet quality? 1,2,3, *American Journal of Clinical Nutrition,* 87(5):1107-1117

De Groote, H. and Kimenju, C. S. (2008). Comparing consumer preferences for color and nutritional quality in maize: application of a semi-double-bound logistic model on urban consumers in Kenya. *Journal of Food Policy*, 33: 362-70

De Groote, H. and Kimenju, S. C. (2012). Consumer preferences for maize products in urban Kenya. *Food and Nutrition Bulletin,* 33: 99-110

De Groote, H., Kimenju, S. C. and Morawetz, U. B. (2010). Estimating consumer willingness to pay for food quality with experimental auctions: the case of yellow versus fortified maize meal in Kenya (forthcoming). *Journal of Agricultural Economics*, 42: 1-16

Dhliwayo, T., Palacios-Rojas, N., Crossa, J. and Pixley, K. V. (2014). Effects of S1 recurrent selection for provitamin A carotenoid content for three open-pollinated maize cultivars. *Journal of Crop Science*. 54: 2449-2460

Faber, M. and Laurie, S. M. (2011). A home gardening approach developed in South Africa to address vitamin A deficiency. In Thompson B, Amoroso L, eds. Combating micronutrient deficiencies: food-based approaches. FAO and CABI bookshop, 13: 163-182

Faber, M., Witten, C. and Drimie, S. (2011). Community-based agricultural interventions in the context of food and nutrition security in South Africa. *South African Journal of Clinical Nutrition*. 24(1): 21-30

Faber, M. and Wenhold, F. (2007). Nutrition in contemporary South Africa. *Journal of Water South Africa*, *Special edition*, 33(3): 393-400

Fiedler, J. L., Lividini, K. and Bermudez, O. I. (2015). Estimating the impact of vitamin A-fortified vegetable oil in Bangladesh in the absence of dietary assessment data. *Journal of Public Health Nutrition,* 18(3): 414-20

Gannon, B., Kaliwile, C. and Arscott, S. (2014). Biofortified orange maize is as efficacious as a vitamin A supplement in Zambian children even in the presence of high liver reserves of vitamin A: a community-based, randomized placebo-controlled trial*. American. Journal of Clinical. Nutrition,* 100(6): 1541-50

Gibson, R. (2005). Principles of nutritional assessment, 2nd edition. Oxford University Press, Oxford.

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.

Govender, L., Pillay, K., Derera, J. and Siwela, M. (2014). Acceptance of a complementary food prepared with yellow, provitamin A biofortified maize by black caregivers in rural KwaZulu-Natal. *South African Journal of Clinical Nutrition*, 27(4): 217-221

HarvestPlus. (2010). Disseminating orange-fleshed sweet potato: Findings from a HarvestPlus Project in Mozambique and Uganda, Washington, DC (2010)

HarvestPlus. (2014). International food policy research institute. Biofortification progress briefs.

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

IOM. (2000). Dietary reference intakes for vitamin C, vitamin E, selenium, and carotenoids. (Institute of Medicine), Washington, DC: National Academy Press.

Johns, T. and Eyzaguirre, P. B. (2007). Biofortification, biodiversity and diet: A search for complementary applications against poverty and malnutrition, *Journal of Food Policy*, 32: 1-24

Kearney, J. (2010). Food consumption trends and drivers, *Journal of Philosophical Transactions of the Royal Society of London series B Biological Sciences,* 27(365): 2793-2807

Kerab, M., Douglas, G., Mallewa, M., Jalloh, A. A., Voskuijl, W. P., Groce, N., Gladstone M. and Molyneux, E. (2014) The interaction of malnutrition and neurologic disability in Africa. *Journal of Serminars in Pediatric Neurology*, 21(1): 42-49

Kimenju, S. C. and De Groote, H. (2008). Consumer willingness to pay for genetically modified food in Kenya. *Journal of Agricultural Economics*, 38(1): 35-46

Labadarios, D., Steyn, N., Maunder, E., Macintyre, U., Swart, R., Gericke, G., Huskisson, J., Dannhauser, A., Vorster, H. H. and Nesamvuni, E. A. (2000). The National Food Consumption Survey (NFCS): Children Aged 1-9 Years, South Africa, 1999. Department of Health: Directorate of Nutrition, Pretoria. 1046

Lividini, K. and Fiedler, J. L. (2015). Improving household consumption and expenditure surveys' food consumption metrics. *Journal of Food Policy*, 54: 65-77

Lofti, M., Manar, V., Richard, M. G. and Van den Heuwel, J .H. M. (1999). Micronutrients fortification of foods, developing a program. *Journal of Food Technology in Africa.* 4: 10

Marfo, B., Gonzalez, E .C., Moursi, M., Perez, S., Schwarz, J., Zeller, N. and Asare, D. (2013). Prioritizing countries for biofortification Interventions using country-level data, No 11 HarvestPlus Working Paper | October 2013 N

Wartemann, G., Sağlam, T., and McAvoy, M. (2015). Youth and Performance: Perceptions of the Contemporary Child. Medien und Theater 13, Hildesheim, Zürich, New York: Georg Olms Verlag.

McCann, .J. C. (2005). Africa and the world ecology of maize. In Maize and grace: Africa's encounter with a New World crop, 1500–2000. Cambridge (MA): Harvard University Press, 1-22

Melash, A. A., Mengistu, D. K. and Dereje A. A. (2016) Linking Agriculture with Health through Genetic and Agronomic Biofortification. *Journal of Agricultural Sciences,* 7(5): 295-307

Miller, D. D. and Welch, R. M. (2013). Food system strategies for preventing micronutrient malnutrition. *Journal of Food Policy*, 42: 115-128

Mulualem, T. (2015). Application of bio-fortification through plant breeding to improve the value of staple crops. *Biomedicine and Biotechnology,* 3(1): 11-19

Murdia, L. K., Wadhwani, N., Wadhwani, R., Bajpai, P. and Shekhawat, S**.** (2016). Maize utilization in India: An overview. *American Journal of Food and Nutrition*, 4(6): 169-176

Muzhingi, T., Yeum, K. J., Russell, R. M., Johnson, E. J., Qin, J. and Tang, G. (2008). Determination of carotenoids in yellow maize, the effects of saponification and food preparations. *International Journal for Vitamin Nutrition Research,* 78(3):112-20

Nair, K. M., Augustine, L. F. and Konapur, A. (2015). A food-based intervention to modify diet quality and diversity to address multiple micronutrient deficiency Front Public Health DOI: 10.3389/fpubh.2015.00277

Natalie, J., Nannas, R. and Kelly D. (2015). Genetic and genomic toolbox of Zea mays, *Journal of Genetic,* 199: 655-669

Nestel, P., Howarth, E., Bouis, J., Meenakshi, V. and Feiffer, W. (2006). Biofortification of Staple Food Crops. *Journal of. Nutrition*, 136(4): 1064-1067

Ortiz-Monasterio, I., Palacios-Rojas, N., Meng, E., Pixley, K., Trethowan, R. and Pena R. J. (2007). Enhancing the mineral and vitamin content of wheat and maize through plant breeding. *Journal of Cereal Science,* 46: 293-307

Pillay, K., Derera, J., Siwela, M. and Veldman, F. J. (2011). Consumer acceptance of yellow, provitamin A biofortified maize in KwaZulu-Natal. *South African Journal of Clinical Nutrition,* 24(4):186-191

Pradhan, P., Fischer, G., Van Velthuizen, H., Reusser, D. E. and Kropp, J .P. (2015). Closing yield gaps: How Sustainable Can We Be*? PLoS ONE,* 10: 6

Ravisankar, P., Reddy, A.A., Nagalakshmi, B., Koushik, O.S., B., Kumar, B.V. and Anvith, P. (2015). The Comprehensive Review on Fat Soluble Vitamins. *IOSR Journal Of Pharmacy,* 5(11):12-28

Reboul, E. (2013). Absorption of Vitamin A and Carotenoids by the Enterocyte. *Journal of Focus on Transport Proteins,* 5(9): 3563-3581

Salim, E. R., Ahmed, W. A., Mohamed, M. A., ALSiddig, M. A. and Hamed, S. Y. (2017). Fortified Sorghum as a Potential for Food Security in Rural Areas by Adaptation of Technology and Innovation in Sudan. *Journal of Food Nutrition and Population Health,* 1:1

Shisana, O., Labadarios, D., Rehle, T., Simbayi, L., Zuma, K., Maluleke, T., Mchunu, G., Naidoo, P., Davids, Y .D., Mokomane, Z., Onoya, O. D. and the SANHANES-1 Team.

(2014). South African National Health and Nutrition Examination Survey (SANHANES-1): 2014 Edition. Cape Town: HSRC Press.

Soetan, K. O., Olaiya, C. O. and Oyewole, O. E. (2010). The importance of mineral elements for humans, domestic animals and plants: A review. *African Journal of Food Science*, 4(5): 200-222

Stevens, R. and Winter-Nelson, A. (2008). Consumer acceptance of provitamin A biofortified maize in Maputo, Mozambique. *Journal of Food Policy,* 33(4): 341-351

Stevens, G. A., Bennett, J. E., Hennocq, Q., Lu, Y., De-Regil, L. M., Rogers, L., Danaei, G., Li, G., White, R. A., Flaxman, S. R., Oehrle, S. P., Funucane, M. M., Guerrero, R., Bhutta, Z. A., Then-Paulino, A., Fawzi, W., Black, R. E. and Ezzati, M. (2015). Trends and mortality effects of vitamin A deficiency in children in 138 low-income and middle-income countries between 1991 and 2013: a pooled analysis of population-based surveys. *Journal of The Lancet Global Health,* 3(9): e528-e536

Tanumihardjo, S. A. (2012). Xanthophylls as provitamin A carotenoids. *Journal of Sight and Life*, 26(2): 48-55

Tothova, M. and Meyers, W. H. (2006). Modelling the acceptance of high beta-carotene maize, Annual Meeting, 23-26 July. Long Beach, CA: American Agricultural Economics Association.

Tschirley, D. L and Santos, A. P. (1995). Who eats yellow maize? Preliminary results of a survey of consumer maize preferences in Maputo, Mozambique. International Development Working Paper 53. East Lansing, Mich., U.S.A. Michigan State University.

Tucker, G. (2003). Nutritional enhancement of plants. *Journal of Current Opinion in Biotechnology,* 14: 221-225

UNICEF. (2013). Improving child nutrition: The achievable imperative for global progress. New York.

Vijayan, J., Slaughter, D. C. and Paul, S. R. (2015). Optical properties of maize oil during frying*. Journal of International Food Science and Technoly,* 31: 353-358

Wenhold, F. and Faber, M. (2008). Nutritional status of South Africans: Links to agriculture and water. Water Research Commission Report No TT 362/P/08. Pretoria.

World. Health Report. (2003). Shaping the future. World Health Organization: Geneva.

WHO. (2003). Combating vitamin A deficiency. World Health Organisation, Rome, Italy.

WHO. (2009). Foods derived from modern biotechnology, World Health Organization, Food and Agriculture Organization, Rome.

Zarnowiecki, D. M., Parletta, N. and Dollman, J. (2014). The role of socioeconomic position as a moderator of children's healthy food intake. *Journal of Public Health Nutrition* 112(5): 830-84

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).

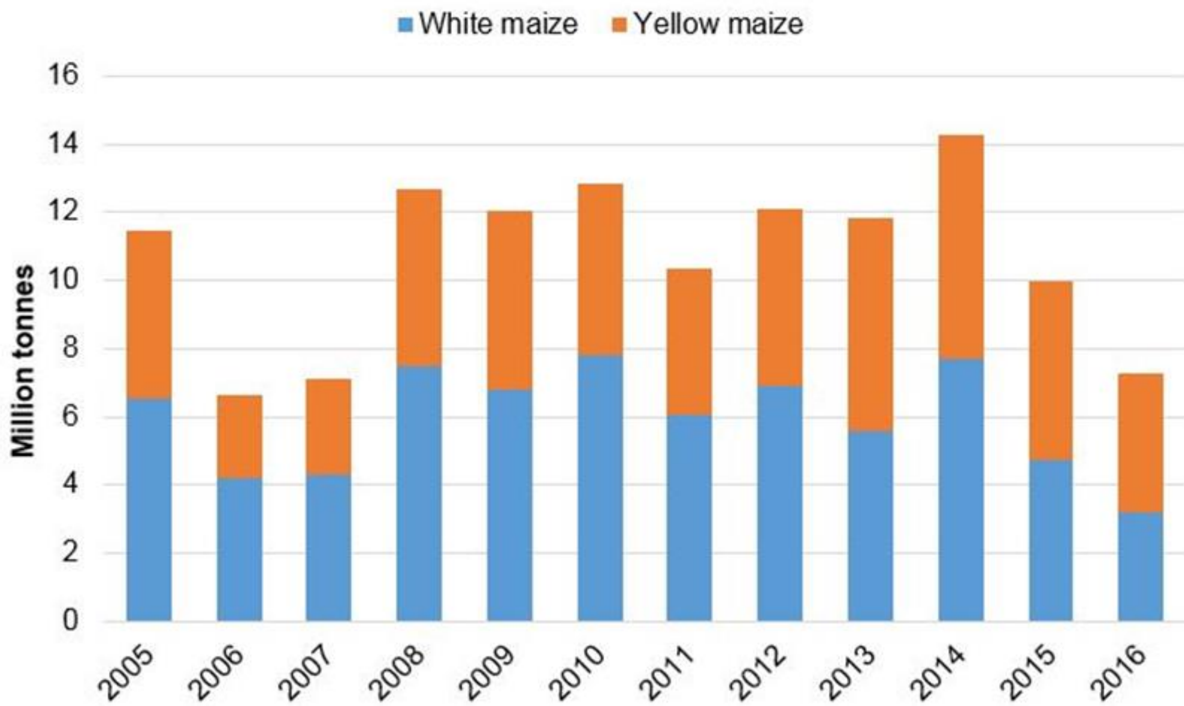
Worldwide production of maize is 785 million tons, with the United States, China, and Brazil being the top three maize-producing countries, producing approximately 563 of the total production of 717 million metric tons/year (Ranum *et al*., 2014 (Table 2.1).

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

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

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).



Source: CEC, South Africa (2017)

Figure 2.1: Maize Production in South Africa. South Africa's Crop Estimates Committee (NCEC) (2005-2016)

2.2.2 Nutritional composition of maize

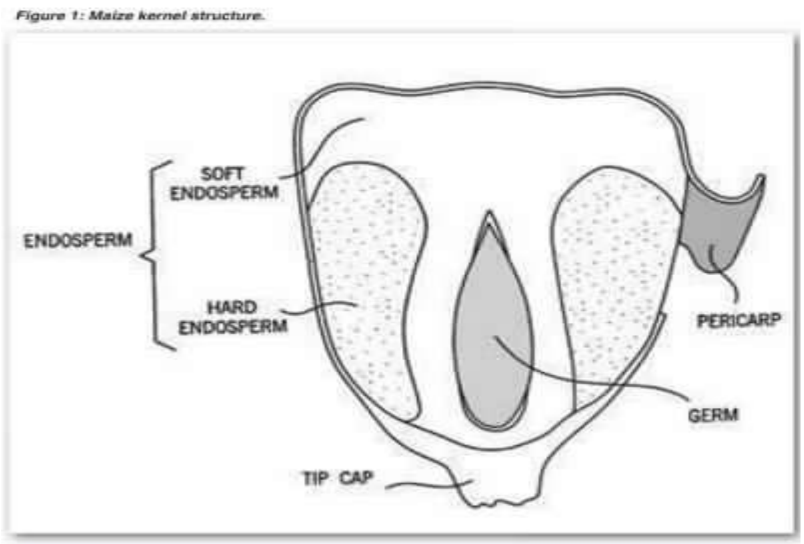
Maize is composed of different minerals and vitamins that improve health in humans, however, it is devoid of nutrition. The composition of the edible portion of maize (dry) is given in Table 2.2 (Gopalan *et al.*, 2007).

Table 2. 2: Composition per 100 g of the edible portion of maize (on dry basis) AICRP on Maize, 2007

Component	Weight
Macronutrients and moisture	
Carbohydrates	66.2 g
Moisture	14.9 g
Protein	11.1 g
Amino acids	1.78 mg
Fat	3.6 g
Fibre	2,7 g
Calories	342 mg
Minerals (1.5 g)	
Phosphorus	348 mg
Sodium	15,9 mg
Sulphur	114 mg
Copper	0.14 mg
Calcium	10 mg
Iron	2.3 mg
Potassium	286 mg
Magnesium	139 mg
Vitamins	
Thiamine	0.42 mg
Carotene	90 µg
Vitamin C.O.	12 mg
Riboflavin	0.10 mg

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).



Source: Jéan du Plessis, 2003.

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).

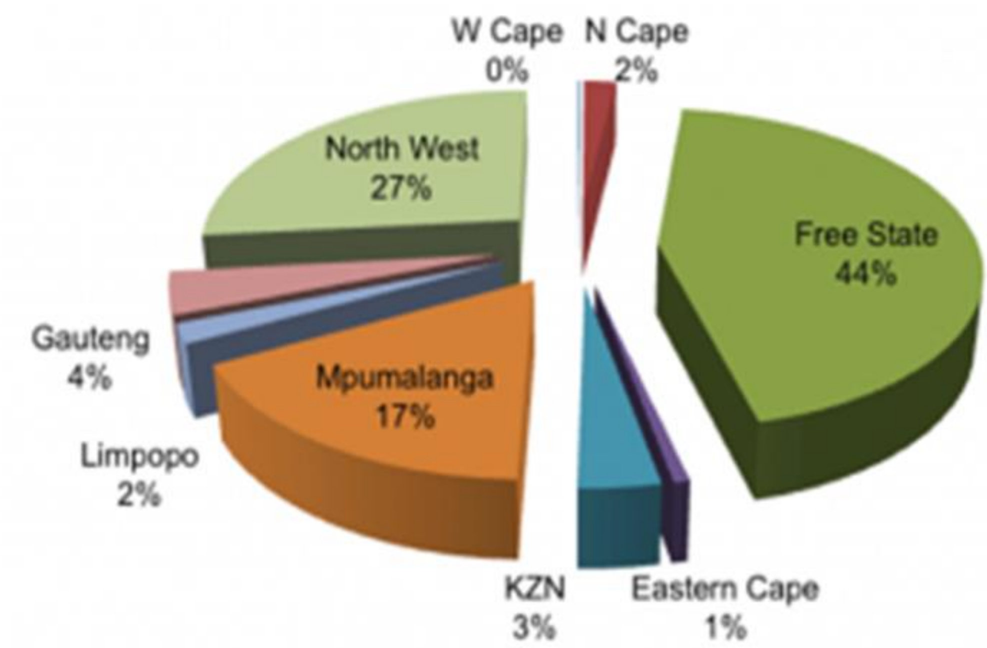
Although maize availability is considered an indicator for food security, heavy reliance on a maize-based diet and/or the consumption of a diet composed solely of maize can lead to malnutrition. The nutritional quality of maize grain is inadequate due to its deficiency in the essential amino acids, lysine, 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)

Maize 1,000Mt	White	Yellow	Total	White	Yellow	Total	White	Yellow	Total
		2013/14			2014/15			2015/16	
Human	4,360	480	4,840	4,200	500	4,700	4,400	500	504,4
Animal	1,470	3,570	5,040	200	4,800	5,000	500	4,500	5000
Other	110	270	380	100	200	300	100	300	4000
TOTAL	**5,940**	**4,320**	**10,260**	**4,500**	**5,500**	**10,000**	**5,000**	**5,300**	**10,300**

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 j*eqe* are popular maize products.

Nutrition interventions such as food fortification, supplimentation, and food deversification 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 45ºC. 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.

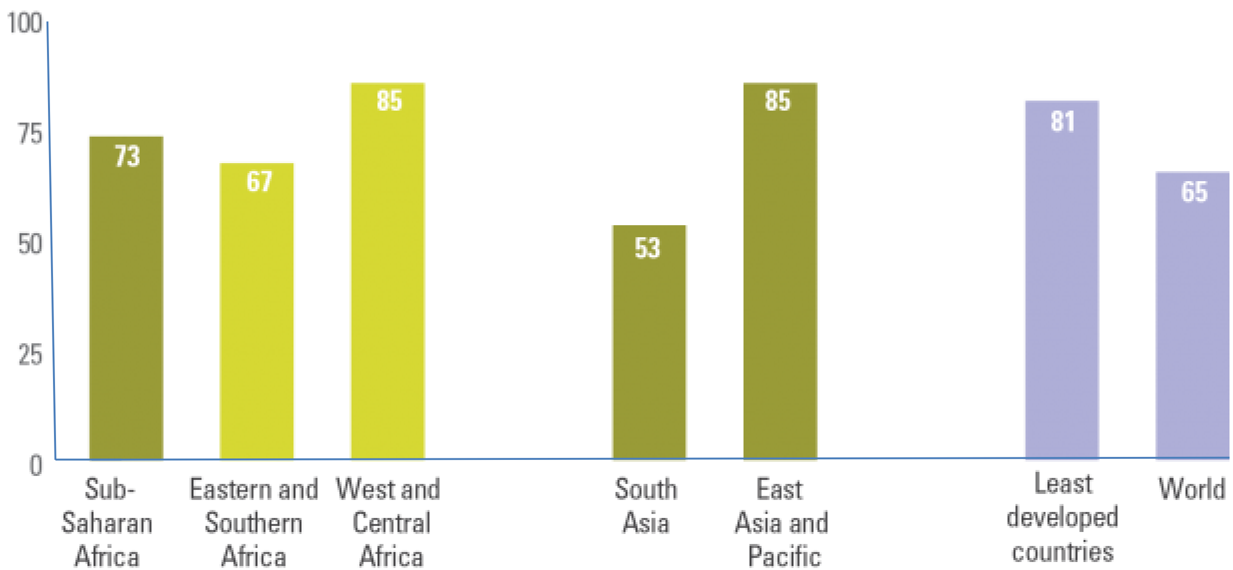


Figure 2. 4: Vitamin A supplementation status (UNICEF, 2015)

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 Immunsation (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

Province	Inadequate vitamin A status (%)	Vitamin A deficiency (%)
Eastern Cape	64.2	8.2
Free State	61.7	11.3
Gauteng	65.2	11.2
KwaZulu-Natal	88.9	44.7
Limpopo	75.7	12.5
Mpumalanga	52.1	4.2
North West	49.6	5.8
Northern Cape	23	3.8
Western Cape	43.5	2.3
South Africa	63.6	13.7

Sources: Labadarios D (ed.) (2007) The National Food Consumption Survey- Fortification Baseline (NFCS-FB)

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 astrategy 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-analye 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):

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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

Abdel-Aal, E.M., Akhtar, H., Zaheer, K. and Ali, R. (2013). Dietary Sources of Lutein and Zeaxanthin Carotenoids and Their Role in Eye Hea. *Journal of Nutrients*, 5(4): 1169-1185

ACC/SCN. (2000) 4th Report on the World Nutrition Situation. Nutrition throughout the Life Cycle. United Nations Administrative Committee on Coordination, Sub-Committee on Nutrition in collaboration with International Food Policy Research Institute (IFPRI): Geneva. 121

Bagozzi, R. P., Zeynep, G. and Priester, J. R. (2002). The Social Psychology of Consumer Behavior, Open University Press, Buckingham, United Kingdom.

Bandura, A. (1999). A social cognitive theory of personality. In L. Pervin & O. John (Ed.), New York: Guilford Publications. *Handbook of personality* 2:154-196

Bell, R. and Meiselman, H. (1995). The role of eating environments in determining food choice. In Marshall, DW. Food choice and the consumer. London. Blackie Academic and Professional. Chapter 12.

Bohn, L., Meyer, A. S. and Rasmussen, S. K. (2008). Phytate: impact on the environment and human nutrition. A challenge for molecular breeding. *Journal of Zhejiang University Society B,* 9:165-91

Bouis, H. E. and Welch, R. M (2010). Biofortification—A Sustainable Agricultural Strategy for Reducing Micronutrient Malnutrition in the Global South. *Journal of Crop Science*, 50: S-20–S-32

Bouis, H. E. (2017). Improving nutrition through biofortification: A review of evidence from HarvestPlus, 2003 through 2016. *Journal of Global Food Security,* 12: 49-58

Britton, G. (1995). Structure and properties of carotenoids in relation to function. *Journal of Faseb*, 9:1551-1558

Buah, S., Mlalazi, B., Khanna, H., Dale, J. L. and Mortimer, C. L. (2016). The quest for golden bananas: investigating carotenoid regulation in a Fe'i group Musa cultivar. *Journal of. Agriculture and. Food Chemistry,* 64: 3176-3185

Bruins, M. J., Kupka, R., Zimmermann, M. B., Lietz, G., Engle-Stone, R. S. and Kraemer, K. (2016). Maximizing the benefits and minimizing the risks of intervention programs to address micronutrient malnutrition: symposium report. *Journal of Maternal Nutrition*, 12(4): 940-948

Carm, E. (2014). Inclusion of indigenous knowledge system (IKS) - A precondition for sustainable development and an integral part of environmental studies. *Journal of Education and Research,* 4(1): 58-76

Charles, H., Godfray-Beddington, J., Crute, I. R and Toulmin, C. (2010). Food Security: The Challenge of Feeding 9 Billion People. *Journal of Science,* 327(5967): 812-8

Choudhary, A. K., Kumar, S., Patil, B. S., Bhat, J. S., Sharma, M., Kemal, S., Ontagodi, T. P., Datta, S., Patil, P., Chaturvedi, S. K., Hegde, R. V. S., Choudhary, Kamannava, P.Y. and Vijayakumar, A. G. (2013). Narrowing yield gaps through genetic improvement for fusarium wilt resistance in three pulse crops of the semi-arid tropics, Sabrao. *Journal of Breeding and Genetics,* 45(3): 341-370

Combs, G. F. (2012). Fundamental Aspects in Nutrition and Health, Ed 4. Academic Press, New York, NY. *Journal of Vitamin A*, 93-138

Dary, O and Mora, J. O. (2002). Food fortification to reduce vitamin A deficiency: international vitamin A consultative group recommendations. *Journal of Nutrition*, 132(9): 2927S-2933S

De Groote, H., Kimenju, S. C. and Morawetz, U. B. (2011). Estimating consumer willingness to pay for food quality with experimental auctions: the case of yellow versus fortified maize meal in Kenya. *Journal of Agriculture and Economics,* 42: 1-16

Demissie, T., Ali, A., Mekonen, Y.,Haider, J. and Umeta, M. (2010). Magnitude and distribution of vitamin A deficiency in Ethiopian food and Nutrition Bulletin, 31, 2

Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J. and Willingham, D. T. (2013). Improving students' learning with effective learning techniques: promising directions from cognitive and educational psychology. *Journal of Psychological science in the public interest*, 14(1): 4-58

Eubanks, M. W. (1997b). Molecular analysis of crosses between Tripsacum dactyloides and Zea diploperennis (Poaceae). *Journal of Theoratical and Applied Genetics,* 94: 707-712

Fang, E., Palmatier R. W. and Steenkamp, J. B. (2008) Effect of service transition strategies on firm value. *Journal of Marketing*, 72(4): 1-14

FAO., IFAD., UNICEF., WFP. and WHO. (2017). The State of Food Security and Nutrition in the World 2017. *Building resilience for peace and food security*. Rome, FAO.

Flynn, L. R. and Goldsmith, R. E. (2016). Introducing the super consumer. Journal of Consumer Behaviour. *Journal of. Consumer Behaviour,* 15: 201-207

Frelat, R., Lopez-Ridaura, S., Giller, K. E., Herrero, M., Douxchamps, S., Djurfeldt, A. A., Erenstein, O., Henderson, B., Kassie, M., Paul, B. K., Rigolot, C., Ritzema, R. S., Rodriguez, D., Van Asten, P.J., and Van Wijk, M. T. (2016). Drivers of household food availability in sub-Saharan Africa based on big data from small farms. *Proceedings of the National Academy of Sciences of the United States of America,* 113(2): 458-463

Foxall, G. R. and Goldsmith, R. E. (1994). Consumer psychology for marketing. Routledge. London.

Friedma, D. S. (2014) . Racial Variations in Causes of Vision Loss in Nursing Homes. *Archives of Ophthalmology,*1099 -1024 (7): 122 ;2004

Galinat, W .C. (1988). The origin of maize. In Sprague, G.F. and Dudley, J.W. Eds. Maize and maize improvement. Agronomy Monographs. American Society of Agronomy: Madison. Wisconsin. 18: 1-31

Gannon, B., Kaliwile, C., Arscott S. A., Schmaelzle, S., Chileshe, J., Kalungwana, M., Mosonda, N., Pixley, K. S. C. (2014). Biofortified orange maize is as efficacious as a vitamin A supplement in Zambian children even in the presence of high liver reserves of vitamin A: a community-based, randomized placebo-controlled trial. *American Journal of Clinical Nutritio,* 100(6): 1541-1550

Garcia-Casal, M. N., Layrisse, M., Solano, L., Baron, M. A., Arguello, F., Llovera, D., Ramirez, J., Leets, I. and Tropper, E. (1998). Vitamin A and beta-carotene can improve nonheme iron absorption from rice, wheat and maize by humans. *Journal of Nutrition,* 128: 646-650

Girum, A., Menkir, A., Gedil, M. and Spillane, C. (2013. Marker-trait association analysis of functional gene markers for provitamin A levels across diverse tropical yellow maize inbred lines. *Journal of Biomedical Central Plant Biology,* 13(1): 227

Goff, S. A and Klee, H. J. (2006). Plant volatile compounds: sensory cues for health and nutritional value. *Journal of Science.* 311: 815-819

Gopalan, C., Sastri, R. B. V and Balasubramanian, S. (2007). Nutritive Value of Indian Foods, published by National Institute of Nutrition (NIN), ICMR.

Govender, L., Pillay, K., Derera, J., Siwela, M. 2014). Acceptance of a complementary food prepared with yellow, provitamin A-biofortified maize by black caregivers in rural KwaZulu-Natal South African *Journal of Clinical Nutrition*, 27(4): 217-221

Grune, I., Lietz, G., Palou., A. Catharine, R., Stahl, W., Tang, G., Thurnham, D., Yin, S. and Biesalski, H. K. (2010). B-Carotene Is an Important Vitamin A Source for Humans. *Journal of Nutrition,* 140(12): 2268S-2285S

HarvestPlus. (2010). Disseminating Orange-fleshed Sweet Potato: Findings from a HarvestPlus Project in Mozambique and Uganda, Washington, DC (2010).

Hambidge, K. M. (2010) Micronutrient bioavailability: Dietary Reference Intakes and a future perspective. *American Journal of Clinical Nutrition,* 91(5): 1430S-1432S

Hefferon, K. L. (2015). Nutritionally Enhanced Food Crops; Progress and Perspectives International. *Journal of. Molecular. Science,* 16: 3895-3914

Hurrell, R. F., Reddy, M. B., Juillerat, M. and Cook, J. D. (2003). Degradation of phytic acid in cereal porridges improves iron absorption by human subjects. *American. Journal of. Clinical*. *Nutrition,* 77: 1213-1219

Jaliya, M. M., Sani, B. M., Sani, Y. A., Babaji, B. A. and Zongoma, A. M. (2016). Effect of nitrogen and sulfur nutrient ratios on the levels of protein content in maize grains. *Sky Journal of Agricultural Research, 5*(2): 029-033

Jerome-Morais, A., Diamond, A. M. and Wright, M .E. (2011). Dietary supplements and human health: For better or for worse*? Journal of Molecular. Nutrition. Food Research,* 55: 122-135

Johnson, L. A. (2000). Maize: The Major Cereals of the Americas, 2nd ed. In: Kulp K, Ponte J.G, eds. Handbook of Cereal Science and Technology. New York: Marcel Dekker.

Kansaki, J. K. (2015). Assessment of postharvest losses of maize in the Sissala East and West districts of the upper west region of Ghana. Thesis

Kapil, U. and Sachdev, H. P. S. (2013). Massive dose vitamin A programme in India - Need for a targeted approach. *Indian Journal of Medical Research*. 138(3): 411-417

Kauppi, S. (2015). Behaviour change and communication: - a descriptive literature review of behaviour change and communication in Sub-Saharan countries. Master's Degree in Global Health Care. Degree: Master of Health Care. Diaconia University of Applied Sciences.

Kolanisi, U. (2010). *Consumer attitudes towards rural water provision and learning strategies to enhance community participation: The case study of Madibogo, North-West Province.* Unpublished Master's dissertation, North-West University, Potchefstroom, South Africa.

Kaya, H. (2014). The road ahead: Multicultural adult education. *International Journal of Humanities and Social Sciences*, 48 (1): 164

Khabanyane, K. E., Maimane, J. R., Ramabenyane, M. J. (2014). A Critical Reflection on Transformative Learning as Experienced by Student-Teachers during School-Based Learning. *Mediterranean Journal of Social Sciences,* 5(27): 1

Khoo H. E., Prasad, K. N., Kong K. W., Jiang, Y., Ismail., A. (2011). Carotenoids and their isomers: colour pigments in fruits and vegetables. *Journal of Molecules*, 16:1710-1738

Krinsky, N. I. (2003). Carotenoids and oxidative stress. In: Cutler, R.G., Rodriguez, H. (Eds.), Oxidative Stress and Aging: Advances in Basic Science, Diagnostics, and Intervention. World Scientific Publishing Co., New York, 598-611

Krondl, M and Coleman, M. S. (1988). The role of food perceptions in food use. *Journal of Current concepts in nutrition,* 16: 53-58

Lagerkvist, C. J., Okello, J., Muoki, P., Heck, S., Prain, G. (2016). Nutrition promotion messages: The effect of information on consumer sensory expectations, experiences and emotions of vitamin A-biofortified sweet potato. *Journal of Food quality and preference*, 52: 143-152

Lividini, K. and Fiedler, J. L. (2015). Assessing the promise of biofortification: A case study of high provitamin A maize in Zambia. *Journal of Food Policy,* 54: 65-77

Labadarios, D., Moedie, I. M. and Van Rensburg, A. (2007). Selected micronutrient status: Vitamin A. in Labadarios, D. (Ed) National food consumption Survey-Fortification Baseline (NFCS-FB): South Africa, 2005. Directorate Nutrition, Department of health, Stellenbosch, South Africa. 409-446

Layrisse, M., Garcia-Casal, M. N., Solano, L., Baron, M. A., Arguello, F., Llovera, D., Ramirez, J., Leets, I. and Tropper, E. (2000). A new property of vitamin a and beta-carotene on human iron absorption: Effect on phytate and polyphenols as inhibitors of iron absorption. *Archivos Latinoamericanos de Nutrition*, 50(3): 243-248

Lazarova, R. and Athanasios, K. (2010). Consumer’s perception of food quality and its relation to the choice of food. Master’s thesis, Department of marketing and statistics. Handelshøjskolen. Aarhus Universitet.

Lott, J. N. A., Ockenden, I., Raboy, V. and Batten, G. D. (2000). Phytic acid and phosphorus in crop seeds and fruits: a global estimate. *Journal of Seed Science Research*, 10: 11-33

Mann, K. V. (2011). Theoretical perspectives in medical education: Past experience and future possibilities. *Journal of Medical Education*, 45: 60-68

McNamara, M. S. (2005). Knowing and doing phenomenology: The implications of the critique of 'nursing phenomenology' for a phenomenological inquiry: a discussion paper. *International Nursing Journal of Studies.* 42 (6): 695-704

McCrickerd, K., Forde, C. G. (2016). Sensory influences on food intake control: moving beyond palatability. *Journal of Etiology and Pathophysiology*, 17(1) 18-29

Maunder, E. M. W., Matji, J. and Hlatshwayo-Molea, T. (2001). Enjoy a variety of foods-Difficult but necessary in developing countries. Supplement. *South. African. Journal of. Clinical. Nutrition,* 14(3): S7-S11

Meenakshi, J. V., Johnson, N. L., Manyong, V. M., DeGroote, H. and Javelosa, J. (2010). How cost-effective is biofortification in combating micronutrient malnutrition? An Ex-ante Assessment. *Journal of World Developmen,* 38: 64-75

Merrill, W. L., Hard, R. J., Mabry, J. B., Fritz, G. J., Adams, K. R., Roney, J. R., and MacWilliams, A. C. (2009) The diffusion of maize to the southwestern United States and its impact. *Proceedings of Natlonal Academy of Sciences of United States of America*, 106(50): 21019-21026

Mesgarani, M. and Shafiee, S. (2016). Advanced biotechnology reseach. International Jou*rnal of Advanced Biotechnology and Research*, 7(3): 172-183

Mezirow, J. (2012). Learning to think like an adult: Core concepts of transformation theory. In Taylor, E. W., Cranton, P., and Associates, San Francisco, CA: Jossey-Bass. *The Handbook of Transformative Learning: Theory, Research, and Practice*, 73-95

Mbabazi, J., Bah, M. E. M. and Verdier-Chouchane, A. (2015). Transforming Africa's agriculture to improve competitiveness. http://reports.weforum.org/africa-competitiveness-report-2015/chapter-2-1-transforming-africas-agriculture-to-improve-competitiveness/

Moise, A. R., Al-Babili, S. and Wurtzel, E. T. (2014). Mechanistic aspects of carotenoid biosynthesis. *Journal of Chemical review*, 114: 164-93

Murdia, L. K., Wadhwani, N., Wadhwani, R., Bajpai, P. and Shekhawat, S. (2016). Maize Utilization in India: An Overview. *American Journal of Food and Nutrition*, 4(6): 169-176

Muzhingi, T., Langyintuo, A. S., Malaba, L. C. and Banziger, M. (2008). Consumer acceptability of yellow maize products in Zimbabwe. *Journal of Food Policy*, 33: 352-61

Nadzri, W. N. M., Musa, R., Muda, M. and Hassan, F. (2016). The Antecedents of Brand Experience within the National Automotive Industry, *Journal of Procedia Economics and Finance,* 37: 317-323

Nestel, P., Bouis, H. E., Meenakshi, J. V. and Pfeiffer, W. (2006). Biofortification of staple food crops. *Journal of. Nutrition,* 136: 1064-1067

Nordtest, T. (2002). Acoustics: Human sound perception-guidelines for listening tests. [Www document 1519-00/2].www.nordtest.org

Nuss, E. T. and Tanumihardjo, S. A. (2011). "Quality Protein Maize for Africa: Closing the Protein Inadequacy Gap in Vulnerable Populations*." Advances in Nutrition Journal,* 2: 217-224

Obel-lawson, E. (2006). The efficacy of awareness campaigns by the African leafy vegetables projects on nutrition behaviour change among the Kenyan urban population: the case of Nairobi. M.S. thesis, University of Nairobi, Kenya.

Ogbebor, O. (2011). The value of indigenous knowledge system based on literature review.osarome.blogspot.com/2011/12/write-on-value-of-indigenous-knowledge.html

Oluwalana, I. B. (2014). Comparative effects of sprouting on proximate, mineral composition and functional properties of white and yellow sweet maize (*Zea mays var Saccharata*). *Journal of Emerging Trends in Engineering and Applied Sciences,* 5 (7): 111-115

Oriade, A. D. (2013). An empirical investigation of the relationship between perceived quality, value, satisfaction and behavioural intentions among visitors to UK attractions, PhD thesis, University of Salford.

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

Padulosi, S., Meldrum, G. and Gullotta, G. (2016). Agricultural biodiversity to manage the risks and empower the poor. Proceedings of the International Conference 27-29 April 2015, Rome, Italy. Bioversity International, Rome, Italy.

Pillay, K., Derera, J., Siwela, M. and Veldman, F. J. (2011). Consumer acceptance of yellow provitamin A-bio-fortified maize in KwaZulu-Natal. *South African Journal of Clinical Nutrition,* 2 (4): 186-191

Purseglove, J. W. (1972). Tropical Crops: Monocotyledons 1. Longman Group Limited, London.

Raboy, V. (2003). Myoinositol-1, 2, 3,4,5,6 hexakisphosphate. *Journal of Phytochemistry,* 64: 1033-43

Radu, A., Urechean, V., Naidin, C. and Motorga, V. (1997). The theoretical significance of a mutant in the phylogeny of the species Zea mays L. *Maize Newsletter*. 71: 77-78

Ramakrishman, U. (2002). Prevalence of micronutrients malnutrition worldwide. *Nutrition Review Journal*, 60 (5pt2): 546-552

Ranum, P., Peña-Rosas, J. P. and Garcia-Casal, M. N. (2014). Global maize production, utilization, and consumption. *Annals of the New York Academy of Sciences*, 1312: 105-112

Ranum, P. (2014) Technical Considerations for Maize Flour and Maize Meal Fortification in Public Health. *African journal of plant science,* 1312:105-112

Ravisankar, P., Reddy, A. A., Nagalakshmi, B., Koushik, O.S., Kumar, B.V., Anvith, P. S. The Comprehensive Review on Fat-Soluble Vitamins. *International Organisation of Science Research Journal of Pharmacy*, 5(11): 12-28

Reboul, E. (2013). Absorption of Vitamin A and Carotenoids by the Enterocyte: Focus on Transport Proteins. *Journal of Nutrients*, 12(5): 9

Revy, P. S., Jondreville, C., Dourmad, J. Y. and Nys, Y. (2006). Assessment of dietary zinc requirement of weaned piglets fed diets with or without microbial phytase. *Journal of Animal Physiology and Animal Nutrition,* 90(1-2): 50-59

Rowe, L. A. and Dodson, D. M. (2012). A knowledge-to-action approach to food fortification: Guiding principles for the design of fortification programs as a means of effectively addressing micronutrient malnutrition. *Health,* 4(10): 904-909

Samaniego-Vaesken, M., Alonso-Aperte, E. and Varela-Moreiras, G. (2012). Vitamin food fortification today. *Journal of Food and Nutrion Research*, 56

Schiffman, L. G and Kanuk, L L. (2010). Consumer Behavior. 10th ed. Upper Saddle River, New Jersey: Prentice Hall.

Schiffman, L. G. and Kanuk, L. L. (1991). Consumer behaviour. Fourth Edition. Englewood Cliffs, New Jersey: Prentice-Hall International, Inc.

Schwarz, N., and Xu, J. (2011) Why don't we learn from poor choices? The consistency of expectation, choice, and memory clouds the lessons of experience. *Journal of Consumer Psychology*, doi:10.1016/j.jcps.2011.02.006.

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

Schlitz, M. M., Vieten, C. and Miller, E. M. (2010). Worldview Transformation and the Development of Social Consciousness. *Journal of Consciousness Studies*, 17(7-8): 18-36

Sokrab, A. M., Mohamed Ahmed, I. A., Babiker, E. E. (2014). Effect of fermentation on antinutrients, and total and extractable minerals of high and low phytate corn genotypes. *Journal of Food Science and Technology*, 51(10): 2608-2615

Simpungwe, E.; Dhliwayo, T.; Palenberg, M.; Taleon, V.; Birol, E.; Oparinde, A.; Saltzman, A.; and Diressie, M.T. (2017). Orange maize in Zambia: crop development and delivery experience. *African Journal of. Food and Agriciculture, Nutrition.and Development*, 17(2): 11973-11999

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

Sniffen, C.J. and Robinson, P. H. (1987). Symposium: Protein and fiber digestion, passage, and utilization in lactating cows*. Journal of. Dairy Science,* 70: 425-441

Stahl, W. and Sies, H. (2005). Bioactivity and protective effects of natural carotenoids. *Journal of Biochemical Biophysical Acta,* 1740:101-7

Stone, H. and Sidel, J. (1993). Sensory evaluation practices. California: Academic Press.

Starr, L., (2017). *Theory of Change: Facilitator's Guide*. Washington, DC: TANGO International and the Technical and Operational Performance Support (TOPS) Program.

Tanumihardjo, S. A., Bouis, H., Hotz, C., Meenakshi, J. V. and McClafferty, B. (2008). Biofortification of staple crops: an emerging strategy to combat hidden hunger. On “Food Technology for Better Nutrition.” Comp. *Rev. Food Sci*. *Safety.* 7: 329-334

Tripathi, K. K., Warrier, R., Govila, O. P. and Ahuja, V. (2011). “Biology of Zea mays (Maize)”. Department of Biotechnology, Ministry of Science and Technology and Ministry of Environment and Forests, Government of India. 2011

Troesch, B., Egli, I., Zeder, C., Hurrell, R. F., de Pee, S. and Zimmermann, M. B. (2009). Optimization of a phytase-containing micronutrient powder with low amounts of highly bioavailable iron for the in-home fortification of complementary foods *Am. J. Clin. Nutr*, 89: 539-544

Taylor, E. W. and Cranton, P. (2013). A theory in progress? Issues in transformative learning theory. *European journal for Research on the Education and Learning of Adults* 4 (2013): 1, S. 33-47

UNICEF. 2007. Vitamin A Supplementation: A decade of progress.

UNICEF. (2015). The State of the world’s children, United Nations children’s fund. New York.

Veale, R. (2007). Investigating the simultaneous influence of intrinsic and extrinsic cues: an examination of the interaction between country of origin, price and selected sensory variables.Retrieved72012.http://digital.library.adelaide.edu.au/dspace/bitstream/2440/38837/2/02/whole.pdf

Verheye, W. (2010). Soils, plant growth and crop production. Growth and production of maize: Traditional low input cultivation. UNESCO-EOLSS. 11

Watson, L. and Dallwitz, M. J. (1992). Grass Genera of the World: Descriptions, Illustrations, Identification, and Information Retrieval; including Synonyms, Morphology, Anatomy, Physiology, Phytochemistry, Cytology, Classification, Pathogens, World and Local Distribution, and References. Version: 18th August 1999.

Wesley, A. and Ranum, P. (2004). Fortification Handbook: Vitamin and mineral fortification of wheat flour and maize "micronutrients initiative". Ottawa. Available online: http://www.miconutrients.ord/resources/publicatios/fort-handbook.pdf.

Whitney, E. N. and Rolfes, S. R. (1999). Understanding Nutrition. 8th edition. Belmont. West/Wardsworth.

WHO. (2011). *Guideline: Vitamin A supplementation in infants and children 6–59 months of age*. Geneva, World Health Organization, 2011

WHO. (2012). National vitamin a supplementation policy guidelines for South Africa 2012.

WHO. (2012).Complementary feeding. http://whqlibdoc.who.int/publications/2002/924154614x.pdf (accessed on 01/03/2012).

WHO. (2014). Making fair choices on the path to universal health coverage, Final report of the WHO Consultative Group on Equity and Universal Health Coverage.

Young, A. J. and Lowe, G. L. (2018) Carotenoids-Antioxidant Properties. *Antioxidants* 7: 28

CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY

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 km^2.This study was conducted in two communities, Ongoye (KwaMkhwanazi) and KwaMbonambi. KwaMbonambi has an 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.

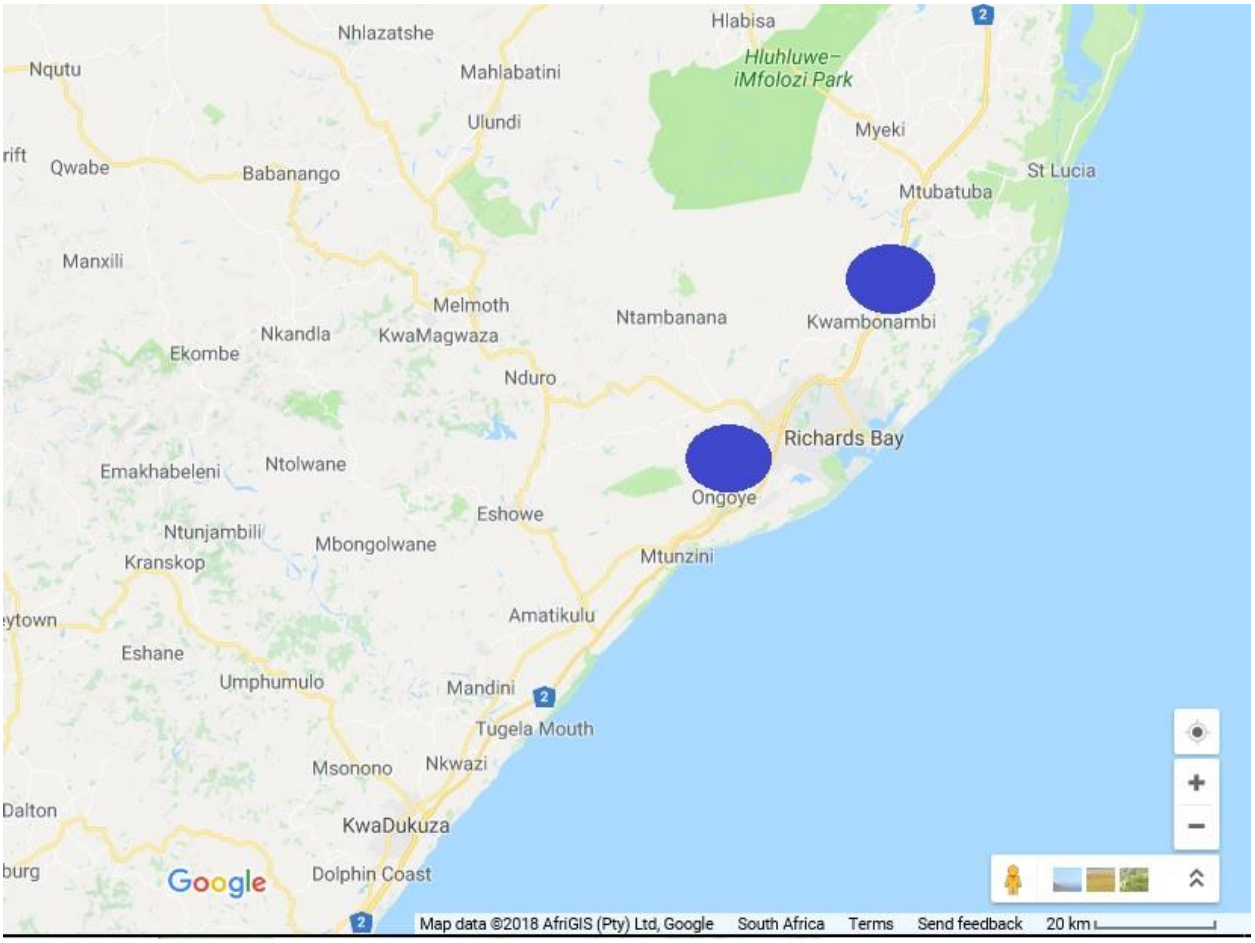


Figure 3.1: Map of Uthungulu District Municipality-Demarcation Boundaries (IDP, 2014).

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).

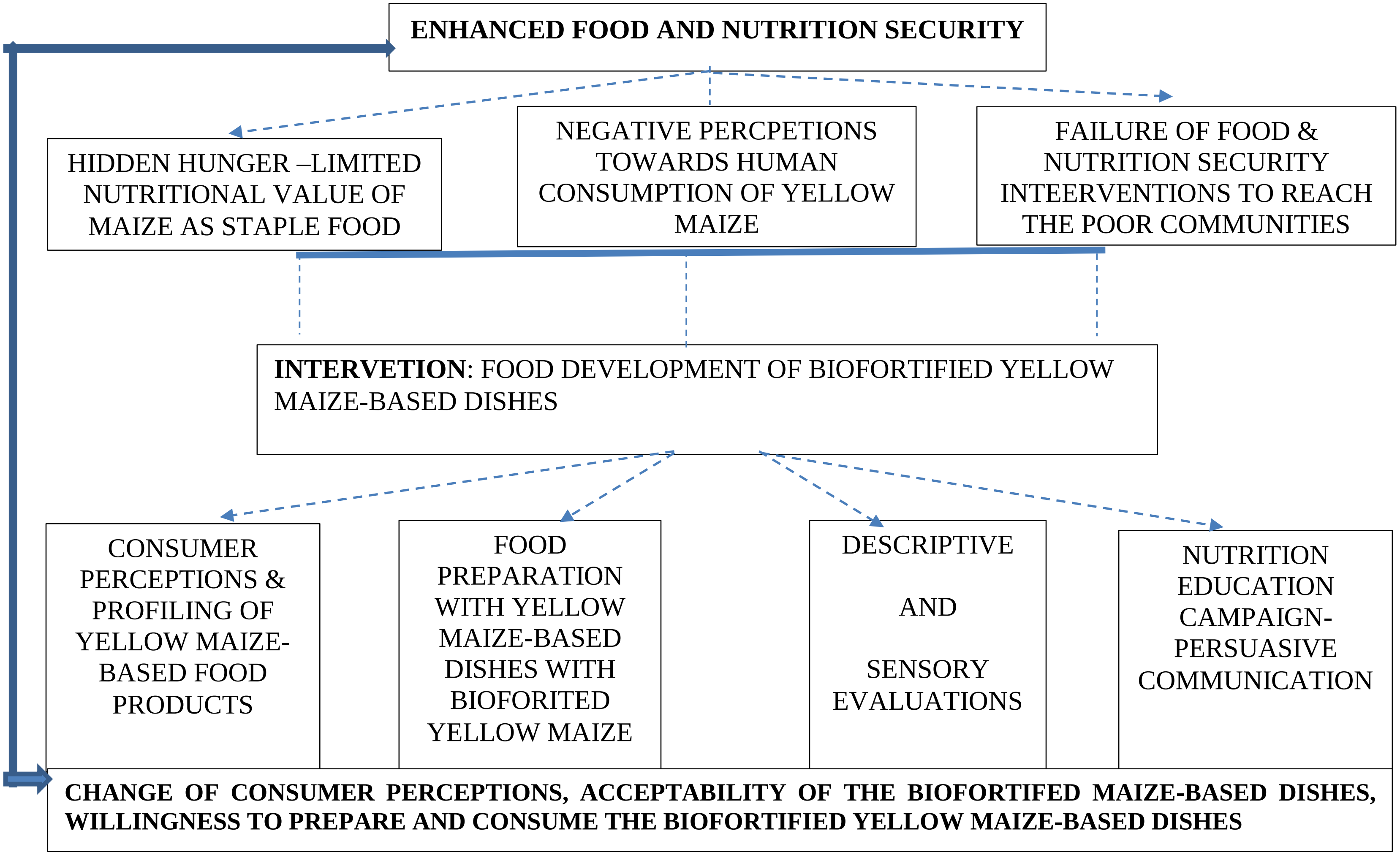


Figure 3.2: The conceptual framework for consumer acceptability of biofortified yellow maize.

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

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

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

Govender, L., Pillay., K., Derera., J. and Siwela. M. (2014). Acceptance of a complementary food prepared with yellow, provitamin A biofortified maize by black caregivers in rural KwaZulu-Natal. South African Journal of Clinical Nutrition, 27(4): 217-221

HarvestPlus. (2014). International food policy research institute. Biofortification progress briefs.

Govender, L., Pillay, K., Derera, J. and Siwela, M. (2014). Acceptance of a complementary food prepared with yellow, provitamin A-biofortified maize by black caregivers in rural KwaZulu-Natal. South African Journal of Clinical Nutrition, 27(4) 217-221

Pillay, K., Derera, J., Siwela, M. and Veldman, F. J. (2011). Consumer acceptance of yellow provitamin A-bio-fortified maize in KwaZulu-Natal. South African Journal of Clinical Nutrition, 2(4): 186-191

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 todeveloping (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.

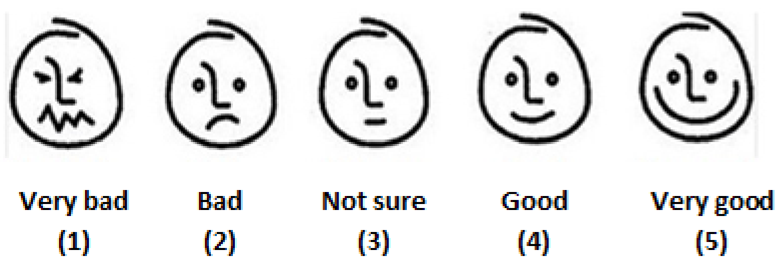


Figure 4.1: Pictorial smiley faces used for sensory evaluation

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, p*huthu* 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 temperatue 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^{0}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^{0}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

Age group	Percentage (%)
18 -20 years	1.5
21 – 29 years	13.2
30 – 39 years	22.1
40 – 49 years	16.2
50 – 59 years	30.9
60 – 69 years	11.8
70 – 79 years	2.9
80 – 89 years	1.5

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)

	WHITE *PHUTHU*					**BIOFORTIFIED YELLOW *PHUTHU***				
Age	***Very Bad (%)**	**Bad (%)**	**Not sure (%)**	**Good (%)**	**Very Good (%)**	**Very Bad (%)**	**Bad (%)**	**Not sure (%)**	**Good (%)**	**Very Good (%)**
18-20	**0.0**	**0.0**	**0.0**	**0.0**	**1.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.5**
21-29	**0.0**	**0.0**	**0.0**	**4.4**	**9.0**	**1.5**	**1.5**	**2.9**	**2.9**	**4.4**
30-39	**2.9**	**1.5**	**0.0**	**2.9**	**15.0**	**5.9**	**2.9**	**2.9**	**0.0**	**10.3**
40-49	**0.0**	**0.0**	**2.9**	**2.9**	**10.0**	**1.5**	**1.5**	**2.9**	**2.9**	**7.4**
50-59	**1.5**	**1.5**	**0.0**	**2.9**	**25.0**	**1.5**	**1.5**	**4.4**	**10.3**	**13.2**
60-69	**1.5**	**1.5**	**0.0**	**2.9**	**6.0**	**0.0**	**2.9**	**0.0**	**7.4**	**1.5**
70-79	**0.0**	**0.0**	**0.0**	**0.0**	**3.0**	**0.0**	**1.5**	**0.0**	**0.0**	**1.5**
80-89	**1.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.5**
TOTAL	**7.4**	**4.5**	**2.9**	**16.0**	**69.0**	**10.4**	**11.8**	**13.1**	**23.5**	**41.3**

*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 j*eqe* according to consumer age (n = 68)

	WHITE *PHUTHU*					BIOFORTIFIED YELLOW *PHUTHU*				
Age Groups	*Very Bad (%)	Bad (%)	Neutral (%)	Good (%)	Very Good (%)	Very Bad (%)	Bad (%)	Neutral (%)	Good (%)	Very Good (%)
18-20	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	1.5	0.0
21-29	2.9	0.0	5.9	2.9	1.5	2.9	0.0	1.5	7.4	1.5
30-39	2.9	0.0	4.4	7.4	7.4	2.9	0.0	2.9	5.9	10.3
40-49	1.5	1.5	5.9	4.4	2.9	0.0	0.0	1.5	5.9	8.8
50-59	2.9	2.9	5.9	8.8	10.3	5.9	0.0	2.9	5.9	16.2
60-69	1.5	4.4	1.5	2.9	1.5	1.5	0.0	0.0	4.4	5.9
70-79	0.0	1.5	0.0	0.0	1.5	0.0	0.0	0.0	0.0	2.9
80-89	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	1.5
TOTAL	11.7	10.3	23.6	26.4	28.1	13.2	0.0	8.8	31.0	47.1

*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)

	White *phuthu*				**Biofortified Yellow *phuthu***			
Rating*	**Aroma**	**Appearance**	**Texture**	**Flavour**	**Aroma**	**Appearance**	**Texture**	**Flavour**
1	**2.9**	**5.9**	**4.4**	**8.8**	**14.7**	**10.3**	**14.7**	**10.3**
2	**4.4**	**2.9**	**4.4**	**1.5**	**11.8**	**8.8**	**10.3**	**16.2**
3	**16.2**	**11.8**	**8.8**	**2.9**	**14.7**	**18.2**	**13.2**	**14.7**
4	**30.9**	**26.5**	**26.5**	**26.5**	**35.3**	**32.4**	**27.9**	**26.5**
5	**45.6**	**52.9**	**55.9**	**60.3**	**23.5**	**35.3**	**33.8**	**32.4**

*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)

Type of *phuthu* Ratings	**White *Phuthu* Respondents (%)**	**Biofortified Yellow *Phuthu* Respondents (%)**
1	11.8	16.2
2	2.9	10.3
3	0.0	7.4
4	14.7	27.9
5	**70.6**	**38.2**

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)

Ratings	White steamed Bread (*jeqe*) Respondents (%)	Biofortified Yellow steamed Bread (*jeqe*) Respondents (%)
1	13.2	17.6
2	7.4	4.4
3	20.6	7.4
4	29.4	26.5
5	29.4	44.1

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)

Panellists who found white *Jeqe* acceptable				Panellists who found biofortified yellow *Jeqe* acceptable			
Aroma (%)	Appearance (%)	Texture (%)	Flavour (%)	Aroma (%)	Appearance (%)	Texture (%)	Flavour (%)
6.0	4.5	13.4	11.9	10.11	11.9	13.4	13.4
13.4	13.4	9.0	16.4	11.9	6.0	7.5	9.0
19.4	16.4	22.4	14.9	22.4	10.4	16.4	13.4
37.3	35.8	29.9	31.3	23.9	29.9	20.9	22.4
23.9	29.9	25.4	25.4	31.3	41.8	41.8	41.8

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)

		Mean rating	Mean difference	Standard Deviation	Mean Difference	P value	
Aroma acceptability	**Male**	4.12	0.088	1.122	0.088	0.733	NS
	Female	4.03		1.000			
Appearance acceptability	**Male**	4.03	-0.265	1.314	0.277	0.343	NS
	Female	4.29		0.938			
Texture acceptability	**Male**	4.12	-0.206	1.320	0.272	0.452	NS
	Female	4.32		0.878			
Taste acceptability	**Male**	4.03	-0.500	1.381	0.285	0.085	NS
	Female	4.53		0.929			

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)

		Mean rating	Standard Deviation	Mean Difference	P value
Aroma perception	**Male**	3.29	1.548	-0.176	0.594
	Female	3.47	1.134		
Appearance perception	**Male**	3.56	1.440	-0.353	0.270
	Female	3.91	1.164		0.271
Texture perception	**Male**	3.41	1. 1.219	-0.294	0.400
	Female	3.71			
Taste perception	**Male**	3.29	1. 1.250	-0.500	0.132
	Female	3.79			

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)

		Mean ratings	Standard Deviation	Mean Difference	P value
Aroma acceptability	**Male**	3.743	1.355	0.324	0.260
	Female	0.41			
Appearance acceptability	**Male**	3.88	1.175	0.353	0.283
	Female	3.53	1.161		
Texture acceptability	**Male**	3.56	1.501	0.235	0.467
	Female	3.32	1.121		
Taste acceptability	**Male**	3.56	1.460	0.265	0.420
	Female	3.29	1.219		

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)

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

**= 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 of *isishebo* for yellow *phuth*u 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

Abrha, T., Girma, Y., Haile, K., Hailu, M. and Hailemariam, M (2016). Prevalence and associated factors of clinical manifestations of vitamin a deficiency among preschool children in Asgede-tsimbla rural district, North Ethiopia, a community-based cross-sectional study. *Archives of Public Health,* 74(4): 1-8

Argyropoulou, S. E. (2016). The association between the diversity of crop production and nutritional indicators of rural households in Northern Ghana. Thesis Human Nutrition (HNE-85336). The Netherlands Division of Human Nutrition Wageningen University, Europe.

Arigony, A. L. V., De-Oliveira, I. M., Machado, M., Bordin, D. L. B., Berter, L., Prá, D. and Henriques, J. A. P. (2013). The influence of micronutrients in cell culture: A reflection on viability and genomic stability. *Journal of BioMedical Research International*, 13: 1-22

,

Barber, T., Esteban-Pretel, G., Marín, M. P. and Timoneda J. (2014). Vitamin A deficiency and alterations in the extracellular matrix, *Journal of Nutrients,* 6(11): 4984–5017

Blancquaert, D., De Steur, H., Gellynck, X. and Van Der Straeten, D. (2014). Present and future of folate biofortification of crop plants. *Journal of Experimental Botany*, 65(4): 1895-906

Bouis, H. E., Hotz, C., McClafferty, B., Meenakshi, J. V. and Pfeiffer, W. H. (2011). Bio-fortification: a new tool to reduce micronutrient malnutrition. *Food and Nutrition Bulletin,* 32: S31-40S

Costell, E., Tárrega, A. and Bayarri, S. (2010). Food Acceptance: The Role of Consumer Perception and Attitudes. *Journal of Chemosensory. Perception*, 3: 42

Doldo, E., Cosnanza, G., Agostinelli, S., Tarquini, C., Ferlosio, A., Arcuri, G., Passeri, D., Scioli, M.G. and Orlandi, A. (2015). Vitamin A, cancer treatment and prevention: The new role of cellular retinol binding proteins. *Journal of BioMedical Research International*, 2015: 1-14

FAO. (2003). Trade Reforms and Food Security. Commodity Policy and Projection Service of the Commodity and Trade Division. FAO: Rome.

FAO., IFAD. and WFP. (2015). The State of Food Insecurity in the World 2015. Meeting the 2015 International Hunger Targets: Taking Stock of Uneven Progress. Rome: FAO.

Govender, L., Pillay, K., Derera, J. and Siwela, M. (2014). Acceptance of a complementary food prepared with yellow, provitamin A-biofortified maize by black caregivers in rural KwaZulu-Natal. *South African Journal of Clinical Nutrition*, 27(4): 217-221

Gwirtz, J. A. and Garcia-Casal, M. N. (2014). Processing maize flour and maize meal food products. *Annals of the New York academy of sciences*, 1312(1): 66-75

Hall, K.,Sambu, W., Berry, L., Giese, S., Almeleh, C. and Rosa, S. (2016). South African Early Childhood Review 2016. Cape Town: Children's Institute, University of Cape Town and Ilifa Labantwana.

Mboya, R., Tongoona, P., Derera, J., Mudhara, M. and Langyintuo, A. (2011). The dietary importance of maize in Katumba ward, Rungwe district, Tanzania, and its contribution to household food security. *African Journal of Agricultural Research*, 6(11): 2617-2626

Muzhingi, T., Langyintuo, A., Malaba, L. and Banzinger, M. (2008). Consumer acceptability of yellow maize products in Zimbabwe. *Journal of Food Policy*, 33: 352-361

Nali, M. K. (2015). Food-based interventions to modify diet quality and diversity to address multiple micronutrient deficiencies. *Journal of Frontiers in Public Health*, 3(277): 1-14

Olaniyan, A. B. (2015). Maize: Panacea for hunger in Nigeria. *African Journal of Plant Science*, 9(3): 155-174

Pillay, K., Derera, J., Siwela, M. and Veldman, F. J. (2011). Consumer acceptance of yellow provitamin A-bio-fortified maize in KwaZulu-Natal. *South African Journal of Clinical Nutrition*, 2(4): 186-191

Ranum, P., Pena-Rosas, J. P. and Garcia-Casal, M .N. (2013). Global maize production, utilization, and consumption. *Annals of the New York Academy of Sciences*, 1312: 105 - 112

Shisana, O., Labadarios, D., Rehle, T., Simbayi, L., Zuma, K., Dhansay, A., Reddy, .P, Parke,r W., Hoosain., E, Naidoo, P., Hongoro, C., Mchiza, Z, Steyn, N.P., Dwane, N., Makoae, M., Maluleke, T., Ramlagan, S., Zungu, N., Evans, M.G., Jacobs, L., Faber M, and the SANHANES-1 Team (2014) *South African National Health and Nutrition Examination Survey (SANHANES-1)*: 2014 Edition. Cape Town: HSRC Press.

Talsma, E. F., Boonstra, A. M., de Kock, B. P., Gloria, N .K., Mbera, G., NMwangi, A. M. and Brouwer, I. D. (2013). Biofortified Cassava with provitamin A is sensory and culturally acceptable for consumption by primary school children in Kenya. PLoS One, 8 (9): e73433

Tumuhimbise, G. A., Namutebi, A., Turyashemererwa, F. and Muyonga, J. (2013). Provitamin A crops: acceptability, bioavailability efficacy and effectiveness. *Food and Nutrition Sciences,* 4(4): 430-435

Vabo, N. and Hansen, H. (2014). The Relationship between Food Preferences and Food Choice: A Theoretical Discussion. *International Journal of Business and Social Science* 5: 7

CHAPTER FIVE: DESCRIPTIVE SENSORY ANALYSIS OF PROVITAMIN A-BIOFORTIFED (YELLOW) MAIZE *PHUTHU* (CRUMBLED 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 *amahewu*[1] 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 (Beswa, 2015). Beswa (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. Characterisng 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

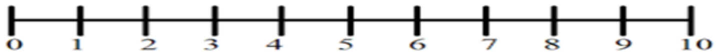
Four cups of provitamin A biofortified (yellow) maize meal, 1/8 measuring spoon salt and 1 litre of water were used to prepare provitamin A biofortified maize meal *phuthu*. First, the water was boiled at a high temperature. Second, 4 cups of provitamin A biofortified maize were poured in the boiling 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

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

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.

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

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

Sensory attributes	PC1	PC2	PC3
Yellowness	-0.987	0.161	0.000
Rough appearance	0.981	-0.102	0.168
White specks	0.856	0.511	-0.075
Dry appearance	0.999	-0.048	-0.021
Cooked maize aroma	0.999	-0.033	-0.028
Cooke maize flavour	0.997	-0.042	-0.065
Crumbliness	0.994	-0.109	-0.030
Chewiness	0.996	-0.085	-0.023
Roughness	0.998	-0.055	-0.037
ility	0.995	-0.095	0.028
Residue	-0.993	0.119	0.011
Stickiness	-0.884	-0.457	-0.098

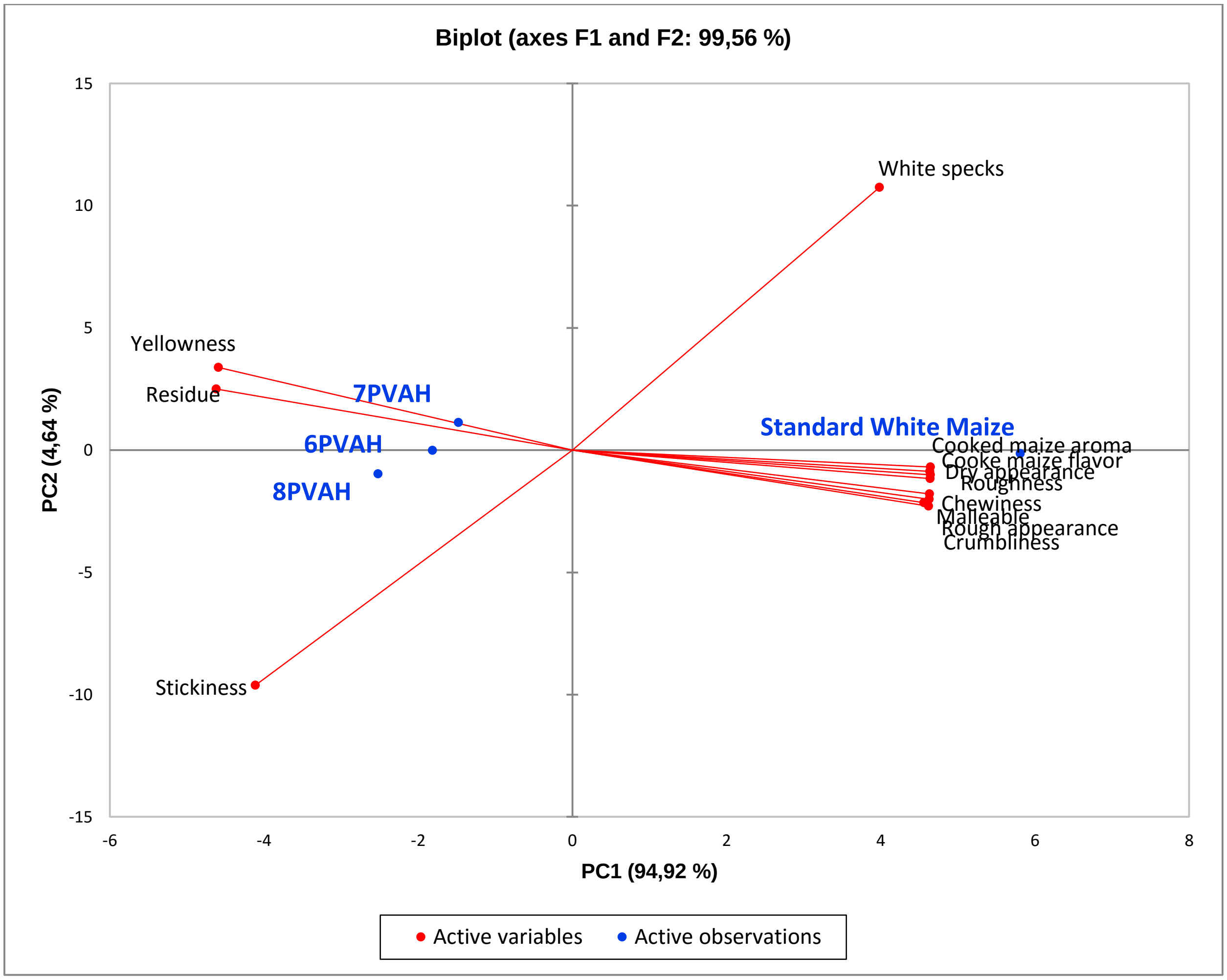


Figure 5.2: Biplot of principal component (PC) 1 versus PC2 loadings of biofortified maize *phuthu* and standard white maize *phuthu*

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)

Sensory attribute	Mean + SE		
	White maize	Yellow maize	p value
Aroma	3.70 ± 0.15^a	3.81 ± 0.15^a	0.632
Appearance	3.96 ± 0.14^b	3.94 ± 0.16^b	0.911
Texture	3.91 ± 0.15^c	3.90 ± 0.17^c	0.992
Taste/ flavour	3.91 ± 0.15^d	3.90 ± 0.17^d	0.992
Overall Acceptability	3.97 ± 0.17^e	4.02 ± 0.17^e	0.858

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

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

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 (Beswa, 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

Awobusuyi, T. D., Amonsou, E. O., Siwela, M and Kolanisi. U (2016). Provitamin A retention and sensory acceptability of amahewu, a non-alcoholic cereal-based beverage made with provitamin A biofortified maize. *Journal of the Science of Food and Agriculture*, 96: 1356-1361

Beswa, D. (2015). Nutritional, sensory and health-promoting properties of provitamin A biofortified maize stiff porridges and extruded snacks. PhD thesis, University of KwaZulu-Natal, Pietermaritzburg, South Africa.

Cardello, A. V. (1994). Consumer expectations and their role in food acceptance. In Measurement of Food Preferences, Eds. D. Thompson and H. Macfie. Blackie, London, 253-97

CLARK, J .E. (1998). Taste and flavour: their importance in food choice and acceptance. *Proceedings of the Nutrition Society*, 57: 639-643

Govender, L., Pillay, K., Derera, J. and Siwela, M. (2014) Acceptance of a complementary food prepared with yellow, provitamin A biofortified maize by black caregivers in rural KwaZulu-Natal, *South African Journal of Clinical Nutrition*, 27: 4

Pillay, K., Siwela, M., Derera, J. and Veldman, F. J. (2014) .Provitamin A carotenoids in biofortified maize and their retention during processing and preparation of South African maize foods. Journal of Food Science and Technology, 1(4): 634-44

Pillay, K., Siwela, M., Derera, J. and Veldman, F. J. (2011). Consumer acceptance of yellow, provitamin A-biofortified maize in KwaZulu-Natal. *South African Journal of Clinical Nutrition,* 24 (4):186-191

Ruwaida, A., Pillay, K., Siwela, M. and Kolanisi, U. (2016) Acceptance of a Complementary Food based on Provitamin A Biofortified Maize and Chicken Stew. *Journal Human Ecology*, 55(3): 152-159

CHAPTER SIX: AN APPRAISAL OF INTEGRATING INDIGENOUS KNOWLEDGE SYSTEM-BASED AND WESTERN-BASED METHODS OF LEARNING: A CASE STUDY OF SMALLHOLDER FARMERS IN KWADLANGEZWA, KWAZULU-NATAL, SOUTH AFRICA

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'. A*s 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.

6.2.1Sampling 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

Transformative learning	Gagne’s model integrated with IK
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

Statement	**Strongly disagree (%)**		**Disagree (%)**		**Not sure (%)**		**Agree (%)**		**Strongly Agree (%)**		**Wilcoxon Signed Ranks Test results**
	Pre vit A awareness campaign	Post vit A awareness campaign	Pre vit A awareness campaign	Post vit A awareness campaign	Pre vit A awareness campaign	Post vit A awareness campaign	Pre vit A awareness campaign	Post vit A awareness campaign	Pre vit A Awareness campaign	Post vit A awareness campaign	
White maize has more nutrients than other foods	9.5	38.1	28.6	19.1	33.3	14.3	9.5	14.3	19	14.3	0.286 (NS)
I know about vitamin A biofortification	14.3	0	4.8	0	28.6	4.8	23.8	19	28.6	76.2	0.003
I know about vitamin A deficiency	0	0	9.5	0	14.3	4.8	28.6	47.6	47.6	61.9	0.104 (NS)
I am aware that vitamin A is a health problem	0	0	4.8	0	19	9.5	23.8	52.4	52.4	71.4	0.145 (NS)
I understand that vitamin A is a health as well as an economic problem	9.5	0	9.5	0	9.5	14.3	23.8	47.6	47.6	61.9	0.087 (NS)
White maize is a natural food	14.3	19.6	14.3	4.8	33.3	19	28.6	19.0	14.3	14.3	0.944 (NS)
White maize is healthy	14.3	29.8	14.3	9.6	47.6	19	9.5	9.5	14.3	14.3	0.276 (NS)
Yellow maize is not natural	52.4	57.1	9.5	28.6	19	19	9.5	9.5	9.5	4.8	0.727 (NS)
Maize yield consideration is more important than consideration for nutrients found in maize	23.8	42.9	14.3	28.6	47.6	9.5	9.5	4.3	4.3	14.3	0.036 (NS)

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 ululates. 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

Questions	Percentage (%) of participants (N=21)	Verbatim quotes
1. I see a great need for us to start using provitamin A maize	98	*'today's food is unhealthy; we no longer live a longer life because of the food we eat; provitamin A is our future'*
2. I have a responsibility to ensure that my family has access to nutritious foods	98	*'that is why we are farmers trying to ensure that our families are healthy'*
3. As a farmer, I have a role to play in enhancing the health and nutrition of my community	90	'*the primary purpose of waking up early in the morning and go to the fields is to provide for my people and family'*
3. I am ready to be a producer of provitamin A maize	100	*'Where can we get the seeds?'*
4. I am satisfied with the facilitation, pitching and interaction during learning	96	*'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'*
5. The learning materials were at my level	80	*'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'*

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 yakho iphuphuma ezingqondweni 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.

Siyokwephulela ezithebeni nasezingqokweni, ubuhle sobubona ngawe Vitamin A. Akukho luhlobo lwesifo olodlula wena, amazibulo empilo abasaphila akuwe. Intokozo emazweni ivele ngo Consumer Science, abocwaningo lwezempilo ende kaqholiwe. Bahlanganise imiqondo mbono kwaphuma isosha lempilo eliqholiwe, eligcina lilwa nezinkinga zomsoco. Vukani Mzansi Africa nangu uVitamin A esebuyile, nangu umsizi womnotho wempilo wesizwe. Abanye sebochaza ngebuya lakho qholiwe, umendo wempova wandise impilo, nesizukulwane sesiyowadla anhlamvana.

Abakhulelwe, abagulayo, amavila bayovuka, nabantwana bazokhula behlakaniphile ngawe Vitamin A. Mmbila obomvu sondela nganeno, izintombi nezinsizwa zikwethulele isizwe. Sagxuma sakikizela sahlala amagqozo, izalukazi namaxhegu zagiya ngesikhwebu. Umbala wakho udliwa ngamehlo qholiwe. Ulisoka ngemisebenzi yakho qholiwe-Vitamin A. Sonke sithi mmbila obomvu , uyiphilisi elingenazinkinga qholiwe. Odla wena uyobeka induku ebandla. Phambili mmbila obomvu, phambili. Soqina amadolo ngawe Vitamin A. *Umbhali: Mrs Ncanana Nomusa.*

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 motivationand 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

Abbott, J. and Ryan, T. (2001). *The unfinished revolution: learning, human behaviour, community, and political paradox*, Alexandria, VA: Association for Supervision and Curriculum Development.

Bardi, A., Baron, R. A. And Byrne, D. (2003). Advances in experimental social psychology. *Journal of Personality and Social Psychology,* 87: 5-22

Baron, R. A. and Byrne, D. (2003). Social psychology. (10th ed.). Needham, MA: Allyn and Bacon.

Cengiz, E. (2010). Measuring customer satisfaction: Must or not? *Journal of Naval Science and Engineering*. 6(2): 76-88

Collado, J., Herrero, A. and Rodriquez del Bosque, I. (2012). “Adherence to customer loyalty programs and changes in buying behaviour,” *The service industries Journal*, 32 (8): 1323-1341

Crano, W. D. and Prislin R. (2008). Attitudes and Attitude Change. New York: Psychology Press.

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

Padilla-Díaz, M. P. (2015). Phenomenology in educational qualitative research: Philosophy as science or philosophical science? *International Journal of Educational Excellence,* 1(2): 101-110

Dirkx, J. M. (1998). Transformative learning theory in the practice of adult education: An overview. *PAACE Journal of Lifelong Learning*, 7: 1-14

Du Plessis, P. J. and Rousseau, G. G. (2003). *Buyer Behavior: A Multi-Cultural Approach. (3rd ed*). Cape Town: Oxford University Press.

Fazio, R. H. (1990). Multiple processes by which attitudes guide behaviour: The MODE model as an integrative framework. *Advances in experimental social psychology Journal,* 23: 75-109

Franz, N. (2007). Adult Education Theories: Informing Cooperative Extension's. *Transformation Journal of Extension*, 45(1): 11

Kaya, H. and Seleti, Y. (2013). African indigenous knowledge systems and relevance of higher education in South Africa. *The International Education Journal: Comparative Perspectives,* 12(1): 30-44

Kaya, H. (2014). The road ahead: Multicultural adult education. *International Journal of Humanities and Social Sciences*, 48 (1) 164

Kolanisi, U. (2010). *Consumer attitudes towards rural water provision and learning strategies to enhance community participation: The case study of Madibogo, North-West Province.* Unpublished Master's dissertation, North-West University, Potchefstroom, South Africa.

Kulkarni, P. P. (2013). A literature review on training and development and quality of work life. *International Refereed Research Journal,* 4 (2): 136

Maila, M. W. and Loubster, C. P. (2003). Emancipatory indigenous knowledge system. Implications for environmental education in South Africa. *South African Journal of Education,* 23 (4): 276-280

Mann, K. V. (2011). Theoretical perspectives in medical education: Past experience and future possibilities. *Journal of Medical Education*, 45: 60-68

McNamara, M. S. (2005). Knowing and doing phenomenology: The implications of the critique of 'nursing phenomenology' for a phenomenological inquiry: a discussion paper. *International Nursing Journal of Studies,* 42 (6): 695-704

Mezirow, J. (1998). On critical reflection. *Adult Education Quarterly*, 48 (3): 185-198

Mezirow, J. (2000). Learning to think like an adult: Core concepts of transformation theory. (*In* J. Mezirow and Associates (Eds.), *Learning as Transformation: Critical Perspectives on a Theory in Progress*). San Francisco, CA: Jossey-Bass.

Mezirow, J. (2004). Forum comment on Sharan Merriam's: "The role of cognitive development in Mezirow's transformational learning theory." *Adult Education Quarterly,* 55(1): 69-70

Nakashima, D. (2010). Indigenous Knowledge in Global Policies and Practice for Education, Science and Culture. Paris: UNESCO.

Nkondo, O. M. (2010). The future of the indigenous knowledge systems in global knowledge innovations. Paper presented at the regional symposium on indigenous knowledge and community innovations in the bioscience and biotechnology in South Africa, Kwa Maritane game lodge.

Obel-lawson, E. (2006). The efficacy of awareness campaigns by the African leafy vegetable projects on nutrition behaviour change among the Kenyan urban population: the case of Nairobi. M.S. thesis, University of Nairobi, Kenya.

Ogbebor, O. (2011). The value of indigenous knowledge system based on literature review.osarome.blogspot.com/2011/12/write-on-value-of-indigenous-knowledge.html

Ogden, J. (2007). Health Psychology: *A Textbook (4th edition)*. Buckingham, GBR: Open University Press.

Onwuekwe, C. (2007). The ideology of the commons and property rights: Who owns plant genetic resources and the associated traditional knowledge? In accessing and sharing the benefits of the genomic revolution. *The International Library of Environmental, Agricultural and Food Ethics,* 11*:* 21-48

Pillay, K., Siwela,M., Derera, J. and Veldman, F. (2011). Consumer acceptability of yellow, provitamin A-biofortified maize in KwaZulu-Natal*. South African Journal of Clinical Nutrition*, 24 (4): 186-191

Roth, M. and Lee, S. (2004). Science education as/for participation in the community. *Journal of Science Education*, 88: 263-291

Schiffman, L. G. and Kanuk, L. L. (2004). *Consumer Behaviour*. *(8th ed*). Upper Saddle River, Prentice Hall.

Taylor, J. and Russo, V. (2002). “The SADC regional environmental education programme”. In The Long Walk to Sustainability: A southern Africa perspective, South Africa: Johannesburg.11: 36-40

Timmons, V. and Alur, M. (2004). Transformational learning: a description of how inclusionary practice was accepted in India. *International Journal of Special Educatio*n, 19(1): 1-11

Verplanken, B. and Wood, W. (2006). Interventions to break and create consumer habits. *Journal of Public Policy and Marketing*. 25(1): 90-103

WHO. (2012). Health Education: Theoretical Concepts, Effective Strategies and Core Competencies. Rome, Italy: WHO.

WIPO. (2006). “Intergovernmental committee on intellectual property and genetic resources, Traditional knowledge and folklore”. Draft secretariat report: 27. 34. WIPO/GRTKF/IC/9/10 Geneva http://www.wipo.int.

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 and* 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 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

Abdel-Aal, E.M., Akhtar, H., Zaheer, K. and Ali, R. (2013). Dietary Sources of Lutein and Zeaxanthin Carotenoids and Their Role in Eye Hea. *Journal of Nutrients*, 5(4): 1169-1185

Abrha, T., Girma, Y., Haile, K., Hailu, M. and Hailemariam, M (2016). Prevalence and associated factors of clinical manifestations of vitamin a deficiency among preschool children in Asgede-tsimbla rural district, North Ethiopia, a community-based cross-sectional study. *Archives of Public Health,* 74(4): 1-8

ACC/SCN. (2000) 4th Report on the World Nutrition Situation. Nutrition throughout the Life Cycle. United Nations Administrative Committee on Coordination, Sub-Committee on Nutrition in collaboration with International Food Policy Research Institute (IFPRI): Geneva. 121

Akhtar, S., Ahmed, A., Randhawa, M. A., Atukorala, S., Arlappa, N. and Ismail, T. Z. (2013). Prevalence of vitamin A deficiency in South Asia: causes, outcomes, and possible remedies. *Journal of Health Population and Nutrition,* 31(4): 413-423

and human nutrition. A challenge for molecular breeding. *Journal of Zhejiang University Society B,* 9:165-91

Argyropoulou, S. E. (2016). The association between the diversity of crop production and nutritional indicators of rural households in Northern Ghana. Thesis Human Nutrition (HNE-85336). The Netherlands Division of Human Nutrition Wageningen University, Europe.

Arigony, A. L. V., De-Oliveira, I. M., Machado, M., Bordin, D. L. B., Berter, L., Prá, D. and Henriques, J. A. P. (2013). The influence of micronutrients in cell culture: A reflection on viability and genomic stability. *Journal of BioMedical Research International*, 13: 1-22

Awobusuyi, T. D., Amonsou, E. O., Siwela, M and Kolanisi. U (2016). Provitamin A retention and sensory acceptability of amahewu, a non-alcoholic cereal-based beverage made with provitamin A biofortified maize. *Journal of the Science of Food and Agriculture*, 96:1356-1361

Bagozzi, R. P., Zeynep, G. and Priester, J. R. (2002). The Social Psychology of Consumer Behavior, Open University Press, Buckingham, United Kingdom.

Bailey, R. L., West, K. P and Black, R. E. (2015). The epidemiology of global micronutrient deficiencies. *Annals of Nutrition and Metabolism*, 66 (2): 22-33

Bandura, A. (1999). A social cognitive theory of personality. In L. Pervin & O. John (Ed.),

Barber, T., Esteban-Pretel, G., Marín, M. P. and Timoneda J. (2014). Vitamin A deficiency and alterations in the extracellular matrix, *Journal of Nutrients,* 6(11): 4984-5017

Bardi, A., Baron, R. A. And Byrne, D. (2003). Advances in experimental social psychology. *Journal of Personality and Social Psychology,* 87: 5-22

Baron, R. A. and Byrne, D. (2003). Social psychology. (10th ed.). Needham, MA: Allyn and Bacon.

Bell, R. and Meiselman, H. (1995). The role of eating environments in determining food

Beswa, D. (2015). Nutritional, sensory and health-promoting properties of provitamin A biofortified maize stiff porridges and extruded snacks. PhD thesis, University of KwaZulu-Natal, Pietermaritzburg, South Africa.

Birol, E., Meenakshi, J. V. and Oparinde, A. (2015). Developing country consumers' acceptance of biofortified foods: a synthesis. *Journal of Food Security*, 7: 555

Blancquaert, D., De Steur, H., Gellynck, X. and Van Der Straeten, D. (2014). Present and future of folate biofortification of crop plants. *Journal of Experimental Botany*, 65(4): 1895-906

Bohn, L., Meyer, A. S. and Rasmussen, S. K. (2008). Phytate: Impact on the environment. A challenge for molecular breeding. *Journal of Zhejiang University Science B*, 9(3): 165-91

Bouis, H and Welch, R (2010). Biofortification--A Sustainable Agricultural Strategy for reducing micronutrient malnutrition in the Global South. *Journal of Crop Science*, 50: S-20-S-32

Bouis, H. E. (2017). Improving nutrition through biofortification: A review of evidence from HarvestPlus, 2003 through 2016. *Journal of Global Food Security,* 12: 49-58

Bouis, H. E., Hotz, C., McClafferty, B., Meenakshi, J. V. and Pfeiffer, W. H. (2011). Bio-fortification: a new tool to reduce micronutrient malnutrition. *Food and Nutrition Bulletin,* 32: S31-40S

Britton, G. (1995). Structure and properties of carotenoids in relation to function. *Journal of Faseb*, 9:1551-1558

Bruins, M. J., Kupka, R., Zimmermann, M. B., Lietz, G., Engle-Stone, R. S. and Kraemer, K. (2016). Maximizing the benefits and minimizing the risks of intervention programs to address micronutrient malnutrition: symposium report. *Journal of Maternal Nutrition*, 12(4): 940-948

Bruins, M. J., Kupka, R., Zimmermann, M. B., Lietz, G., Engle-Stone, R. S. and Kraemer, K. (2016). Maximizing the benefits and minimizing the risks of intervention programs to address micronutrient malnutrition: symposium report. *Journal of Maternal Nutrition*, 12(4): 940-948

Buah, S., Mlalazi, B., Khanna, H., Dale, J. L. and Mortimer, C. L. (2016). The quest for golden bananas: investigating carotenoid regulation in a Fe'i group Musa cultivar. *Journal of. Agriculture and. Food Chemistry,* 64: 3176-3185

Bouis, H. E., C. Hotz, B. McClafferty, J. V. Meenakshi, and W. H. Pfeiffer. 2011. “Biofortification: A New Tool to Reduce Micronutrient Malnutrition.” *Food and Nutrition Bulletin,* 32(1): 31S-40S

Caballero, B. (2003). Original communication, fortification, supplementation, and nutrient balance. *European Journal of Clinical Nutrition*, 57(1): 76-78

Campos-Bowers, M. H. and Wittenmyer, B. F. (2007). Biofortification in China: policy and practice. *Journal of Health Research Policy and Systems*, 5:10

Cardello, A. V. (1994). Consumer expectations and their role in food acceptance. In Measurement of Food Preferences, Eds. D. Thompson and H. Macfie. Blackie, London, 253-97

Carm, E. (2014). Inclusion of indigenous knowledge system (IKS) A precondition for sustainable development and an integral part of environmental studies. *Journal of Education and Research,* 4(1): 58-76

Castenmiller, J. J. M. and West, C. E. (1998). Bioavailability and bioconversion of carotenoids. *Journal of Annual. Review of Nutrition,* 18: 19-38

Cazzonelli, C .I. (2011). Carotenoids in nature: insights from plants and beyond Functional. *Journal of functional Plant Biology*, 38: 833-847

Cengiz, E. (2010). Measuring customer satisfaction: Must or not? *Journal of Naval Science and Engineering*. 6(2): 76-88

Charles, H., Godfray-Beddington, J., Crute, I. R and Toulmin, C. (2010). Food Security: The Challenge of Feeding 9 Billion People. *Journal of Science,* 327(5967): 812-8

Chen, W. and Chen, G. (2014). The roles of vitamin A in the regulation of carbohydrate, lipid, and protein metabolism. *Journal of Clinical Medicine,* 3(2): 453-479

Choudhary, A. K., Kumar, S., Patil, B. S., Bhat, J. S., Sharma, M., Kemal, S., Ontagodi, T. P., Datta, S., Patil, P., Chaturvedi, S. K., Hegde, R. V. S., Choudhary, Kamannava, P.Y. and Vijayakumar, A. G. (2013). Narrowing yield gaps through genetic improvement for fusarium wilt resistance in three pulse crops of the semi-arid tropics, Sabrao. *Journal of Breeding and Genetics,* 45(3): 341-370

Christopher, C. I. (2011). Carotenoids in nature: insights from plants and beyond functional. *Journal of Functional Plant Biology,* 38: 833-847

Chumngoen, W. and Tan F. J. (2015). Relationships between descriptive sensory attributes and physicochemical analysis of broiler and Taiwan native chicken breast meat. *Journal of Animal Science.* 28(7): 1028-37

CLARK, J .E. (1998). Taste and flavour: their importance in food choice and acceptance. *Proceedings of the Nutrition Society*, 57: 639-643

Collado, J., Herrero, A. and Rodriquez del Bosque, I. (2012). "Adherence to customer loyalty programs and changes in buying behaviour," *The service industries Journal*, 32 (8): 1323-1341

Combs, G. F. (2012). Fundamental Aspects in Nutrition and Health, Ed 4. Academic Press, New York, NY. *Journal of Vitamin A*, 93-138

Costell, E., Tárrega, A. and Bayarri, S. (2010). Food Acceptance: The Role of Consumer Perception and Attitudes. *Journal of Chemosensory. Perception*, 3: 42

Crano, W. D. and Prislin R. (2008). Attitudes and Attitude Change. New York: Psychology Press.

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

DAFF. (2014). The national policy on food and nutrition security. Pretoria: Government of South Africa.

Darmon, N. and Drewnowski, Adam. (2008). Does social class predict diet quality? 1,2,3, *American Journal of Clinical Nutrition,* 87(5): 1107-1117

Dary, O and Mora, J. O. (2002). Food fortification to reduce vitamin A deficiency: international vitamin A consultative group recommendations. *Journal of Nutrition*, 132(9): 2927S-2933S

De Groote, H. and Kimenju, C. S. (2008). Comparing consumer preferences for color and nutritional quality in maize: application of a semi-double-bound logistic model on urban consumers in Kenya. *Journal of Food Policy*, 33: 362-70

De Groote, H. and Kimenju, S. C. (2012). Consumer preferences for maize products in urban Kenya*. Food and Nutrition Bulletin,* 33: 99-110

De Groote, H., Kimenju, S. C. and Morawetz, U. B. (2011). Estimating consumer willingness to pay for food quality with experimental auctions: the case of yellow versus fortified maize meal in Kenya. *Journal of Agriculture and Economics,* 42: 1-16

Demissie, T., Ali, A., Mekonen, Y.,Haider, J. and Umeta, M. (2010). Magnitude and distribution of vitamin A deficiency in Ethiopian food and Nutrition Bulletin, 31: 2

Dhliwayo, T., Palacios-Rojas, N., Crossa, J. and Pixley, K. V. (2014). Effects of S1 recurrent selection for provitamin A carotenoid content for three open-pollinated maize cultivars. *Journal of Crop Science*. 54: 2449-2460

Dirkx, J. M. (1998). Transformative learning theory in the practice of adult education: An overview. *PAACE Journal of Lifelong Learning*, 7: 1-14

Doldo, E., Cosnanza, G., Agostinelli, S., Tarquini, C., Ferlosio, A., Arcuri, G., Passeri, D., Scioli, M.G. and Orlandi, A. (2015). Vitamin A, cancer treatment and prevention: The new role of cellular retinol binding proteins. *Journal of BioMedical Research International*, 2015: 1-14

Du Plessis, P. J. and Rousseau, G. G. (2003). *Buyer Behavior: A Multi-Cultural Approach. (3rd ed*). Cape Town: Oxford University Press.

Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J. and Willingham, D. T. (2013). Improving students' learning with effective learning techniques: promising directions from cognitive and educational psychology. *Journal of Psychological science in the public interest*, 14(1): 4-58

Eubanks, M. W. (1997b). Molecular analysis of crosses between Tripsacum dactyloides and Zea diploperennis (Poaceae). *Journal of Theoratical and Applied Genetics,* 94: 707-712

Faber, M. and Laurie, S. M. (2011). A home gardening approach developed in South Africa to address vitamin A deficiency. In Thompson B, Amoroso L, eds. Combating micronutrient deficiencies: food-based approaches. FAO and CABI bookshop, 13: 163-182

Faber, M. and Wenhold, F. (2007). Nutrition in contemporary South Africa. *Journal of Water South Africa*, *Special edition*, 33(3): 393-400

Faber, M., Witten, C. and Drimie, S. (2011). Community-based agricultural interventions in the context of food and nutrition security in South Africa. *South African Journal of Clinical Nutrition*. 24(1): 21-30

Fang, E., Palmatier R. W. and Steenkamp, J. B. (2008) Effect of service transition strategies on firm value. *Journal of Marketing*, 72(4): 1-14

FAO. (2003). Trade Reforms and Food Security. Commodity Policy and Projection Service of the Commodity and Trade Division. FAO: Rome.

FAO., IFAD. and WFP. (2015). The State of Food Insecurity in the World 2015. Meeting the 2015 International Hunger Targets: Taking Stock of Uneven Progress. Rome: FAO.

FAO., IFAD., UNICEF., WFP. and WHO. (2017). The State of Food Security and Nutrition in the World 2017. *Building resilience for peace and food security*. Rome, FAO.

Fazio, R. H. (1990). Multiple processes by which attitudes guide behaviour: The MODE model as an integrative framework. *Advances in experimental social psychology Journal,* 23: 75-109

Fiedler, J. L., Lividini, K. and Bermudez, O. I. (2015). Estimating the impact of vitamin A-fortified vegetable oil in Bangladesh in the absence of dietary assessment data. *Journal of Public Health Nutrition,* 18(3): 414-20

Flynn, L. R. and Goldsmith, R. E. (2016). Introducing the super consumer. Journal of Consumer Behaviour. *Journal of. Consumer Behaviour,* 15: 201-207

Foxall, G. R. and Goldsmith, R. E. (1994). Consumer psychology for marketing. Routledge. London.

Franz, N. (2007). Adult Education Theories: Informing Cooperative Extension's. *Transformation Journal of Extension*, 45(1): 11

Frelat, R., Lopez-Ridaura, S., Giller, K. E., Herrero, M., Douxchamps, S., Djurfeldt, A. A., Erenstein, O., Henderson, B., Kassie, M., Paul, B. K., Rigolot, C., Ritzema, R. S., Rodriguez, D., Van Asten, P.J., and Van Wijk, M. T. (2016). Drivers of household food availability in sub-Saharan Africa based on big data from small farms. *Proceedings of the National Academy of Sciences of the United States of America,* 113(2): 458-463

Friedma, D. S. (2004) . Racial Variations in Causes of Vision Loss in Nursing Homes. *Archives of Ophthalmology,*1099 -1024 (7): 122

Galinat, W .C. (1988). The origin of maize. In Sprague, G.F. and Dudley, J.W. Eds. Maize and maize improvement. Agronomy Monographs. American Society of Agronomy: Madison. Wisconsin. 18: 1-31

Gannon, B., Kaliwile, C. and Arscott, S. (2014). Biofortified orange maize is as efficacious as a vitamin A supplement in Zambian children even in the presence of high liver reserves of vitamin A: a community-based, randomized placebo-controlled trial*. American. Journal of Clinical. Nutrition,* 100(6): 1541-50

Gannon, B., Kaliwile, C., Arscott S. A., Schmaelzle, S., Chileshe, J., Kalungwana, M., Mosonda, N., Pixley, K. S. C. (2014). Biofortified orange maize is as efficacious as a vitamin A supplement in Zambian children even in the presence of high liver reserves of vitamin A: a community-based, randomized placebo-controlled trial. *American Journal of Clinical Nutritio,* 100(6): 1541-1550

Garcia-Casal, M. N., Layrisse, M., Solano, L., Baron, M. A., Arguello, F., Llovera, D., Ramirez, J., Leets, I. and Tropper, E. (1998). Vitamin A and beta-carotene can improve nonheme iron absorption from rice, wheat and maize by humans. *Journal of Nutrition,* 128: 646-650

Gibson, R. (2005). Principles of nutritional assessment, 2nd edition. Oxford University Press, Oxford.

Girum, A., Menkir, A., Gedil, M. and Spillane, C. (2013. Marker-trait association analysis of functional gene markers for provitamin A levels across diverse tropical yellow maize inbred lines. *Journal of Biomedical Central Plant Biology,* 13(1): 227

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.

Goff, S. A and Klee, H. J. (2006). Plant volatile compounds: sensory cues for health and nutritional value. *Journal of Science.* 311: 815-819

Gopalan, C., Sastri, R. B. V and Balasubramanian, S. (2007). Nutritive Value of Indian Foods, published by National Institute of Nutrition (NIN), ICMR.

Govender, L., Pillay, K., Derera, J. and Siwela, M. (2014) Acceptance of a complementary food prepared with yellow, provitamin A biofortified maize by black caregivers in rural KwaZulu-Natal, *South African Journal of Clinical Nutrition*, 27: 4

Govender, L., Pillay, K., Derera, J., Siwela, M. (2014). Acceptance of a complementary food prepared with yellow, provitamin A-biofortified maize by black caregivers in rural KwaZulu-Natal South African *Journal of Clinical Nutrition*, 27(4): 217-221

Grune, I., Lietz, G., Palou., A. Catharine, R., Stahl, W., Tang, G., Thurnham, D., Yin, S. and Biesalski, H. K. (2010). Β-Carotene Is an Important Vitamin A Source for Humans. *Journal of Nutrition,* 140(12): 2268S-2285S

Gwirtz, J. A. and Garcia-Casal, M. N. (2014). Processing maize flour and maize meal food products. *Annals of the New York academy of sciences*, 1312(1): 66-75

Hall, K., Sambu, W., Berry, L., Giese, S., Almeleh, C. and Rosa, S. (2016). South African Early Childhood Review 2016. Cape Town: Children's Institute, University of Cape Town and Ilifa Labantwana.

Hambidge, K. M. (2010) Micronutrient bioavailability: Dietary Reference Intakes and a future perspective. *American Journal of Clinical Nutrition,* 91(5): 1430S-1432S

HarvestPlus. (2010). Disseminating orange-fleshed sweet potato: Findings from a HarvestPlus Project in Mozambique and Uganda, Washington, DC (2010)

HarvestPlus. (2014). International food policy research institute. Biofortification progress briefs.

Hefferon, K. L. (2015). Nutritionally Enhanced Food Crops; Progress and Perspectives International. *Journal of. Molecular. Science,* 16: 3895-3914

Hurrell, R. F., Reddy, M. B., Juillerat, M. and Cook, J. D. (2003). Degradation of phytic acid in cereal porridges improves iron absorption by human subjects. *American. Journal of. Clinical*. *Nutrition,* 77: 1213-1219

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

IOM. (2000). Dietary reference intakes for vitamin C, vitamin E, selenium, and carotenoids. (Institute of Medicine), Washington, DC: National Academy Press.

Jaliya, M. M., Sani, B. M., Sani, Y. A., Babaji, B. A. and Zongoma, A. M. (2016). Effect of nitrogen and sulfur nutrient ratios on the levels of protein content in maize grains. *Sky Journal of Agricultural Research,* 5(2): 029-033

Jerome-Morais, A., Diamond, A. M. and Wright, M .E. (2011). Dietary supplements and human health: For better or for worse*? Journal of Molecular. Nutrition. Food Research,* 55: 122-135

Johns, T. and Eyzaguirre, P. B. (2007). Biofortification, biodiversity and diet: A search for complementary applications against poverty and malnutrition, *Journal of Food Policy*, 32: 1-24

Johnson, L. A. (2000). Maize: The Major Cereals of the Americas, 2nd ed. In: Kulp K, Ponte J. G, eds. Handbook of Cereal Science and Technology. New York: Marcel Dekker.

Kansaki, J. K. (2015). Assessment of postharvest losses of maize in the Sissala East and West districts of the upper west region of Ghana. Thesis Kwame Nkrumah University OF science and Technology, Kumasi College of agriculture and natural resources Faculty of horticulture Department of postharvest technology.

Kapil, U. and Sachdev, H. P. S. (2013). Massive dose vitamin A programme in India - Need for a targeted approach. *Indian Journal of Medical Research*. 138(3): 411–417

Kauppi, S. (2015). Behaviour change and communication: - a descriptive literature review of behaviour change and communication in Sub-Saharan countries. Master’s Degree in Global Health Care. Degree: Master of Health Care. Diaconia University of Applied Sciences.

Kaya, H. (2014). The road ahead: Multicultural adult education. *International Journal of Humanities and Social Sciences*, 48 (1): 164

Kaya, H. and Seleti, Y. (2013). African indigenous knowledge systems and relevance of higher education in South Africa. *The International Education Journal: Comparative Perspectives,* 12(1): 30 -44

Kearney, J. (2010). Food consumption trends and drivers, *Journal of Philosophical Transactions of the Royal Society of London series B Biological Sciences,* 27(365): 2793-2807

Kerab, M., Douglas, G., Mallewa, M., Jalloh, A. A., Voskuijl, W. P., Groce, N., Gladstone M. and Molyneux, E. (2014) The interaction of malnutrition and neurologic disability in Africa. *Journal of Serminars in Pediatric Neurology*, 21(1): 42-49

Khabanyane, K. E., Maimane, J. R., Ramabenyane, M. J. (2014). A Critical Reflection on Transformative Learning as Experienced by Student-Teachers during School-Based Learning. *Mediterranean Journal of Social Sciences,* 5(27): 1

Khoo H. E., Prasad, K. N., Kong K. W., Jiang, Y., Ismail., A. (2011). Carotenoids and their isomers: colour pigments in fruits and vegetables. *Journal of Molecules*, 16:1710–1738

Kimenju, S. C. and De Groote, H. (2008). Consumer willingness to pay for genetically modified food in Kenya. *Journal of Agricultural Economics*, 38(1): 35-46

Kolanisi, U. (2010). *Consumer attitudes towards rural water provision and learning strategies to enhance community participation: The case study of Madibogo, North-West Province.* Unpublished Master's dissertation, North-West University, Potchefstroom, South Africa.

Kolanisi, U. (2010). *Consumer attitudes towards rural water provision and learning strategies to enhance community participation: The case study of Madibogo, North-West Province.* Unpublished Master's dissertation, North-West University, Potchefstroom, South Africa.

Krinsky, N. I. (2003). Carotenoids and oxidative stress. In: Cutler, R.G., Rodriguez, H. (Eds.), Oxidative Stress and Aging: Advances in Basic Science, Diagnostics, and Intervention. World Scientific Publishing Co., New York, 598-611

Krondl, M and Coleman, M. S. (1988). The role of food perceptions in food use. *Journal of Current concepts in nutrition,* 16: 53-58

Kulkarni, P. P. (2013). A literature review on training and development and quality of work life. *International Refereed Research Journal,* 4 (2): 136

Labadarios, D., Moedie, I. M. and Van Rensburg, A. (2007). Selected micronutrient status: Vitamin A. in Labadarios, D. (Ed) National food consumption Survey-Fortification Baseline (NFCS-FB): South Africa, 2005. Directorate Nutrition, Department of health, Stellenbosch, South Africa. 409-446

Labadarios, D., Steyn, N., Maunder, E., Macintyre, U., Swart, R., Gericke, G., Huskisson, J., Dannhauser, A., Vorster, H. H. and Nesamvuni, E. A. (2000). The National Food Consumption Survey (NFCS): Children Aged 1-9 Years, South Africa, 1999. Department of Health: Directorate of Nutrition, Pretoria. 1046

Lagerkvist, C. J., Okello, J., Muoki, P., Heck, S., Prain, G. (2016). Nutrition promotion messages: The effect of information on consumer sensory expectations, experiences and emotions of vitamin A-biofortified sweet potato. *Journal of Food quality and preference*, 52:143-152

Layrisse, M., Garcia-Casal, M. N., Solano, L., Baron, M. A., Arguello, F., Llovera, D., Ramirez, J., Leets, I. and Tropper, E. (2000). A new property of vitamin a and beta-carotene on human iron absorption: Effect on phytate and polyphenols as inhibitors of iron absorption. *Archivos Latinoamericanos de Nutrition*, 50(3): 243-248

Lazarova, R. and Athanasios, K. (2010). Consumer's perception of food quality and its relation to the choice of food. Master's thesis, Department of marketing and statistics. Handelshøjskolen. Aarhus Universitet.

Lividini, K. and Fiedler, J. L. (2015). Assessing the promise of biofortification: A case study of high provitamin A maize in Zambia. *Journal of Food Policy,* 54: 65-77

Lofti, M., Manar, V., Richard, M. G. and Van den Heuwel, J .H. M. (1999). Micronutrients fortification of foods, developing a program. *Journal of Food Technology in Africa.* 4: 10

Lott, J. N. A., Ockenden, I., Raboy, V. and Batten, G. D. (2000). Phytic acid and phosphorus in crop seeds and fruits: a global estimate. *Journal of Seed Science Research*, 10: 11-33

Maila, M. W. and Loubster, C. P. (2003). Emancipatory indigenous knowledge system. Implications for environmental education in South Africa. *South African Journal of Education,* 23 (4): 276-280

Mann, K. V. (2011). Theoretical perspectives in medical education: Past experience and future possibilities. *Journal of Medical Education*, 45: 60-68

Marfo, B., Gonzalez, E .C., Moursi, M., Perez, S., Schwarz, J., Zeller, N. and Asare, D. (2013*).* Prioritizing countries for biofortification Interventions using country-level data, No 11 HarvestPlus Working Paper **|** October 2013

Maunder, E. M. W., Matji, J. and Hlatshwayo-Molea, T. (2001). Enjoy a variety of foods- Difficult but necessary in developing countries. Supplement. *South. African. Journal of. Clinical. Nutrition,* 14(3): S7-S11

Mbabazi, J., Bah, M. E. M. and Verdier-Chouchane, A. (2015). Transforming Africa's agriculture to improve competitiveness. http://reports.weforum.org/africa-competitiveness-report-2015/chapter-2-1-transforming-africas-agriculture-to-improve-competitiveness/

Mboya, R., Tongoona, P., Derera, J., Mudhara, M. and Langyintuo, A. (2011). The dietary importance of maize in Katumba ward, Rungwe district, Tanzania, and its contribution to household food security. *African Journal of Agricultural Research*, 6(11): 2617-2626

McCann, .J. C. (2005). Africa and the world ecology of maize. In Maize and grace: Africa's encounter with a New World crop, 1500–2000. Cambridge (MA): Harvard University Press, 1-22

McCrickerd, K., Forde, C. G. (2016). Sensory influences on food intake control: moving beyond palatability. *Journal of Etiology and Pathophysiology*, 17(1): 18-29

McNamara, M. S. (2005). Knowing and doing phenomenology: The implications of the critique of 'nursing phenomenology' for a phenomenological inquiry: a discussion paper. *International Nursing Journal of Studies.* 42 (6): 695-704

McNamara, M. S. (2005). Knowing and doing phenomenology: The implications of the critique of 'nursing phenomenology' for a phenomenological inquiry: a discussion paper. *International Nursing Journal of Studies,* 42 (6): 695-704

Meenakshi, J. V., Johnson, N. L., Manyong, V. M., DeGroote, H. and Javelosa, J. (2010). How cost-effective is biofortification in combating micronutrient malnutrition? An Ex-ante Assessment. *Journal of World Developmen,* 38: 64-75

Melash, A. A., Mengistu, D. K. and Dereje A. A. (2016) Linking Agriculture with Health through Genetic and Agronomic Biofortification. *Journal of Agricultural Sciences,* 7(5): 295-307

Merrill, W. L., Hard, R. J., Mabry, J. B., Fritz, G. J., Adams, K. R., Roney, J. R., and MacWilliams, A. C. (2009) The diffusion of maize to the southwestern United States and its impact. *Proceedings of Natlonal Academy of Sciences of United States of America*, 106(50): 21019-21026

Mesgarani, M. and Shafiee, S. (2016). Advanced biotechnology reseach. International Jou*rnal of Advanced Biotechnology and Research*, 7(3): 172-183

Mezirow, J. (1998). On critical reflection. *Adult Education Quarterly*, 48 (3): 185-198

Mezirow, J. (2000). Learning to think like an adult: Core concepts of transformation theory. (*In* J. Mezirow and Associates (Eds.), *Learning as Transformation: Critical Perspectives on a Theory in Progress*). San Francisco, CA: Jossey-Bass.

Mezirow, J. (2004). Forum comment on Sharan Merriam's: "The role of cognitive development in Mezirow's transformational learning theory." *Adult Education Quarterly,* 55(1): 69-70

Mezirow, J. (2012). Learning to think like an adult: Core concepts of transformation theory. In Taylor, E. W., Cranton, P., and Associates, San Francisco, CA: Jossey-Bass. *The Handbook of Transformative Learning: Theory, Research, and Practice*, 73-95

Miller, D. D. and Welch, R. M. (2013). Food system strategies for preventing micronutrient malnutrition. *Journal of Food Policy*, 42: 115-128

Moise, A. R., Al-Babili, S. and Wurtzel, E. T. (2014). Mechanistic aspects of carotenoid biosynthesis. *Journal of Chemical review*, 114: 164-93

Mulualem, T. (2015). Application of bio-fortification through plant breeding to improve the value of staple crops. *Biomedicine and Biotechnology,* 3(1): 11-19

Murdia, L. K., Wadhwani, N., Wadhwani, R., Bajpai, P. and Shekhawat, S**.** (2016). Maize utilization in India: An overview. *American Journal of Food and Nutrition*, 4(6): 169-176

Muzhingi, T., Langyintuo, A. S., Malaba, L. C. and Banziger, M. (2008). Consumer acceptability of yellow maize products in Zimbabwe. *Journal of Food Policy*, 33: 352-61

Muzhingi, T., Yeum, K. J., Russell, R. M., Johnson, E. J., Qin, J. and Tang, G. (2008). Determination of carotenoids in yellow maize, the effects of saponification and food preparations*. International Journal for Vitamin Nutrition Research,* 78(3):112-20

Nadzri, W. N. M., Musa, R., Muda, M. and Hassan, F. (2016). The Antecedents of Brand Experience within the National Automotive Industry, *Journal of Procedia Economics and Finance,* 37: 317-323

Nair, K. M., Augustine, L. F. and Konapur, A. (2015). A food-based intervention to modify diet quality and diversity to address multiple micronutrient deficiency Front Public Health DOI: 10.3389/fpubh.2015.00277

Nakashima, D. (2010). Indigenous Knowledge in Global Policies and Practice for Education, Science and Culture. Paris: UNESCO.

Nali, M. K. (2015). Food-based interventions to modify diet quality and diversity to address multiple micronutrient deficiencies. *Journal of Frontiers in Public Health*, 3(277): 1-14

Natalie, J., Nannas, R. and Kelly D. (2015). Genetic and genomic toolbox of Zea mays, *Journal of Genetic,* 199: 655-669

Nestel, P., Bouis, H. E., Meenakshi, J. V. and Pfeiffer, W. (2006). Biofortification of staple food crops. *Journal of. Nutrition,* 136: 1064-1067

Nkondo, O. M. (2010). The future of the indigenous knowledge systems in global knowledge innovations. Paper presented at the regional symposium on indigenous knowledge and community innovations in the bioscience and biotechnology in South Africa, Kwa Maritane game lodge.

Nordtest, T. (2002). Acoustics: Human sound perception-guidelines for listening tests. [Www document 1519-00/2].www.nordtest.org

Nuss, E. T. and Tanumihardjo, S. A. (2011). "Quality Protein Maize for Africa: Closing the Protein Inadequacy Gap in Vulnerable Populations*." Advances in Nutrition Journal,* 2: 217-224

Obel-lawson, E. (2006). The efficacy of awareness campaigns by the African leafy vegetables projects on nutrition behaviour change among the Kenyan urban population: the case of Nairobi. M.S. thesis, University of Nairobi, Kenya.

Ogbebor, O. (2011). The value of indigenous knowledge system based on literature review.osarome.blogspot.com/2011/12/write-on-value-of-indigenous-knowledge.html

Ogden, J. (2007). Health Psychology: *A Textbook (4th edition)*. Buckingham, GBR: Open University Press.

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

Olaniyan, A. B. (2015). Maize: Panacea for hunger in Nigeria. *African Journal of Plant Science*, 9(3): 155-174

Oluwalana, I. B. (2014). Comparative effects of sprouting on proximate, mineral composition and functional properties of white and yellow sweet maize (*Zea mays var Saccharata*). *Journal of Emerging Trends in Engineering and Applied Sciences,* 5 (7): 111-115

Onwuekwe, C. (2007). The ideology of the commons and property rights: Who owns plant genetic resources and the associated traditional knowledge? In accessing and sharing the benefits of the genomic revolution. *The International Library of Environmental, Agricultural and Food Ethics,* 11*:* 21-48

Oriade, A. D. (2013). An empirical investigation of the relationship between perceived quality, value, satisfaction and behavioural intentions among visitors to UK attractions, PhD thesis, University of Salford.

Ortiz-Monasterio, I., Palacios-Rojas, N., Meng, E., Pixley, K., Trethowan, R. and Pena R. J. (2007). Enhancing the mineral and vitamin content of wheat and maize through plant breeding. *Journal of Cereal Science,* 46: 293-307

Padilla-Díaz, M. P. (2015). Phenomenology in educational qualitative research: Philosophy as science or philosophical science? *International Journal of Educational Excellence,* 1(2): 101-110

Padulosi, S., Meldrum, G. and Gullotta, G. (2016). Agricultural biodiversity to manage the risks and empower the poor. Proceedings of the International Conference 27-29 April 2015, Rome, Italy. Bioversity International, Rome, Italy.

Pillay, K., Derera, J., Siwela, M. and Veldman, F. J. (2011). Consumer acceptance of yellow, provitamin A biofortified maize in KwaZulu-Natal. *South African Journal of Clinical Nutrition,* 24(4): 186-191

Pillay, K., Siwela, M., Derera, J. and Veldman, F. J. (2014) .Provitamin A carotenoids in biofortified maize and their retention during processing and preparation of South African maize foods. Journal of Food Science and Technology, 1(4): 634-44

Pradhan, P., Fischer, G., Van Velthuizen, H., Reusser, D. E. and Kropp, J .P. (2015). Closing yield gaps: How Sustainable Can We Be*? PLoS ONE,* 10: 6

Purseglove, J. W. (1972). Tropical Crops: Monocotyledons 1. Longman Group Limited, London.

Raboy, V. (2003). Myoinositol-1, 2, 3,4,5,6 hexakisphosphate. *Journal of Phytochemistry,* 64: 1033-43

Radu, A., Urechean, V., Naidin, C. and Motorga, V. (1997). The theoretical significance of a mutant in the phylogeny of the species Zea mays L. *Maize Newsletter*. 71: 77-78

Ramakrishman, U. (2002). Prevalence of micronutrients malnutrition worldwide. *Nutrition Review Journal*, 60 (5pt2): 546-552

Ranum, P. (2014) Technical Considerations for Maize Flour and Maize Meal Fortification in Public Health. *African journal of plant science,* 1312:105-112

Ranum, P., Pena-Rosas, J. P. and Garcia-Casal, M .N. (2013). Global maize production, utilization, and consumption. *Annals of the New York Academy of Sciences*, 1312: 105 - 112

Ravisankar, P., Reddy, A.A., Nagalakshmi, B., Koushik, O.S. B., Kumar, B.V. and Anvith, P. (2015). The Comprehensive Review on Fat Soluble Vitamins. *IOSR Journal Of Pharmacy,* 5(11): 12-28

Reboul, E. (2013). Absorption of Vitamin A and Carotenoids by the Enterocyte. *Journal of Focus on Transport Proteins,* 5(9): 3563-3581

Reboul, E. (2013). Absorption of Vitamin A and Carotenoids by the Enterocyte: Focus on Transport Proteins. *Journal of Nutrients*, 12(5) 9

Revy, P. S., Jondreville, C., Dourmad, J. Y. and Nys, Y. (2006). Assessment of dietary zinc requirement of weaned piglets fed diets with or without microbial phytase*. Journal of Animal Physiology and Animal Nutrition,* 90(1-2): 50-59

Roth, M. and Lee, S. (2004). Science education as/for participation in the community. *Journal of Science Education*, 88: 263-291

Rowe, L. A. and Dodson, D. M. (2012). A knowledge-to-action approach to food fortification: Guiding principles for the design of fortification programs as a means of effectively addressing micronutrient malnutrition. *Health,* 4(10): 904-909

Ruwaida, A., Pillay, K., Siwela, M. and Kolanisi, U. (2016) Acceptance of a Complementary Food based on Provitamin A Biofortified Maize and Chicken Stew. *Journal Human Ecology*, 55(3): 152-159

Salim, E. R., Ahmed, W. A., Mohamed, M. A., ALSiddig, M. A. and Hamed, S. Y. (2017). Fortified Sorghum as a Potential for Food Security in Rural Areas by Adaptation of

Technology and Innovation in Sudan. *Journal of Food Nutrition and Population Health,* 1:1

Samaniego-Vaesken, M., Alonso-Aperte, E. and Varela-Moreiras, G. (2012). Vitamin food fortification today. *Journal of Food and Nutrion Research*, 56

Schiffman, L. G and Kanuk, L L. (2010). Consumer Behavior. 10th ed. Upper Saddle River, New Jersey: Prentice Hall.

Schiffman, L. G. and Kanuk, L. L. (1991). Consumer behaviour. Fourth Edition. Englewood Cliffs, New Jersey: Prentice-Hall International, Inc.

Schiffman, L. G. and Kanuk, L. L. (2004). Consumer Behaviour. *(8th ed*). Upper Saddle River, Prentice Hall.

Schlitz, M. M., Vieten, C. and Miller, E. M. (2010). Worldview Transformation and the Development of Social Consciousness. *Journal of Consciousness Studies*, 17, (7-8): 18-36

Schwarz, N., and Xu, J. (2011) Why don't we learn from poor choices? The consistency of expectation, choice, and memory clouds the lessons of experience. *Journal of Consumer Psychology*, doi:10.1016/j.jcps.2011.02.006.

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

Shisana, O., Labadarios, D., Rehle, T., Simbayi, L., Zuma, K., Dhansay, A., Reddy, .P, Parke,r W., Hoosain., E, Naidoo, P., Hongoro, C., Mchiza, Z, Steyn, N.P., Dwane, N., Makoae, M., Maluleke, T., Ramlagan, S., Zungu, N., Evans, M.G., Jacobs, L., Faber M, and the SANHANES-1 Team (2014) *South African National Health and Nutrition Examination Survey (SANHANES-1)*: 2014 Edition. Cape Town: HSRC Press.

Simpungwe, E.; Dhliwayo, T.; Palenberg, M.; Taleon, V.; Birol, E.; Oparinde, A.; Saltzman, A.; and Diressie, M.T. (2017). Orange maize in Zambia: crop development and delivery experience. *African Journal of. Food and Agriciculture, Nutrition.and Development*, 17(2): 11973-11999

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

Sniffen, C.J., Robinson, P. H. (1987). Symposium: Protein and fiber digestion, passage, and utilization in lactating cows*. Journal of. Dairy Science,* 70: 425-441

Soetan, K. O., Olaiya, C. O. and Oyewole, O. E. (2010). The importance of mineral elements for humans, domestic animals and plants: A review. *African Journal of Food Science*, 4(5): 200-222

Sokrab, A. M., Mohamed Ahmed, I. A., Babiker, E. E. (2014). Effect of fermentation on antinutrients, and total and extractable minerals of high and low phytate corn genotypes. *Journal of Food Science and Technology*, 51(10): 2608–2615

Stahl, W. and Sies, H. (2005). Bioactivity and protective effects of natural carotenoids. *Journal of Biochemical Biophysical Acta,* 1740: 101-7

Starr, L., (2017). *Theory of Change: Facilitator's Guide*. Washington, DC: TANGO International and the Technical and Operational Performance Support (TOPS) Program.

Stevens, G. A., Bennett, J. E., Hennocq, Q., Lu, Y., De-Regil, L. M., Rogers, L., Danaei, G., Li, G., White, R. A., Flaxman, S. R., Oehrle, S. P., Funucane, M. M., Guerrero, R., Bhutta, Z. A., Then-Paulino, A., Fawzi, W., Black, R. E. and Ezzati, M. (2015). Trends and mortality effects of vitamin A deficiency in children in 138 low-income and middle-income countries between 1991 and 2013: a pooled analysis of population-based surveys. *Journal of The Lancet Global Health,* 3(9): e528 - e536

Stevens, R. and Winter-Nelson, A. (2008). Consumer acceptance of provitamin A biofortified maize in Maputo, Mozambique. *Journal of Food Policy,* 33(4): 341-351

Stone, H. and Sidel, J. (1993). Sensory evaluation practices. California: Academic Press.

Talsma, E. F., Boonstra, A. M., de Kock, B. P., Gloria, N .K., Mbera, G., NMwangi, A. M. and Brouwer, I. D. (2013). Biofortified Cassava with provitamin A is sensory and culturally acceptable for consumption by primary school children in Kenya. PLoS One, 8 (9): e73433

Tanumihardjo, S. A. (2012). Xanthophylls as provitamin A carotenoids. *Journal of Sight and Life*, 26(2): 48-55

Tanumihardjo, S. A., Bouis, H., Hotz, C., Meenakshi, J. V. and McClafferty, B. (2008). Biofortification of staple crops: an emerging strategy to combat hidden hunger. On "Food Technology for Better Nutrition." Comp. *Rev. Food Sci*. *Safety.* 7: 329-334.

Taylor, E. W. and Cranton, P. (2013). A theory in progress? Issues in transformative learning theory. *European journal for Research on the Education and Learning of Adults* 4 (1): S. 33-47

Taylor, J. and Russo, V. (2002). "The SADC regional environmental education programme". In The Long Walk to Sustainability: A southern Africa perspective, South Africa: Johannesburg.11: 36-40

Ravisankar, P., Reddy, A., Nagalakshmi, B., Koushik1, O., Kumar, V. and Anvith. P. (2015). The Comprehensive Review on Fat-Soluble Vitamins. *International Organisation of Science Research Journal of Pharmacy*, 5(11): 12-28

Timmons, V. and Alur, M. (2004). Transformational learning: a description of how inclusionary practice was accepted in India. *International Journal of Special Educatio*n, 19(1): 1-11

Tothova, M. and Meyers, W. H. (2006). Modelling the acceptance of high beta-carotene maize, Annual Meeting, 23-26 July. Long Beach, CA: American Agricultural Economics Association.

Tripathi, K. K., Warrier, R., Govila, O. P. and Ahuja, V. (2011). "Biology of Zea mays (Maize)". Department of Biotechnology, Ministry of Science and Technology and Ministry of Environment and Forests, Government of India. 2011.

Troesch, B., Egli, I., Zeder, C., Hurrell, R. F., de Pee, S. and Zimmermann, M. B. (2009). Optimization of a phytase-containing micronutrient powder with low amounts of highly bioavailable iron for the in-home fortification of complementary foods *Am. J. Clin. Nutr*, 89: 539-544.

Tschirley, D. L and Santos, A. P. (1995). Who eats yellow maize? Preliminary results of a survey of consumer maize preferences in Maputo, Mozambique. International Development Working Paper 53. East Lansing, Mich., U.S.A. Michigan State University.

Tucker, G. (2003). Nutritional enhancement of plants. *Journal of Current Opinion in Biotechnology,* 14: 221-225

Tumuhimbise, G. A., Namutebi, A., Turyashemererwa, F. and Muyonga, J. (2013). Provitamin A crops: acceptability, bioavailability efficacy and effectiveness. *Food and Nutrition Sciences,* 4(4): 430-435

UNICEF. (2013). Improving child nutrition: The achievable imperative for global progress. New York.

UNICEF. (2015). The State of the world's children, United Nations children's fund. New York.

UNICEF. 2007. Vitamin A Supplementation: A decade of progress.
Vabo, N. and Hansen, H. (2014). The Relationship between Food Preferences and Food Choice: A Theoretical Discussion. *International Journal of Business and Social Science* 5: 7

Veale, R. (2007). Investigating the simultaneous influence of intrinsic and extrinsic cues: an examination of the interaction between country of origin, price and selected sensory variables.Retrieved72012.http://digital.library.adelaide.edu.au/dspace/bitstream/2440/38837/2/02/whole.pdf

Verheye, W. (2010). Soils, plant growth and crop production. Growth and production of maize: Traditional low input cultivation. UNESCO-EOLSS. 11

Verplanken, B. and Wood, W. (2006). Interventions to break and create consumer habits. *Journal of Public Policy and Marketing*. 25(1): 90-103

Vijayan, J., Slaughter, D. C. and Paul, S. R. (2015). Optical properties of maize oil during frying*. Journal of International Food Science and Technoly,* 31: 353-358

Wartemann, G., Sağlam, T., and McAvoy, M. (2015). Youth and Performance: Perceptions of the Contemporary Child*.* Medien und Theater 13, Hildesheim, Zürich, New York: Georg Olms Verlag.

Watson, L. and Dallwitz, M. J. (1992). Grass Genera of the World: Descriptions, Illustrations, Identification, and Information Retrieval; including Synonyms, Morphology, Anatomy, Physiology, Phytochemistry, Cytology, Classification, Pathogens, World and Local Distribution, and References. Version: 18th August 1999.

Wenhold, F. and Faber, M. (2008). Nutritional status of South Africans: Links to agriculture and water. Water Research Commission Report No TT 362/P/08. Pretoria.

Wesley, A. and Ranum, P. (2004). Fortification Handbook: Vitamin and mineral fortification of wheat flour and maize “micronutrients initiative”. Ottawa. Available online: http://www.miconutrients.ord/resources/publicatios/fort-handbook.pdf.

Whitney, E. N. and Rolfes, S. R. (1999). Understanding Nutrition. 8th edition. Belmont. West/Wardsworth.

WHO. (2003). Combating vitamin A deficiency. World Health Organisation, Rome, Italy.

WHO. (2009). Foods derived from modern biotechnology, World Health Organization, Food and Agriculture Organization, Rome.

WHO. (2011). *Guideline: Vitamin A supplementation in infants and children 6–59 months of age*. Geneva, World Health Organization, 2011.

WHO. (2012). Health Education: Theoretical Concepts, Effective Strategies and Core Competencies. Rome, Italy: WHO.

WHO. (2012). National vitamin a supplementation policy guidelines for South Africa 2012.

WHO. (2014). Making fair choices on the path to universal health coverage, Final report of the WHO Consultative Group on Equity and Universal Health Coverage.

WIPO. (2006). “Intergovernmental committee on intellectual property and genetic resources, Traditional knowledge and folklore”. Draft secretariat report: 27.34. WIPO/GRTKF/IC/9/10 Geneva http://www.wipo.int.

World. Health Report. (2003). Shaping the future. World Health Organization: Geneva.

Young, A. J. and Lowe, G. L. (2018) Carotenoids-Antioxidant Properties. *Antioxidants* 7: 28

Zarnowiecki, D. M., Parletta, N. and Dollman, J. (2014). The role of socioeconomic position as a moderator of children's healthy food intake. *Journal of Public Health Nutrition* 112(5): 830-840

CHAPTER EIGHT: APPENDICES

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

Stationary **Equipment** **Food** **Forms** **Other Checklist**

Research files	10 Knives	Juice, assorted	Demography questionnaires	Tape recorder and cassettes	
Pens	Paper plates	Bread	Consent forms	Testing booths	
Pencils	Paper serviettes	Bread spread		Venue	

Exam pads	Small bowls	Yellow/Orange maize seeds		Camera	
Calculator	Measuring spoons	Cake flour		Remuneration	
Pair of scissors	Mixing bowl	Baking powder Salt			
	Measuring jug	Sugar			
	Cup	Yeast			
	Teaspoon	Water			
	Tablespoon				
	Sieve				

	Pot				
	Sunlight liquid				
	Dishwasher				
	Dish drier				
	Metal wrack				
	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.

<u>Personal information</u>:

Education level of household head **(Tick one only)**	1	2	3	4	5	6
	None	Primary school	Std 6-8	Std 9-10	Tertiary education	Don't know
Mother's employment status **(Tick one only)**	1	2	3	4	5	6
	Housewife by choice	Unemployed	Self-employed	Wage earner	Other, specify:	Don't know
Education level of breadwinner **(Tick one only)**	1	2	3	4	5	6
	None	Primary school	Std 6-8	Std 9-10	Tertiary education	Don't know
Father's employment status	1	2	3	4	5	6

(Tick one only)	Unemployed	Self-employed	Wage earner	Retired by choice	Other, specify:	Not applicable e.g. dead	
	1 person 1 person	2 persons 2 persons	3-4 persons 3-4 persons	5-6 persons 5-6 persons	More than 6		
Household income per month (including wages, rent, sales of veggies, etc, state grant) **(Tick one only)**	1	2	3	4	5	6	7
	None	R100-R500	R500-R1000	R1000-R3000	R3000-R5000	Over R5000	Don’t know
	1	2					

Is this usual income of the household? **(Tick one only)**	Yes		No		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)**	1		2							
	Yes		No							
How much money does household on food spend weekly? **(Tick one only)**	1	2	3	4	5	6	7	8	9	10
	R0 - R50	R50- R100	R100- R150	R150- R200	R200- R250	R250- R300	R300- R350	R350- R400	R400- R450	R450- R500

Marital status (tick one only)

1	2	3	4	5	6	7	8
Unmarried	Married	Divorced	Separated	Widowed	Living together	Traditional marriage	Other, specify

Now decide on the following:

Type of dwelling	1	2	3	4	5
	Brick, concrete	Plastic	Tin	Plank, wood	Other, specify:
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)	1	2	3		
	0-2 persons	3-4 persons	More than 4		

Participant ID number:__________________ Interviewer:__________________

Name:_____________________________ Date:_______________________

Address:____

VITAMIN A FOOD ITEMS CONSUMPTION

10.2.1. Do you ever eat the following foods rich in vitamin A?

FOOD	**DESCRIPTION**	**AMOUNT**	**TIME EATEN**				**CODE AMOUNT/DAY**	
Liver			**Per Day**	**Per Week**	**Per Month**	**Seldom /Never**		
Paprika								
Red pepper								
Cayenne pepper								
Chili powder								
Sweet potatoes								
Carrots								

Dark leafy greens								
Butternut								
?								
Squash								
Dried herbs								
Dried basil								
Lettuce								
Dried apricot								
Cantaloupe								

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

Close Close

Interviewer Name	
Respondent name	
Respondent ID	
Note: if person, not a South African	Close and terminate the interview
Respondent Tel nr.	
Respondent email address:	

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
Close Close	**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**

No	Continue with interview
yes	Close and terminate the 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?**

Days		**Periods**	
Monday -Saturday		**11h -12.30 and 13h - 14.30**	
Yes	**No**	**Yes**	**No**

Yes for days and periods: continue with Interview

Close Close

No for days/ or periods: close and terminate the interview

9. Qualitative phase specification (Check by the interviewer)

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

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**

Workstation	Product Number	Product Name	Participant Name	Signature
One				
Two				
Three				
Four				
Five				
Six				
Seven				
Eight				
Nine				
Ten				

Name ………………………………………
Date………………………………………

Product……………………………………….

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 Ndwandwe 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)

Appearance	Definition	Refences	Score 0 - 10
Yellow	The intensity of yellow colour of *phuthu*	Butter Egg yolk	Light yellow = 2 Very yellow = 10
Rough	The degree of roughness perceived on the surface of *phuthu*	Butter surface Broken maize (grits)	Not rough/smooth = 0 very rough = 10
White specks	The presence of white specks in phuthu	Yellow flour Coconut in yellow flour	No specs= 0 Many white particles= 10
Dry	The dryness of *phuthu*	Yello maize paste (20% solid) Yellow maize flour	Moist = 0 Very =dry
Aroma			
Overall aroma of phutu	The intensity of the overall aroma of *phuthu*		Not intense = 0 Very intense = 10

Cooked maize aroma	The degree of cooked maize aroma	25% maize porridge	Not intense = 0 Very intense = 10
Flavour			
Overall Flavour	Intensity of the overall flavour of *phuthu*		Not intense= 0 Very intense= 10
Cooked maize flavour	The intensity of cooked maize flavour of *phuthu*	25% maize porridge	Not intense= 0 Very intense =10
Residues	The number of particles left in the mouth after swallowing *phuthu*	All bran flakes	No particles= 0 Many particles= 10
Texture			
Crumbliness	The force required to crumble *phuthu* at 1st bite in the mouth	Maize puffs Rusks	No force=0 More force= 10
Chewiness	The force required to chew *phuthu* until swallowed	Rusks	No effort= 0 More effort= 10
Roughness	The degree of rough particles perceived while eating *phuthu*	All bran flakes	Not rough= 0 Very rough= 10

Stickiness	The extent to which phuthu adheres ^^^^^	25% cooked starch gel	Not sticky= 0 Very sticky=10
Mouldiness	The ease of moulding *phuthu*	25% maize porridge Yellow maize flour	Very easy= 0 Not easy (Very difficult)= 10

Appendix C: Nutrition education programme

25 November 2014

08h00a.m: - Registration and tea

9h00a.m – 9h10a.m: Opening and welcoming - Researcher

9h15a.m - 10h30a.m: Pre-knowledge questionnaire

10h30a.m – 11h30a.m: What is food – Siboniso Nkosi and Kwazi Zuma

11h30a.m – 12h00p.m: Group discussion

12h00p.m – 13h00pm: Lunch

13h00p.m – Reflection session

13h30p.m – 14h30pm: Food security – Mosa Selepe

14h30p.m – 15h00pm: Group discussion

15h00p.m -15h15p.m: Tea

15h15p.m – 15h30pm: Group discussion

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

12h000p.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

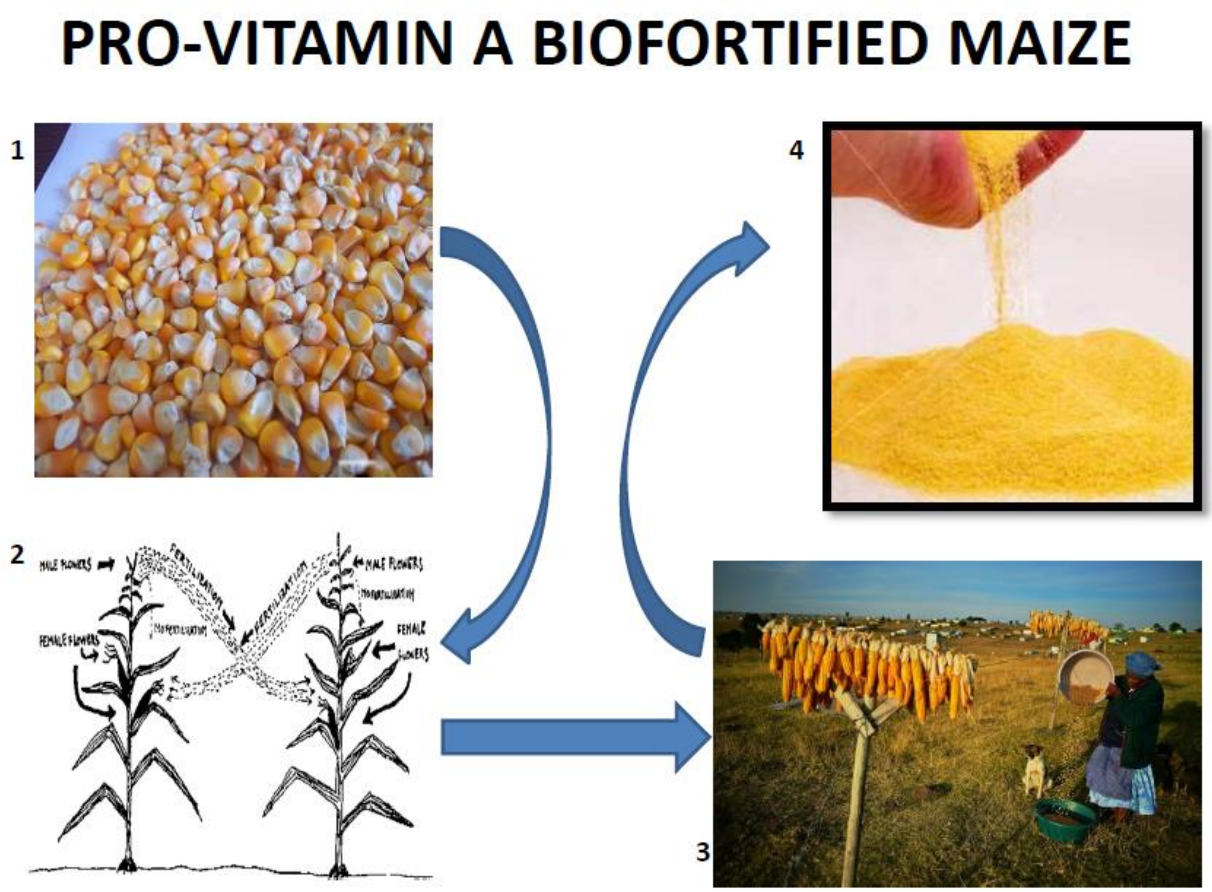
11h30.00a.m – 12h00p.m: Post- knowledge questionnaire

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

13h000p.m – 14h00p.m: Lunch

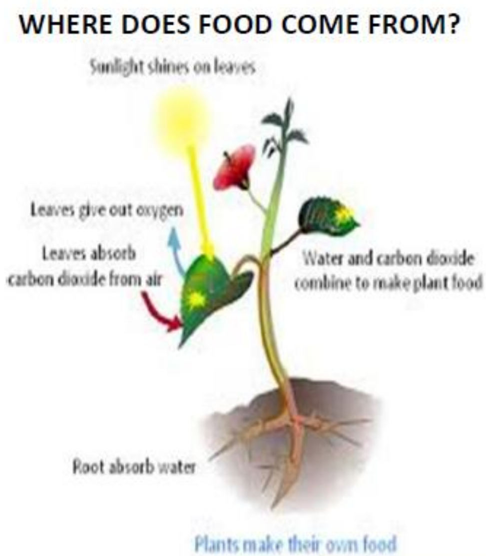
14h00p.m – 16h00p.m: Award ceremony (Dr Siwela and Dr Selepe to lead)

Appendix D: Teaching material for educating communities about provitamin A biofortified maize



1. WHAT IS FOOD?

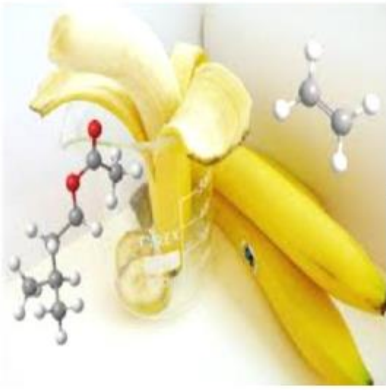
- An item that enters the body's systems and tissues to build, repair and maintain life (Wilson *et al.,* 2009)
- Human survival depends on getting food.



Chemical elements.

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?

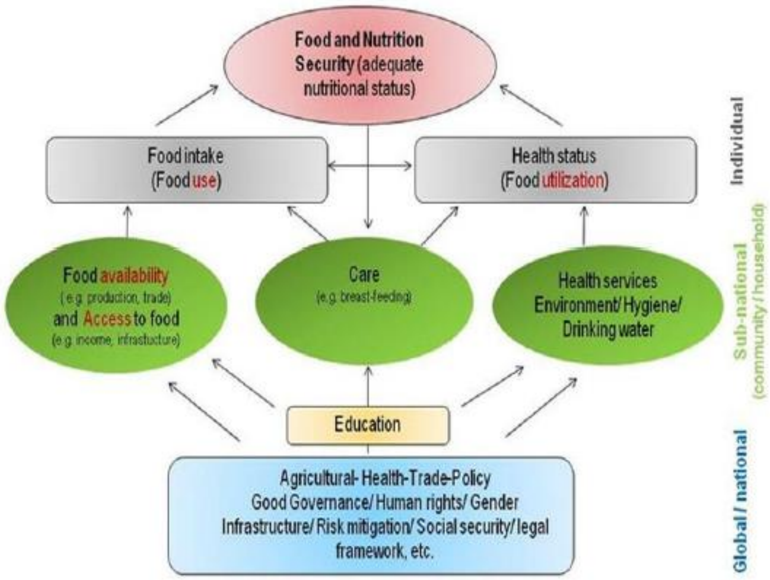
- **2001/2 World Food Summit:** *"Food security is a situation that exists when all people, at all times,* ***have physical, social and economic access to sufficient****, safe and* ***nutritious food that meets their dietary needs*** *and food preferences for an* ***active and healthy life.***

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).

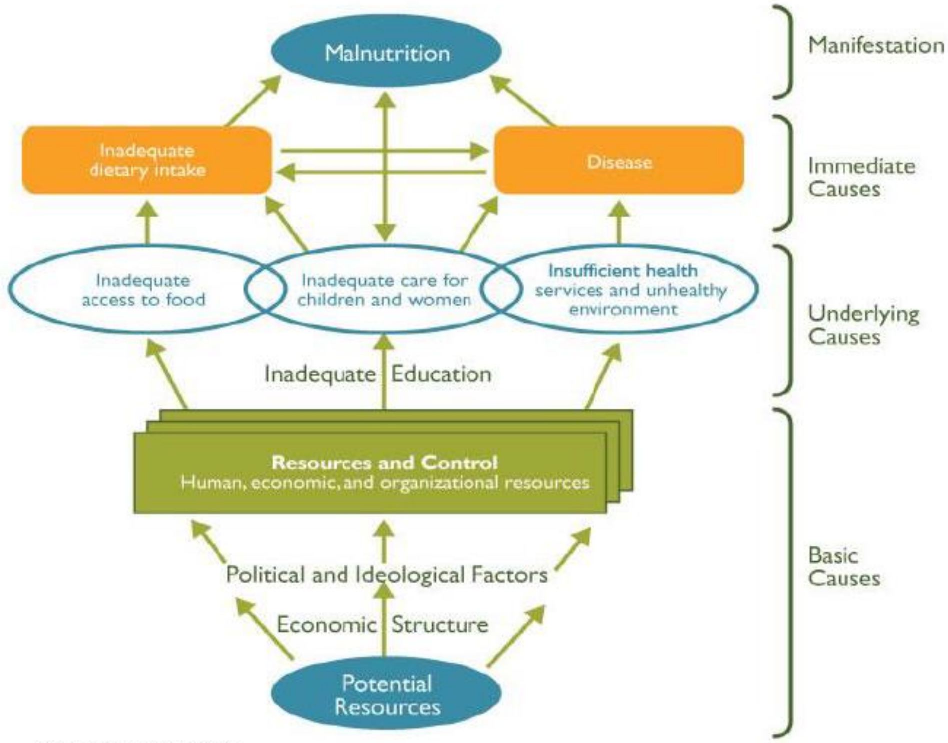
RELATIONSHIP BETWEEN FOOD AND NUTRITION SECURITY



Food and nutrition security is about:

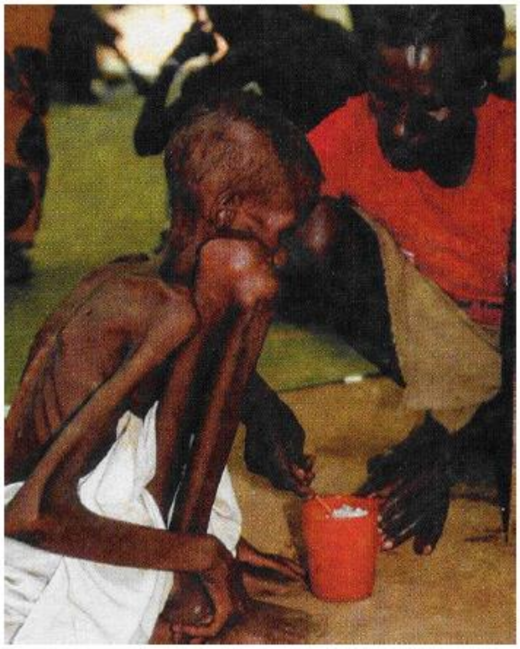
- Where do you get food?
- How much food?
- What kind of food?
- Who should get food?
- When is food available?
- How do you acquire and obtain food?

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.

WAYFORWARD

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

Schedule of product release. Crop	**Nutrient**	**Countries of first release**	**Agronomic trait**	**Release year**
Sweetpotato	Pro-vitamin A	Uganda, Mozambique	Disease resistance, Drought tolerance, acid soil tolerance	2007
Bean	Iron, Zinc	Rwanda, DR Congo	Virus resistance, Heat and drought tolerance	2010
Pearl Millet	Iron, Zinc	India	Mildew resistance, Drought tolerance	2011
Cassava	Pro-vitamin A	Nigeria, DR Congo	Disease resistance	2011-12
Maize	**Pro-vitamin A**	**Zambia**	**Disease resistance, Drought tolerance**	**2011-12**
Rice	Zinc, Iron	Bangladesh, India	Disease and pest resistance, cold and submergence tolerance	2012-13
Wheat	Zinc, Iron	India, Pakistan	Disease resistance, Lodging	2012-2013

STUDIES THAT HAVE BEEN DONE IN KWAZULU NATAL

Studies	Findings	References
Acceptability of Provitamin A biofortified	• Acceptance varied with consumer demographic profiles – younger consumers accepted Provit A the same as white maize whilst older seemed to preferred white maize	Pillay et al (2011)
Acceptability of Provitamin A biofortified dishes/beverages	• Acceptance of Provit A varied food type – an opportunity to increase acceptance through recipe development	
	• **Phuthu** more acceptable than **samp** and thin porridge	Pillay et al (2011)
	• Provit A biofortifed **stiff porridge** was as acceptable as white maize	Daniso et al (2012)
	• Acceptability of corn bread as corresponding to the white corn bread	Ndwandwe (2012)
	• Acceptability of roasted fresh Provitamin A maize was more acceptable than white • Boiled fresh Provit A maize was as acceptable as the corresponding white products	Qwabe (2013)
	• Provit A weaning foods as acceptable as correspond weaning foods by care givers	Govender et al (2013)
	• Pop corn Provit A biofortified maize highly acceptable to consumers	Jele et al (2014)
	• Amahewu Provitamin A biofortified maize was as accpetable as white maize	Awobusuy (2014)

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)*
kolanisi@ukzn.ac.za
Dr Muthulisi Siwela *(Dietetics &Human Nutrition)*
Siwelam@ukzn.ac.za
Mrs Kate Ndwandwe

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.

Table1: Global estimates of malnourishment (Hunger) 1960-2013 *(Source: HLPE, 2012 and FAO, 2014)*

Period	**No of malnourished (million)**
1969-71	875
1979-81	850
1990-92	848
1995-97	792
2000-02	836
2006-08	850
2009	1023*
2010	925*
2011-2013	842*

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

Schedule of product release. Crop	**Nutrient**	**Countries of first release**	**Agronomic trait**	**Release year**
Sweetpotato	Pro-vitamin A	Uganda, Mozambique	Disease resistance, Drought tolerance, acid soil tolerance	2007
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Wheat	Zinc, Iron	India, Pakistan	Disease resistance, Lodging	2012-2013

Multi-Sectoral Holistic Approach

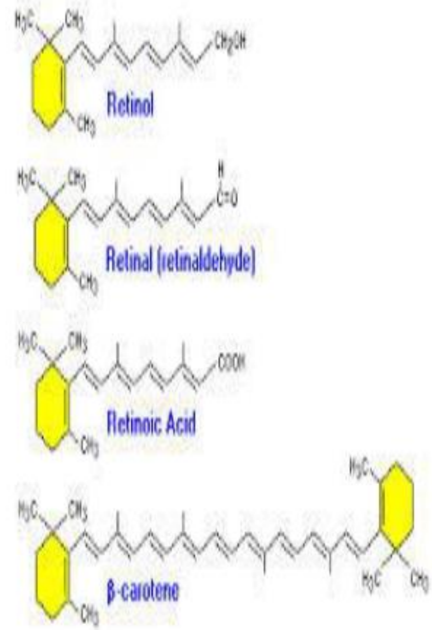
Biofortification is a pro-poor & cost effective intervention that requires:

- 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 Questionnare

	Strongly agree (%)		Disagree (%)		Not sure (%)		Agree (%)		Strongly agree (%)	
	Pre vit. A awareness campaign	Post vit. A awareness campaign	Pre vit. A awareness campaign	Post vit. A awareness campaign	Pre vit. A awareness campaign	Post vit. A awareness campaign	Pre vit. A awareness campaign	Post vit. A awareness campaign	Pre vit. A awareness campaign	Post vit. A awareness campaign
White maize has more nutrients than other foods	9.5	38.1	28.6	19.1	33.3	14.3	9.5	14.3	19	14.3
I know about biofortification	14.3	0	4.8	0	28.6	4.8	23.8	19	28.6	76.2
I know about vitamin A deficiency	0	0	9.5	0	14.3	4.8	28.6	33.3	47.6	61.9
I am aware that vitamin A deficiency is a health problem in South Africa	0	0	4.8	0	19	9.5	23.8	19	52.4	71.4
I understand that vitamin A deficiency is a health as well a economic problem	9.5	0	9.5	0	9.5	14.3	23.8	23.8	47.6	61.9

Sources of Vitamin A

Table 4: Selected Food Sources of Vitamin A

Food	mcg RAE per serving	IU per serving	Percent DV*
Sweet potato, baked in skin, 1 whole	1,403	28,058	561
Beef liver, pan fried, 3 ounces	6,582	22,175	444
Spinach, frozen, boiled, ½ cup	573	11,458	229
Carrots, raw, ½ cup	459	9,189	184
Pumpkin pie, commercially prepared, 1 piece	488	3,743	249
Peppers, sweet, red, raw, ½ cup	117	2,332	47
Mangos, raw, 1 whole	112	2,240	45
Black-eyed peas (cowpeas), boiled, 1 cup	66	1,305	26
Apricots, dried, sulfured, 10 halves	63	1,261	25
Broccoli, boiled, ½ cup	60	1,208	24
Ready-to-eat cereal, fortified with 10% of the DV for vitamin A, ¾–1 cup (more heavily fortified cereals might provide more of the DV)	127–149	500	10
Milk, fat-free or skim, with added vitamin A and vitamin D, 1 cup	149	500	10
Baked beans, canned, plain or vegetarian, 1 cup	13	274	5
Egg, hard boiled, 1 large	75	260	5
Salmon, sockeye, cooked, 3 ounces	59	176	4
Yogurt, plain, low fat, 1 cup	32	116	2
Tuna, light, canned in oil, drained solids, 3 ounces	20	65	1
Chicken, breast meat and skin, roasted, ½ breast	5	18	0

Sources of Vitamin A

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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).*
- Inadequate breastfeeding, poor quality complementary feeding and a poor diet in childhood can also contribute to VAD in children (Ahmed & Darnton-Hill 2004, p201).
- 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).

	WHO (1995-2005)	UNSCN (2007)
Country	Percentage (%)	Percentage (%)
Mozambique	68.60	33.40
Angola	64.30	43.80
DCR	61.10	42.20
Malawi	59.20	47.10
Zambia	54.10	40.20
Swaziland	44.60	30.10
Madagascar	42.10	33.10
Zimbabwe	35.80	27.30
Lesotho	32.70	28.50
Botswana	26.10	23.10
Tanzania	24.20	33.80
Namibia	17.50	25.10
South Africa	16.90	24.80
Mauritius	9.20	18.80
Average	39.74	32.24

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
  - Severe fat malabsorption
  - Chronic diarrhoea
  - Crohn's disease
  - AIDS
  - Alcoholism and liver disorders.
  - Coeliac disease
  - Pancreatic insufficiency
  - Cystic fibrosis
  - Premature infants

Appendix E: Pre/post - focus group discussion guide

Warm up questions

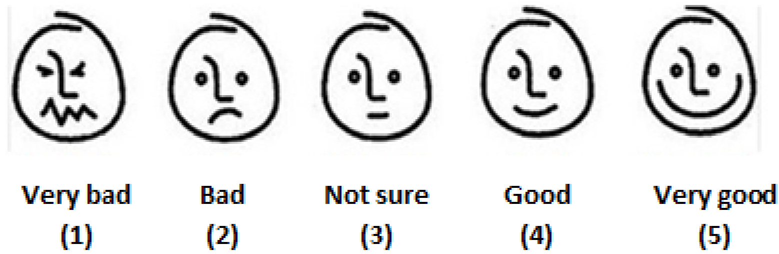
1. What thoughts come to your mind when talking about maize?
    a. What nutrients do you expect from maize?
    b. Are there any major differences between yellow and white maize?
    c.
    d. What food preparation methods do you know for preparing different types of maize?
    e. Production management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



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

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

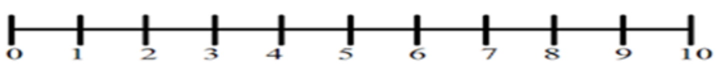


Table of Random Numbers

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46132 81380 75635 19428 88048 08747 20092 12615 35046 67753 69630 10883 13683
31841 77367 40791 97402 27569 90184 02338 39318 54936 34641 95525 86316 87384
84180 93793 64953 51472 65358 23701 75230 47200 78176 85248 90589 74567 22633
78435 37586 07015 98729 76703 16224 97661 79907 06611 26501 93389 92725 68158
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13019 07274 51068 93129 40386 51731 44254 66685 72835 01270 42523 45323 63481
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69226 38655 03811 08342 47863 02743 11547 38250 58140 98470 24364 99797 73498
25837 68821 66426 20496 84843 18360 91252 99134 48931 99538 21160 09411 44659
38914 82707 24769 72026 56813 49336 71767 04474 32909 74162 50404 68562 14088
04070 60681 64290 26905 65617 76039 91657 71362 32246 49595 50663 47459 57072
01674 14751 28637 86980 11951 10479 41454 48527 53868 37846 85912 15156 00865
70294 35450 39982 79503 34382 43186 69890 63222 30110 56004 04879 05138 57476
73903 98066 52136 89925 50000 96334 30773 80571 31178 52799 41050 76298 43995
87789 56408 77107 88452 80975 03406 36114 64549 79244 82044 00202 45727 35709
92320 95929 58545 70699 07679 23296 03002 63885 54677 55745 52540 62154 33314
46391 60276 92061 43591 42118 73094 53608 58949 42927 90993 46795 05947 01934
67090 45063 84584 66022 48268 74971 94861 61749 61085 81758 89640 39437 90044
11666 99916 35165 29420 73213 15275 62532 47319 39842 62273 94980 23415 64668
40910 59068 04594 94576 51187 54796 17411 56123 66545 82163 61868 22752 40101
41169 37965 47578 92180 05257 19143 77486 02457 00985 31960 39033 44374 28352
76418