

Nutrient and sensory quality of orange-fleshed sweet potato

by

Christina Stephanie Leighton

**Dissertation submitted in partial fulfilment of the requirements for the
degree**

Masters in Consumer Science

Department Consumer Science

**School of Agricultural and Food Sciences
University of Pretoria
South Africa**

July 2007

**Study leaders: Prof HC Schönfeldt
Dr R Kruger**

ACKNOWLEDGEMENTS

I hereby wish to express my sincere gratitude and appreciation to the following persons and institutions for their valuable contribution to the successful completion of this study:

My study leader Prof Hettie Schönfeldt of the Department Consumer Science, University of Pretoria for her assistance in designing, executing and writing up of the project. Also for her continuous support, personally and professionally, throughout the study.

Thank you to Dr Rozanne Kruger as my study leader from the Department Consumer Science, University of Pretoria for her assistance and guidance in writing up of the project. Also for her continuous support throughout the study.

My co-workers at the Agricultural Research Council (ARC) i.e. Mrs Janice van Niekerk and Mrs Elsa Visser for their assistance and support in conducting the research, especially with the consumer research and sensory evaluation.

Thank you to Mrs Ina van Heerden and Dr Beryl Zondag of the ARC for their assistance and support with this study.

Mrs MF Smith and Mrs L Morey of ARC- Biometry for the statistical analysis of the study.

Mrs Sunette Laurie from the ARC-Roodeplaat Vegetable and Ornamental Plant Institute for sourcing of the samples and her assistance with this study.

My immediate family and friends for their endurance and endless support during the completion of the study.

ABSTRACT

Nutrient and Sensory quality of orange-fleshed sweet potato

by

Christina Stephanie Leighton

Leaders: Dr HC Schönfeldt
Dr R Kruger

Department of Consumer Science
Faculty Natural and Agricultural Sciences
University of Pretoria

for the Master's Degree in Consumer Science

Vitamin A deficiency has been recognised as a widespread problem affecting about 750 million people, mostly in developing countries. Mortality due to vitamin A deficiency can be reduced by as much as 23 % with improved vitamin A status. Vitamin A's immune-enhancing aspects strengthen the body's defence system against infectious diseases such as measles, malaria and diarrhoea, thus preventing death. Children beyond the weaning age (6 months to 6 years) are most at risk. In South Africa, one in three children has a low vitamin A status, with the rural areas being most affected. Orange-fleshed sweet potato (OFSP) has emerged as a promising plant source with a high beta-carotene content that can make a significant contribution to the vitamin A intake of individuals at risk of vitamin A deficiency.

The purpose of this study was to determine the nutrient and sensory quality of OFSP. To this end, the nutrient content of different cultivars of OFSP was determined as well as the sensory characteristics and consumer acceptability was established.

During the first phase, four different cultivars of OFSP i.e. Resisto, W119, Jewel and A15, plus one composite sample, all cultivated by the Agricultural Research Council (ARC)-Roodeplaat, South Africa, were sampled for nutrient analysis. During the second phase (descriptive sensory analysis), four OFSP cultivars and one white-fleshed sweet potato (WFSP) cultivar i.e. Blesbok, were evaluated. A trained sensory panel was used

to establish terminology for describing the sensory attributes of the different sweet potato cultivars in terms of its aroma, texture, flavour and aftertaste attributes. Consumer preference (n=180) for OFSP and WFSP was measured by means of a paired preference test. Focus group discussions were conducted to verify findings of the consumer preference test.

The results obtained from the nutrient analysis confirmed that OFSP is an excellent source of beta-carotene. A 100 g portion of cooked OFSP can provide up to 6528 µg beta-carotene, which is approximately 136 % of the RDA for vitamin A for children four to eight years. High levels of other nutrients present in OFSP were identified namely vitamin C, calcium and zinc. OFSP further contributes 28 % vitamin C, 13 % calcium, 15 % magnesium and 75.6 % zinc of their daily requirements. This study confirms the valuable contribution that OFSP can make as a food-based approach to reduce vitamin A deficiency in individuals at risk.

The sensory profiles indicated that OFSP differed from WFSP in colour, flavour and texture. OFSP is generally less moist and subsequently more dense and adhesive compared to WFSP. The latter being more fibrous and less firm than OFSP. Overall OFSP had an earthy aroma which was not typical of WFSP and had a sweeter flavour. The flavour of OFSP was described as similar to that of yellow vegetables such as butternut and pumpkin. Although the different OFSP cultivars had similar characteristics, differences were found in the moist, adhesive and grainy texture attributes as well as the vegetable sweet flavour. Resisto had the sweetest in flavour, with the most dense and pasty texture of the four OFSP cultivars. W119 had the grainiest texture. No significant differences were found in the earthy aroma, sweet potato and yellow vegetable flavour attributes. It can be concluded that in flavour, few differences were found among the OFSP, except in sweetness. OFSP differed primarily from each other in texture.

The consumer preference test results showed that overall 85 % of respondents preferred the taste of OFSP to that of WFSP, 53 % liked the orange colour a lot while 24 % liked the colour a little and the remaining 22 % disliked the colour (either a lot, a little, neither like nor dislike). The majority of the consumers (86 %) indicated a willingness to buy OFSP. From these results it can be concluded that the taste and colour of OFSP are

acceptable to consumers of sweet potato and that it has potential to be successful in the marketplace.

Given the high level of consumer acceptability of OFSP, an opportunity exists to address vitamin A deficiency through commercially viable decentralised vine production centres. Such centres could be managed by commercial-, small-scale- and subsistence farmers in South Africa in key sweet potato production areas, with adequate water supply throughout the year. However, availability of commercially produced OFSP in retail stores in recent months, may change this prospect.

Key words: Orange-fleshed sweet potato, sweet potato, nutrient analysis, sensory profiles, consumer acceptance.

TABLE OF CONTENTS

CHAPTER 1	BACKGROUND AND JUSTIFICATION OF THE STUDY	1
1.1	Substantiation of the study	1
1.2	Structure and presentation of the study	4
CHAPTER 2	SWEET POTATO IN PERSPECTIVE	10
2.1	Introduction	10
2.2	Origin and production of sweet potato	10
2.2.1	Global production of sweet potato	10
2.2.2	Sweet potato production in the informal sector in South Africa	13
2.2.3	Uses of sweet potato	12
2.2.4	Constraints in sweet potato production	14
2.3	Nutritional importance of orange-fleshed sweet potato	15
2.4	Quantitative descriptive analysis	16
2.5	Consumer evaluation of food products	21
2.5.1	Influences and understanding food choice	21
2.5.2	Food acceptance	24
2.5.3	Focus group discussions – a brief overview	25
2.6	Motivation for the study	26
CHAPTER 3	RESEARCH METHODOLOGY	31
3.1	Introduction	31
3.2	Research design	31
3.3	Aim of the study	31
3.3.1	Research questions	32

3.4	Conceptual framework	34
3.4.1	Conceptualisation	34
3.5	Unit of analysis	35
3.6	Measurement protocol and Operationalisation	35
3.7	Population and sampling	36
3.8	Data analysis	42
3.8.1	Nutrient analysis of OFSP	42
3.8.2	Quantitative descriptive analysis	43
3.9	Quality of the research	46
3.9.1	Reliability	46
3.9.2	Validity	47
3.9.3	Data analysis	48
CHAPTER 4	NUTRIENT CONTENT OF ORANGE FLESHED SWEET POTATO	51
	Abstract	51
1	Introduction	53
2	Methods and materials	55
2.1	Sampling of storage roots	55
2.2	Preparation of samples	56
2.3	Methods of analysis	56
2.4	Comments on the sweet potato collection sites	56
2.5	Statistical analysis	58
3	Results	58
4	Discussion	63
4.1	Nutrient content of OFSP	63
4.2	Nutrient content of different OFSP cultivars	66

4.3	Conclusion	67
5	Recommendations	68
CHAPTER 5	QUANTITATIVE DESCRIPTIVE SENSORY ANALYSIS OF FIVE DIFFERENT CULTIVARS OF SWEET POTATO	73
	Abstract	73
	Introduction	74
	Materials and methods	75
	Results and discussion	80
	Correlation analysis	84
	Principal component analysis	84
	Discussion	88
	Conclusion	90
	Recommendations	91
CHAPTER 6	CONSUMER TASTE PREFERENCE FOR SWEET POTATO	95
	Abstract	95
	Introduction	96
	Materials and methods	98
	Results	103
	Discussion	105
	Conclusion	106
	Recommendations	106
CHAPTER 7	CONCLUSION AND RECOMMENDATIONS	110
7.1	Introduction	110
7.2	Main findings	110
7.3	Conclusions	112
7.4	Limitations of the study	113

7.5	Recommendations	114
7.6	Thoughts to take home	115

LIST OF TABLES

CHAPTER 2

TABLE 2.1	Comparison of the performance of Resisto OFSP cultivar with Blesbok WFSP cultivar trials at Roodeplaat	19
-----------	--	----

CHAPTER 3

TABLE 3.1	Sampling plan to show units per cultivar from different regions	38
TABLE 3.2	Sampling plan for the consumers who participated in the study	40
TABLE 3.3	Sampling criteria for consumers	41
TABLE 3.4	Summary of the analytical methods used for nutrient analysis	42

CHAPTER 4

TABLE 1	Number of units per OFSP cultivar selected for analysis	55
TABLE 2	Summary of the analytical methods used for nutrient analysis	57
TABLE 3	Mean values for the nutrient content of raw and cooked OFSP including all the cultivars	59
TABLE 4	Mean values for the nutrient content of different OFSP cultivars	61
TABLE 5	Beta-carotene content of different OFSP cultivars	62
TABLE 6	RDA for children between the ages of 4-8 years and nutrient values for other vegetable sources with high beta-carotene content	63

CHAPTER 5

TABLE 1	Weight gain of sweet potatoes during cooking	80
TABLE 2	Lexicon for descriptive sensory analysis of five different sweet potato cultivars	81
TABLE 3	Least square mean values for the sensory analysis of five	83

sweet potato cultivars and the shear force measure

TABLE 4	Correlation coefficients among sensory attributes	86
---------	---	----

CHAPTER 6

TABLE 1	South African and Gauteng population criteria relevant to the respondents used for this study	99
TABLE 2	Summary of participants in different focus group interviews	100
TABLE 3	Observed frequencies on consumers' taste preference and colour acceptance	103
TABLE 4	Summary of consumer preference for sweet potato and willingness to buy OFSP (n =182)	104

LIST OF FIGURES

CHAPTER 1

FIGURE 1.1	Conversion of vitamin A compounds	1
------------	-----------------------------------	---

CHAPTER 2

FIGURE 2.1	Schematic diagram showing basic sensory, perceptual and hedonic stages in the processing of the structure of food, resulting in food acceptance	24
------------	---	----

CHAPTER 3

FIGURE 3.1	Broad conceptual framework	33
------------	----------------------------	----

CHAPTER 5

FIGURE 1	Graphical presentation of the serving procedures of the sweet potato	78
FIGURE 2	Graphical presentation of the position of each sweet potato cultivar in relation to the PC-scores of each cultivar	87
FIGURE 3	Graphical presentation of the main attributes identified in the PCA that discriminated between the sweet potato cultivars	88

LIST OF ADDENDUMS

ADDENDUM A	Quantitative descriptive analysis	120
ADDENDUM B	Consumer questionnaire	121
ADDENDUM C	Photo gallery	122

LIST OF ABBREVIATIONS

AI	Adequate Intake
ANOVA	Analysis of variance
AOAC	Association of Official Analytical Chemists
ARC-ANPI	Agricultural Research Council-Animal Nutrition and Animal Products Institute
ASTM	American Society for Testing and Materials
DRI	Dietary Reference Intake
g	gram
HPLC	High Performance Liquid Chromatography
kJ	kiloJoules
kcal	kilocalories
kg	kilogram
LSD	Least significant difference
MIC	Meat Industry Centre
mg	milligram
NFSC	National Food Consumption Survey
OFSP	Orange-fleshed sweet potato
PC	Principal Component
PCA	Principal Component Analysis
PPECB	Perishable Products Export Control Board
QDA	Quantitative Descriptive Analysis
r	Correlation coefficient
RDA	Recommended Dietary Allowances
SANAS	South African National Accreditation Services
SAVACG	The South African Vitamin A Consultative Group
%	Percentage
µg	Microgram
USDA	United States Department of Agriculture
WFSP	White-fleshed sweet potato

CHAPTER 1

BACKGROUND AND JUSTIFICATION FOR THE STUDY

1.1 SUBSTANTIATION OF THE STUDY

Retinoids are micro-nutrients that are obtained from the diet as it cannot be synthesised by the body. There are two sources of retinoids in the diet of which the one is provitamin A carotenoids, obtained from plant foods such as dark green leafy vegetables, red palm oil, palm fruits, carrots, orange-fleshed sweet potato (OFSP), mature squashes and pumpkins, mangoes, papayas and some other yellow / orange fruits. The second source is as preformed vitamin A from animal foods i.e. meat and dairy, which are excellent sources of vitamin A (Packer, Obermüller-Jevic, Kraemer & Sies, 2005:2), but economically out of the daily reach of most sub-Saharan African populations. Up to 80 % of the dietary intake of vitamin A in Africa comes from plant foods (Codjia, 2001:358). The best studied provitamin A carotenoid is beta-carotene, which in the body undergoes cleavage to retinal, which is then reduced to two molecules biologically active retinol (Packer *et al.*, 2005:2). Some carotenoids have vitamin A activity and although the absorption and conversion of beta-carotene to retinol are less efficient than retinoids from animal foods, it plays an essential role in the diet (Whitney & Rolfes, 2002:355). Figure 1.1 is a graphic presentation of the conversion of vitamin A compounds.

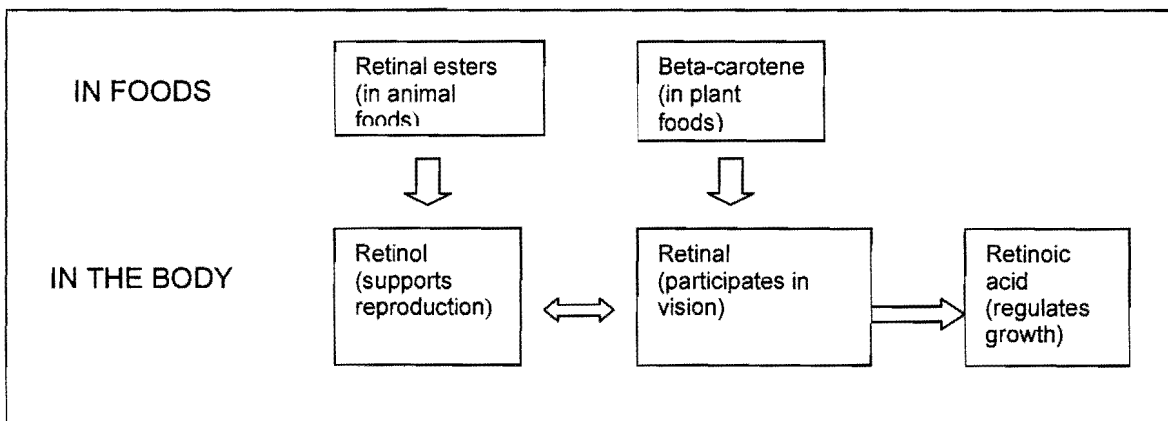


FIGURE 1.1: Conversion of vitamin A compounds (Whitney & Rolfes, 2002:356)

The role of vitamin A in the body is far-reaching and deficiencies can have detrimental effects. Vitamin A promotes vision and a deficiency thereof can lead to night blindness, which is a common condition in developing countries. Beta-carotene participates in protein synthesis and cell differentiation i.e. keeping the epithelial tissues and skin healthy, contributing to the growth of an individual as well as preventing illness due to infectious diseases (Garrow, James & Ralph, 2000: 210; Whitney & Rolfes, 2002:358).

A lack of micronutrients in the diet of many people in developing countries is referred to as 'hidden hunger', which is not as visible as plain lack of food and is a far more serious problem than a lack of energy or a lack of protein (Packer *et al.*, 2005: 275). Worldwide over two billion women and children suffer from micro-nutrient deficiencies in vitamin A, folate, iodine, iron and zinc (Packer *et al.*, 2005:276). In developing countries, infectious diseases are a major problem - killing as many as two million children per year due to related infections such as pneumonia and severe diarrhoea. The risk of dying from diarrhoea, measles and malaria is increased by 20-24% in children with vitamin A deficiency; and the risk from dying from diarrhoea, pneumonia and malaria is increased by 13-21 % in children with zinc deficiency (Black, Morris & Bryce, 2003:2229). Vitamin A supplementation reduces mortality in vitamin A deficient communities (Caulfield, de Onis, Blössner & Black, 2004: 197; Whitney & Rolfes, 2002:358).

Children between the ages of four to eight years require 400 µg vitamin A per day, an adult man 900 µg, adult females 700 µg and lactating mothers 1300 µg (USDA, 1998). The content of provitamin A carotenoids in foods, as well as the bioavailability thereof, are important determinants of the vitamin A status of an individual (Nestel & Nalubola, 2003a:1). Bioavailability refers to the degree to which the nutrient is available after ingestion for normal physiological functions in the body (Nestel & Nalubola, 2003a:1; Faber, Laurie & Venter: 2006:10). Vitamin A activity of 1µg of a provitamin A carotenoid is not equal to 1µg retinol (Nestle & Nalubola: 2003b:1). However, 1 µg retinol is equivalent to 12 µg beta-carotene and 24 µg of other provitamin A carotenoids respectively (USDA 1998). This conversion rate of 1:12 (i.e. 12 mg beta-carotene is equivalent to 1 mg retinol) was confirmed by the US Institute of Medicine (IOM) (Nestel & Nalubola, 2003b:1) as well as by West, Eilander & Van Lieshout, (2003: 2917S). However, it is important to note that the Retinol Activity Equivalent (RAE) conversion factor of 12µg beta-carotene to 1 µg retinol was based on the bioefficacy of carotenoids in a mixed diet eaten by healthy people in developed countries (Van Jaarsveld, Marais,

Harmse, Laurie, Nestel & Rodriguez-Amaya, 2006), and that bioefficacy varies depending on the vitamin A status of the individual. It may be higher in populations from developing countries with vitamin A deficiency, because such people are more efficient in converting provitamin A carotenoids (Nestel & Trumbo, 1999: 26-33).

Vitamin A rich plant foods are more affordable than vitamin A rich animal sources. OFSP has emerged as a promising plant source with a high beta-carotene content that can make a significant contribution to the vitamin A intake of communities at risk of vitamin A deficiency (Low, Walker & Hijmans, 2001:5). This supports the food-based approach as a strategy employed to reduce vitamin A deficiency (Faber, Laurie & Venter, 2006: 14). A half-cup (100 g) serving of the boiled roots can supply up to 136 % (6528 µg / 100 g) of the daily requirements of beta-carotene for young children, whereas white-fleshed sweet potato (WFSP) contributes a mere 0.42 % (20 µg) (Kruger, Sayed, Langenhoven & Holing, 1998:36).

OFSP has been cultivated by the ARC-Roodeplaat as part of an effort to introduce vitamin A-rich vegetables to people in rural areas (Laurie in Niederwieser, 2004:3). Research has focussed on identifying OFSP cultivars that will deliver a satisfactory yield, prove to be pest resistant and with good flavour characteristics. Sweet potato is a hardy crop that has relatively low demands on soil nutrients, while also being more drought tolerant than many other vegetables. It offers flexibility in planting and harvesting times as it has a shorter growing cycle than other root crops, for example the average crop growth period for sweet potato is 140 days and for cassava, 330 days (Laurie & Niederwieser in Niederwieser, 2004:3). Sweet potato plays an important role as a household food security crop in resource-poor farming where sweet potato is grown in home gardens as well as for income (Domola, 2003:49, 50).

One way of ensuring that a new product such as OFSP is correctly introduced into a population or commercial market is to conduct strategic food marketing research which concerns all aspects of the consumer's food related behaviour (Low, Osman & Zano, 2005:1). In addition, the needs of the present and future consumer must be understood in order to identify products with attributes that are desired by the target consumers.

In most sub-Saharan African countries, consumers are familiar with the intrinsic characteristics of WFSP as it is often grown by women and frequently consumed by the

whole family (Van Trijp & Schifferstein, 1994:130). (The intrinsic characteristics refer to the physical and sensory characteristics of a product.)

Ultimately, tapping the potential of OFSP in communities at risk of vitamin A deficiency, hinges on a sustained effort to identify cultivars that are acceptable in colour, taste and texture by different cultural groups. To date, the nutrient content of OFSP grown in South Africa has not yet been determined with the exception of the beta-carotene content on a limited amount of samples. Consumer preference for OFSP over WFSP has not been explored.

From the above mentioned the problem statement for this research study could be formulated as follows: to determining the nutrient content of different cultivars of OFSP, identifying sensory differences in taste and texture for different cultivars OFSP in comparison with WFSP and determining the acceptability of OFSP by consumers of sweet potato. Cultivars that would be acceptable in taste and colour will be identified.

1.2. STRUCTURE AND PRESENTATION OF THE STUDY

From the preceding background and justification, the study will be presented according to the following outline: Chapters 2 and 3 covers a literature overview and research methodology. Chapters 4, 5 and 6 are presented in article format and were submitted individually for publication. For this reason, figures, tables and references are adapted according to the specifications of the specific journal. Therefore, inconsistencies will exist between the different chapters. In chapters 4, 5 and 6 some of the information is repeated, as each chapter is treated as an entity. Furthermore, chapters 5 and 6 are presented as separate articles as not all the same cultivars were evaluated in the two chapters. Therefore, comparisons of the different cultivars would be inadequate if these two chapters are to be combined.

- **CHAPTER 2: SWEET POTATO IN PERSPECTIVE**

Chapter 2 discusses the origin of sweet potato with focus on its uses internationally and locally. It provides a literature overview on the background and justification of the study including the nutritional importance of vitamin A, a brief overview of the quantitative descriptive analysis, consumer sensory research and focus group discussions. It

provides the broad conceptual framework for the study and the concepts relating to the framework are discussed in the chapter.

- **CHAPTER 3: RESEARCH METHODOLOGY**

In chapter 3 the research design is laid out. This was followed by the researcher in order to solve the research problem. It reflects the methods, techniques and procedures that were used in the study.

- **CHAPTER 4: NUTRIENT CONTENT OF ORANGE FLESHED SWEET POTATO**

Chapter 4 is presented in the format of an article and tables, figures and references are presented according to the specifications for the Journal of Food Composition and Analysis, the official publication of INFOODS (International Network of Food Data Systems), a joint project for Food and Agriculture Organisation of the United Nations and the United Nations University. This chapter addresses the nutrient content of OFSP and includes a discussion on the nutrient content of different OFSP cultivars.

- **CHAPTER 5: QUANTITATIVE DESCRIPTIVE SENSORY ANALYSIS OF FIVE DIFFERENT CULTIVARS OF SWEET POTATO**

Chapter 5 is presented in the format of an article and tables, figures and references are presented according to the specifications for the J Sensory Stud. This chapter addresses the sensory analysis of different sweet potato cultivars in terms of aroma, flavour, texture and aftertaste.

- **CHAPTER 6: CONSUMER PREFERENCES FOR SWEET POTATO**

Chapter 6 is presented in the format of an article and tables, figures and references are presented according to the specifications for Development Southern Africa. This chapter addresses the preference tests with consumers in order to establish consumer acceptability of OFSP.

- **CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS**

In chapter 7 the main findings and recommendations for the study are presented according to the conceptual framework compiled for this research study.

REFERENCES

BLACK, R.E., MORRIS, S.S. & BRYCE, J. 2003. Where and why are 10 million children dying every year? *Lancet*. 361: 2226-2234.

CAULFIELD, L.E., DE ONIS, M., BLÖSSNER, M AND BLACK, R.E. 2004. Undernutrition as an underlying cause of child deaths associated with diarrhoea, pneumonia, malaria and measles. *Am J Clin Nutr* 2004. 80: 193-198.

CODJIA, G. 2001. Food source of vitamin A and provitamin A specific to Africa: A FAO perspective. *Food Nutr Bull*, 22(4): 357 – 365.

DOMOLA M.J. 2003. *Survey and characteristics of sweet potato viruses in South Africa*. M. Inst Agrar (Plant Protection). University of Pretoria.

FABER, M., LAURIE, S. & VENTER, S. 2006. *Home gardens to address vitamin A deficiency in South Africa: A food-based approach*. Pretoria. CDP Printers.

GARROW, J.S., JAMES, W.P.T. & RALPH, A. 2000. *Human nutrition and dietetics*. London. Churchill Livingstone.

KRUGER, M., SAYED, M., LANGENHOVEN, M. & HOLING, F. 1998. *Composition of South African Foods: Vegetables and Fruit*. UDMS, Cape Town.

LAURIE, S.M. 2004. The sweet potato plant. In: Niederwieser, J.G. *A guide to sweet potato production in South Africa*. ARC-Roodeplaat Vegetable and Ornamental Plant Institute. Pretoria. CDP Printers.

LAURIE, S.M. & NIEDERWISER J.G. 2004. Sweet potato cultivars. In: Niederwieser, J.G. *A guide to sweet potato production in South Africa*. ARC-Roodeplaat Vegetable and Ornamental Plant Institute. Pretoria. CDP Printers.

LOW, J.W., OSMAN, N. & ZANO, F. 2005. Ensuring supply and creating demand for beta-carotene-rich sweet potato. Paper presented at the 18th Nutritional Congress of Nutrition, Durban, South Africa.

LOW, J., WALKER, T. & HIJMANS, R. 2001. The potential of orange-fleshed sweet potato on vitamin A intake in sub-Saharan Africa. Paper presented at a regional workshop on food-based approaches to human nutritional deficiencies.

NESTEL, P. & NALUBOLA, R. 2003a. The amount of bioavailability of provitamin A carotenoids in plant foods vary widely. ILSI Human Nutrition Institute. Washington.

NESTEL, P. & NALUBOLA, R. 2003b. Beta-carotene in fruits is more bioavailable than that in vegetables. ILSI Human Nutrition Institute. Washington.

NESTEL, P. & TRUMBO, P. 1999. The role of provitamin A carotenoids in the prevention and control of vitamin A deficiency. *Archivos Latinoamericanos de Nutricion* 49, 26S –33 S.

PACKER, L., OBERMÜLLER-JEVIC, U., KRAEMER, K. & SIES, H. 2005. *Carotenoids and Retinoids: Molecular Aspect and Health Issues*. Illinois. AOCS Press.

THE DIRECTORATE: AGRICULTURAL STATISTICS. 2005. *Abstract of Agricultural Statistics*. Pretoria. South Africa.

USDA-NCC. 1998. Dietary Reference Intake: Recommended Intakes for Individuals. National Academy of Sciences. Institute of Medicine. Food and Nutrition Board. (www.fnict.nal.usda.gov/nal_display/index.php?info_center)

VAN JAARVELD, P.J., MARAIS, De Wet., HARMSE, E., LAURIE, S.M., NESTEL, P & RODRIGUEZ-AMAYA, D.B. 2006. Retention of beta-carotene in boiled, mashed orange-fleshed sweet-potato. *J Food Compos Anal*, 19: 321-329.

VAN TRJIP, H.C.M., & SCHIFFERSTEIN, H.N.J. 1994. Sensory analysis in marketing practice: comparison and integration. *J Sensory Stud*, 2 (10): 127-147.

WEST, C.E., EILANDER, A., VAN LIESHOUT, M. 2003. Consequences of revised estimates of carotenoid bioefficacy for dietary control of vitamin A deficiency in



developing countries. American Society for Nutritional Services. Proceeding of the XX International Vitamin A Consultative Group Meeting. *J Nutr.* 133. 2917 and 2920S – 2926S.

WHITNEY, E.N., & ROLFES, R.R. 2002. *Understanding nutrition, 9th Ed.* London. Wadsworth.

CHAPTER 2

SWEET POTATO IN PERSPECTIVE

2.1 INTRODUCTION

The nutrient and sensory quality of OFSP within the South African context of a population that suffers from both under and over-nutrition has not been investigated before. The study aims to investigate the potential of OFSP as a nutritional food crop within urban communities. The discussion will focus on both the global and local production of sweet potato, followed by the uses from a food industry perspective. Nutritional relevance to rural communities will be indicated. This chapter further explains the sensory and consumer research methods that were applied in order to obtain a better understanding of sweet potatoes.

2.2 ORIGIN AND PRODUCTION OF SWEET POTATO

2.2.1. Global production of sweet potato

Sweet potato found its origin in the New World – either in the Central or South American lowlands and was known as *batatas*. Some remains were also found in the Casma valley of Peru as far back as 2000 B.C. Columbus discovered sweet potatoes in Hispaniola and Cuba in 1492 during his first voyage, and introduced it to Spain where it spread to Europe. It was introduced into Africa by the Portuguese from the Atlantic coast regions of mid-latitude America (Woolfe, 1992: 2).

Today, sweet potato is cultivated in more than a 100 countries in the world and plays an important part in the diet of many nations while ranking seventh in terms of total production as a world food crop. The annual production of sweet potatoes in 2000 was 140.9 million tonnes (Mt) of which Asia produced 91 % (128.8 Mt) that is mostly consumed in China, Africa 7 % (9.1 Mt), Central North America 1 % (1.1 Mt), South America 1 % (1,2Mt), Oceania 0.5 % (0.59 Mt) and Europe 0.35V% (46 000 t) (PPECB Export Directory, 200). In production value (monetary) of food commodities, sweet

potato ranks thirteenth globally and, in developing countries, sweet potato ranks as the fifth most valuable food crop, accounting for one third of the production of root and tuber crops (Woolfe, 1992:1-3).

Nearly all sweet potato production and consumption takes place in developing countries (Woolfe, 1992:5). In African countries such as Uganda, Rwanda and Burundi where starchy crops such as sweet potato are the staple food, the per capita consumption of sweet potato is 75 – 150 kg per person annually. In Malawi, Angola, Mozambique and the Democratic Republic of Congo, where maize is the staple food and sweet potato is an additional crop, the per capita consumption of sweet potato is in the region of 5 – 50 kg per person per annum (Minde, Ewell & Teri, 1999:169-182).

According to the production figures for South Africa, the sweet potato industry is relatively small, with an average annual production in 2005 of 51 000 t – 56 000 t, averaging a gross value of R 30-35 million (National Department of Agriculture 2001). The value and average price of sweet potato sold on the fresh market for 2005 was 26 938t averaging a value of R 30 076 072 which calculates to a price of R 1127/t (National Department of Agriculture, 2006). According to the information extracted from the Food and Agricultural Organisation of the United Nations (FAO) website, the total production of sweet potato in South Africa for 2004 - 2005 was 54 800 t – 64 530 t, (FAO, 2007). However, sweet potato is produced and sold in large quantities by the informal sector, which is not reflected in the official production figures (Laurie in Niederwieser, 2004:2; Domola, 2003:48). An estimated total acreage under sweet potato production is 2000-3000 hectares with an average yield of 5-10 t/ha (commercially the average yield is 40t/ha with a field size of up to 30ha) (Laurie in Niederwieser, 2004:2; Domola, 2003:52).

Most germplasm today comes from Taiwan, Peru, USA, Nigeria and Burundi. The International Potato Centre in Lima, Peru, maintains an international sweet potato germplasm collection consisting of about 900 pathogen tested accessions (Laurie in Niederwieser, 2004:1). The ARC-Roodeplaat Vegetable and Ornamental Plant Institute has a comprehensive sweet potato breeding programme. To date, at least 22 cultivars have been released by the programme and more cultivars will be released in the future. Currently, most South African commercially available cultivars have a white to light creamy-yellow flesh colour. However, beta-carotene rich OFSP is being introduced in

South Africa based on its possible contribution to reducing the prevalence of vitamin A deficiency. Vitamin A deficiency is a serious health problem in Eastern and Southern Africa (De Wagt, 2001:352). In sub-Saharan Africa, this deficiency contributes up to 25.1 % of child mortality due to related diseases such as malaria, diarrhoeal diseases, acute respiratory infections and vaccine preventable diseases (Black, Morris & Bryce, 2003: 2226). The ARC-Roodeplaat is focussing on breeding high beta-carotene cultivars with a good yield, wide adaptability, drought tolerance as well as good storability. Trials are being carried out in various sweet potato producing areas in South Africa such as the Limpopo, North West Province, Free-State, KwaZulu Natal, Eastern Cape, Mpumalanga and Gauteng, in order to establish which cultivars will be released in the future for commercial production (Laurie in Niederwieser, 2004:65).

Sweet potato has the potential to combat increasing food shortages as it provides high yield in terms of edible energy per unit area per unit time. It is one of the most efficient food crops in terms of energy per land area (Van Oirschot, Rees & Aked, 2003:673), while also supplying substantial amounts of vitamins and minerals. The sweet potato crop is widely adapted and provides variety in the diet in terms of taste and texture. OFSP flesh colour varies from light orange to a dark orange colour and the skin from cream to orange to purple (Laurie in Niederwieser, 2004:57). The orange colour is an indication of the beta-carotene content of the sweet potato cultivar. A bright or deep orange colour is an indicative of a high beta-carotene content (Whitney & Rolfes, 2002: 343).

Furthermore, sweet potato is a hardy crop that has relatively low demands on soil nutrients, while also being more drought tolerant than many other vegetables, offering flexibility in planting and harvesting times as it has a shorter growing cycle than other root crops. For example, the average crop growth period for sweet potato is 140 days and, for cassava, 330 days. Rice and maize also have a crop growth period of 120-140 days (Laurie in Niederwieser, 2004:3). Sweet potato is harvested in South Africa during the months of March to June, but is dependent on production area and planting time. For example, in frost-free areas where sweet potato is planted from February to March, harvesting takes place from July to November. In warmer areas, planting takes place in August and harvest is in November or January (Van den Berg, Laurie & Niederwieser in Niederwieser, 2004:39).

In rural communities, farmers often harvest only enough sweet potato to feed their family, leaving the plants in the field to prolong availability (Domola, 2003:52). Sweet potato does not ripen or mature and can be kept in the ground for some time, having a longer keeping time than most root crops (Laurie in Niederwieser, 2004:2, 3). Storage roots can be kept in the soil for up to two months. However, sweet potatoes lose weight during storage as a result of water loss (1-2 % per month) and, therefore, the soil temperature must not be too low (> 10 °C, but not higher than 15 °C) and no rain should be expected during the storage period. Roots stored in the ground run the risk of being attacked by weevils (Laurie & Van den Berg, 2002).

There are different cultivar preferences found among different people in the world. The very dry cultivars, with a dry matter of around 30% are preferred in Africa (Laurie in Niederwieser, 2004: 57). The ARC-Roodeplaat has shown some success with various OFSP cultivars and aims to introduce them to secondary nurseries as well as to sweet potato farmers and subsistence farmers with the aim of becoming a widely utilised crop.

2.2.2. Sweet potato production in the informal sector of South Africa

Sweet potatoes can be produced in all the provinces of South Africa with major production areas in Limpopo (Marble Hall, Burgersfort, Levubu); Mpumalanga (Nelspruit); KwaZulu Natal and Western Cape provinces (Laurie in Niederwieser, 2004:2). The main white-fleshed sweet potato (WFSP) varieties produced in South Africa are Blesbok, Bosbok, Ribbok and Koedoe (Laurie in Niederwieser, 2004:57). The Blesbok and Bosbok are similar in skin colour (purple) and flesh colour (white to light yellow) and both cultivars produce a relatively good yield within 4-5 months after planting. Blesbok, a white-fleshed sweet potato (WFSP) with a purple skin, is the most popular variety with 70% of the sweet potato production (Laurie & Van den Berg, 2002), which is mostly consumed as a vegetable as opposed to a staple food.

The informal sector produces and sells sweet potato in relatively large quantities. The ARC-Roodeplaat conducted a survey in 2001 to 2003 in seven provinces in South Africa that were identified as sweet potato growing areas. These were Limpopo, Mpumalanga, Western Cape, Eastern Cape, Kwa-Zulu Natal, Gauteng and the North West provinces. During this survey, it was found that, although rural farmers did not always own large pieces of land, sweet potatoes were cultivated on any piece of land available in the home garden. Sweet potato is normally produced for home consumption and, up to

95 % of the farmers that participated in the study, were subsistence farmers that depended on agricultural activities for their household supply. Sweet potato plays an important role as a food security crop in resource-poor farming where sweet potato is grown in home gardens for own consumption and to generate income (Domola, 2003:49,50). In rural communities, grain crops such as maize is rated as the most important crop for food supply, followed by vegetables. Root vegetables such as sweet potatoes are rated as the third most important food crop and, according to Domola (2003:49 - 51), sweet potato is sometimes exchanged for maize.

Sweet potato sales in rural areas have been found to be irregular and prices vary depending on quantity, size of the storage root, the place of sale and the people to whom they were selling to. Some farmers harvested only to feed their family but where sufficient sweet potato is available, farmers would sell to their neighbours or to the local market. In 2003, prices ranged from 50c – R 1 / kg to R 3 / kg, in different regions. The average price in all provinces for sweet potatoes sold by rural people is R 1,11 / kg (Domola, 2003:49,52).

While the largest portion of the South African production (26 000t) is sold on the commercial fresh produce market in pockets of 14 – 34 kg, a substantial amount is also sold directly to the large chain stores where it is sold per kg or pre-packed. Approximately 2000t are further processed by freezing and dehydration. Approximately 2000 – 3000 t sweet potato are exported to the United Kingdom (40 %) and Europe (60 %) and 40 t were imported in 2001. Sweet potato has a good keeping quality and is suitable for export by sea – it accounts for about 5 % of the vegetables exported by sea (PPECB, 2004; Laurie in Niederwieser, 2004:2).

2.2.3 Uses of sweet potato

International food industry

Sweet potato flour is used in the baking industry as a 20 % supplement to wheat. Mashed sweet potato can also be used to replace more expensive ingredients in products such as ice-cream, tarts and desserts. In its puree form, it lends itself as an ingredient in sauces such as tomato sauce and baby foods, as well as fruit flavoured jams like pineapple, mango, guava and orange. In the USA, sweet potato is canned in various forms. It is frozen as cubed, sliced, fried, mashed, halved and as whole roots.

In China, sweet potato is used for the production of starch which is used for making pasta and as a substrate for alcoholic drinks (Laurie in Niederwieser, 2004:4).

South African food industry

Industrially, 1000-1500 t of the 2000 t sweet potato that is processed in South Africa, is dehydrated and the powder is then used in instant soups and infant products and the remaining, approximately 650 t that is processed, is frozen (Laurie in Niederwieser, 2004:5). Sweet potato is consumed as a fresh vegetable in many domestic households. The uses of sweet potato can be extended to an ingredient in recipes for baked products such as biscuits, scones, buns and cakes, soups, jams, juices, chutney and pickles (Laurie in Niederwieser, 2004:3).

Rural South African communities and households

In rural households the sweet potato roots are generally boiled and consumed as fresh roots, while in other regions, roots are sliced and dried to extend their storage life (Van Oirschot *et al.*, 2003: 673). Boiled sweet potatoes are sometimes eaten cold with tea, but, when eaten as part of the main meal, they are first boiled and then mashed (Domola, 2003:49, 53). The tops or leaves of the sweet potato plant may be consumed as a green vegetable (Domola, 2003:49, 53). The tops and leaves are also fed to cattle, goats, pigs, poultry, even fish when green or as hay or silage (Laurie in Niederwieser, 2004:3).

Although the processing of sweet potatoes is still under-utilised, there is a growing interest in the processing of sweet potatoes for human consumption (Laurie in Niederwieser, 2004: 3). Future potential uses of sweet potato include deep-fat frying to make chips (Domola, 2003:49,53).

2.2.4. Constraints in sweet potato production

Rural farmers do not fully understand the constraints of growing sweet potato crops. In the study conducted by Domola (2003: 50), it was found that nine different viruses occur naturally on sweet potato grown by small scale farmers in South Africa (Domola, 2003: 54). Generally, viruses cause yield and quality loss of the food product and, where proper fencing is not constructed around vegetable gardens, goats and chickens cause

damage by eating the leaves. Irrigation required in areas where there is a low rainfall pattern is another constraint, as well as farming equipment, planting material, production cost, storage places and markets for selling products (Domola, 2003: 57).

In order to improve farming practices among rural and small scale farmers, the ARC-Roodeplaat has started to supply disease-free OFSP cuttings to farmers in targeted rural communities, as well as teaching them how to grow crops correctly and to extend the planting practices in communities not utilising this advantage. To increase yield, small scale farmers need to know that they should select disease-free planting material, use fertilisers before planting and crop rotation to prevent the depletion of nutrients from the soil, making it possible for a crop to survive and still produce in times of poor rainfall (Domola, 2003:58,59).

2.3 NUTRITIONAL IMPORTANCE OF ORANGE-FLESHED SWEET POTATO

The nutritional content of food is recognised as being related to food choice in that it influences diet, health and disease (Shepherd & Sparks in MacFie & Thomson, 1994:202). The South African Vitamin A Consultative Group (SAVACG, 1995), which was formed in 1993 to assess the vitamin A and iron status of South African children, established that one in three children suffered from vitamin A deficiency. Its main findings identified the prevalence of vitamin A deficiency in South Africa as a cause of concern. The SAVACG study (1995) identified iron status as deficient, where one in five children was anaemic. In 1999, the National Food Consumption Survey (NFCS), that was conducted among children between the ages of 1–9 years, observed that one out of two children had an intake of less than half of the recommended level for energy, vitamin A, vitamin C, riboflavin, niacin, vitamin B6, folate, calcium, iron and zinc. The nutrient intake of children living in rural areas was considerably lower than that of children living in urban areas (Labadarios, Steyn, Maunder, Macintyre, Swart, Gericke, Dannhauser, Voster & Nesamvuni, 2000:6). SAVACG recommended vitamin A supplementation for children between the ages of 6 month and 6 years, as well as for lactating mothers to be introduced in high risk areas. The vitamin A status of the people living in rural and urban areas in South Africa requires strategies that are aimed at increasing production, availability, access and subsequently, the consumption of foods rich in vitamin A and provitamin A carotenoids in order to limit the prevalence of vitamin A deficiency..

Generally there are three approaches that assist in combating vitamin A deficiencies. These include:

- the fortification of food products such as maize meal and bread (flour) that are consumed in large quantities. Fortification of maize meal with vitamin A, thiamine, riboflavin, niacin, folic acid, pyridoxine, iron and zinc, became mandatory in October 2004 in South Africa. A logo, identifying fortified maize and wheat has been introduced and appears on all maize-meal packaging as well as on packaging of breads that are fortified (Department of Health, 2002),
- supplementation through the use of vitamin A capsules or drops for children, which is an effective approach. However, not all people in need of vitamin A supplementation are able to visit mobile clinics in order to get the required dose,
- dietary diversification which aims at increasing the consumption of vitamin A rich foods, especially through planting vitamin A rich vegetables such as OFSP, carrots, butternut, pumpkin and spinach in home gardens. Products that could increase the vitamin A intake of South Africans that are cost effective and, simple to grow on small pieces of land, should be actively promoted. Therefore the cultivation of sweet potatoes that have a high nutritional content (especially that of vitamin A), such as OFSP, could be beneficial to South Africans in terms of reducing vitamin A deficiencies (Labadarios *et al.*, 2000:6).

Products that are rich in vitamin A should be readily available in all markets to make it more accessible to all South Africans and for improved dietary diversity. Vitamin A-rich home gardens can increase the availability of fruits and vegetables that are rich in beta-carotene for home consumption.

Small quantities of the high beta-carotene sweet potato added to a family's diet can substantially reduce vitamin A deficiencies in both children and adults (Savage King and Burgess, 2003:261). In a study done by the Medical Research Council (MRC), OFSP was successfully incorporated during a trial period, into the school feeding programme. The children's vitamin A status improved after they consumed a half a cup of OFSP for 53 days as part of the school meal (Van Jaarsveld, Faber, Tanumihardjo, Nestel, Lombard & Benade, 2005:1081). In rural areas, the high beta-carotene sweet potatoes can be produced on small pieces of land in order to produce vegetables that are rich in beta-carotene and readily available. African mothers have been found to be more open to accepting the new varieties of sweet potato once they understood their nutritional value and contribution to alleviating vitamin A deficiency (Mukhala, 2000:9). This was

confirmed in a study by Hagenimana, Low, Anyango, Kurz, Gichuki & Kabira (2001:384) where it was found that nutritional education and counselling activities significantly increase the consumption of vitamin A rich foods.

The Resisto cultivar OFSP is rich in beta-carotene. WFSP has a high energy value but is devoid of beta-carotene and is widely produced and consumed by rural and urban consumers in South Africa (Van Jaarsveld, Marais, Harmse, Laurie, Nestel & Rodrigues-Amaya, 2006:321). Although the absorption and conversion of beta-carotene are less efficient than those of retinoids (derived from animal foods), it still plays an essential role in the diet in that it contributes to the daily requirement of vitamin A (Parker, 1996: 542-551). Sweet potato is a hardy crop and produces a high yield in terms of kiloJoules per unit area per unit time, with low demands on soil nutrients and cultivation input (Laurie in Niederwieser, 2004:3; Woolfe, 1992: 59).

Research has been conducted on OFSP in South Africa for more than ten years in order to select cultivars that would be accepted for their flavour attributes by African consumers, while, at the same time, preserving the beta-carotene content (Mukhala (2000:9). However, the sensory properties of new crop cultivars have generally been ignored in traditional breeding programmes (Van Oirschot *et al.*, 2003: 673). In view of the role that OFSP could play in reducing vitamin A deficiency, it is important to identify its sensory properties, as well as determine the consumer acceptability of OFSP by targeted consumers.

Table 2:1 compares the general performance of Resisto cultivar OFSP and Blesbok cultivar (Laurie in Niederwieser, 2004: 65). It shows that the yield of OFSP is not compatible with that of WFSP. A cost benefit analysis should be performed to justify the production of OFSP as compared to WFSP.

TABLE 2.1: COMPARISON OF THE PERFORMANCE OF THE RESISTO CULTIVAR OFSP WITH BLESBOK CULTIVAR WFSP IN TRIALS AND ROODEPLAAT (Laurie in Niederwieser, 2004:74)

Cultivar	Total soluble solids %	Dry matter content %	Keeping ability %	Marketable yield t/ha	Marketable yield %	Total yield t/ha
Resisto OFSP	8.4	23.0	45	44.6	81	55.4
Blesbok WFSP	5.5	14.2	80	64.2	79	81.3

2.4 QUANTITATIVE DESCRIPTIVE ANALYSIS

In this study quantitative descriptive analysis (QDA) was applied in order to develop sensory profiles for the different cultivars of sweet potato.

Application of descriptive analysis

Descriptive analysis is used to obtain a detailed description of the aroma, flavour and oral texture of foods and beverages. The sensory profiles or pictures obtained are used in product development and manufacturing and are of particular value to nutritionists and food scientists who are interested in the development of food and beverage products (Woods, 1998:605). These include activities such as the development of standards for quality control purposes, to document product attributes prior to consumer testing to assist in selecting appropriate attributes for inclusion in the consumer questionnaire, to help explain the results of consumer tests to track sensory changes and to reformulate existing products (Meilgaard, Civille & Carr, 1991:188).

The sensory panel consists of people who are recruited from the immediate area through local media such as the placing of advertisements in the local newspaper. Panel members are screened for their ability to discriminate between different food samples. Selected panel members are then exposed to an introductory sensory course during which they are exposed to the four basic tastes i.e. sweet, salt, sour and bitter. Panel members are also required to complete threshold tests for the basic taste profiles as described by Jellinek (1985:162). Once this has been completed, panellists are able to participate in descriptive sensory evaluation of food products. Further training is applied on the specific product being evaluated. Panellists are then exposed to two-hour training sessions on four consecutive days in order to develop a clear definition of each

attribute. Panellists each receive a representative sample of the sweet potatoes and are trained to increase sensitivity and ability to discriminate between the sensory attributes of the different cultivars.

Language development in descriptive analysis

During the training phase of descriptive analysis, the panellists describe the characteristics of a product by creating their own scientific language for the product or product category of interest – this is also referred to as the lexicon. A set of terms that describe differences among products is developed and a definition plus a reference standard are agreed upon by the panel members in order to anchor the descriptive term. This is then used by the trained panel throughout the evaluation of the products. Concepts are formed and labelled and panellists are trained to use the same concepts so that they are able to communicate precisely with one another. Consumer language is often imprecise and non-specific and does not allow sensory specialists to measure and understand underlying concepts in a way that will provide meaningful data. Often concept formation requires exposure to many similar products in order for it to be meaningful. However, when the boundaries are clear, for example sweetness, a single standard may be adequate (Lawless & Heymann, 1998:342-4). The panel further determines the sequence of evaluating each attribute (Lawless & Heymann, 1998:351), i.e. attributes that are more prominent in a product would be analysed first.

Data generated using descriptive analysis by a trained panel can be used to interpret consumers' hedonic responses to the same samples (like / dislike), allowing concepts developed during descriptive analysis to be related to concepts that lead consumers to accept or reject a product (Lawless & Heymann, 1998:354).

Scaling and score sheet

In descriptive sensory analysis, samples are evaluated for a number of attributes by a trained panel (Lea, Næs & Rødbotten, 1998:4). Scaling involves the allocation of numbers by sensory panellists to quantify sensory experiences (Lawless & Heymann, 1998:209). The intensities of the attributes are quantified on a scale of any length possible e.g. 1-7, 1-9, 0-100 (Lea *et al.*, 1998:4). Category scales are commonly used in descriptive analysis, which is a limited set of words or numbers with equal intervals between categories. Scales should allow panellists to respond in varying degrees. A guideline to help decide how long a scale should be is to evaluate how many steps a

panellist can meaningfully employ and then adopt a scale twice as long, which is not recommended for panellists with limited skills. Other scales used in descriptive analysis are line scales and magnitude estimation, which were not used in this study (Meilgaard *et al.*, 1991: 191).

An eight-point category scale was used to measure the intensity of each sensory attribute (aroma, texture, flavour and aftertaste) for each treatment. One (1) on the category scale denoted the least intense condition (e.g. no sweet potato aroma) and eight (8) denoted the most intense condition (e.g. extremely intense sweet potato aroma).

2.5 CONSUMER EVALUATION OF FOOD PRODUCTS

Consumer sensory evaluation is conducted with coded, unbranded samples, whereas in marketing research, branded products are used. In consumer sensory testing, the researcher is interested in finding out whether the consumer likes the product and prefers it above another product in order to determine the acceptability of the product, based on its sensory characteristics (Lawless & Heymann, 1998:430).

An important function of the introduction of new products into the market place, such as OFSP, is the ability to understand the needs of the present and future consumer in order to identify products with attributes that are desired by the target consumers. Specific cultivars OFSP have been selected to potentially meet nutrient and energy requirements of sub-Saharan African people as part of a food-based approach (Faber, Laurie & Venter, 2006: 14). In most sub-Saharan African countries, only WFSP is available, which contains very little or no beta-carotene.

2.5.1. Influences and understanding food choice

According to Shepherd (in McBride & MacFie, 1990:3), a better understanding of the factors that influence food choice is required to improve the diet of people in general. Food choice and food consumption is also closely related as both refer to the behavioural act involving the acquisition of food. Food acceptance, on the other hand, denotes the pleasure derived from the consumption of food and comprises both a behavioural and attitudinal component (Randall & Sanjur, 1981:151), including the

palatability or taste of food. Sensory perception is one of the most important determinants of consumer food choice behaviour (Van Trijp & Schifferstein, 1994:128).

In order to understand the determinants of food choice as a human behaviour, one has to look at research done on the psychological process and individual attitudes for making food choices. Attitudes have been defined as learned dispositions or mannerisms of an individual to act in a consistently favourable or unfavourable way towards some objects and consist of three distinguishable components:

- firstly it is either our emotional or affective reactions to objects – a natural preference (like or dislike) for a particular food;
- secondly our behaviour tendencies (cognitive) towards objects – therefore our need or wish to consume or avoid certain foods;
- and thirdly our thoughts or cognitive ability – the information we have about the food, including what we believe the benefits or consequences are of a particular food (Conner, 1993: 27, 28).

This approach was developed by Fishbein and Ajzen (1975), as published in Shepherd, (1990:4) and offers a coherent framework within which these three components of attitude could be related (Shepherd, 1990:4). Preferences are also based on the belief that, by consuming a particular food, the outcome will be positive (Conner, 1993: 27). The positive outcomes include beliefs about foods that are healthy or unhealthy; foods that are appropriate for certain occasions or people and those that are not (Conner, 1993: 28). This relationship between attitudes and beliefs has been widely studied, although the relationship has remained somewhat unclear. However, within this framework, attempts have been made to relate attitudes to food consumption, which have lead to the development of the framework of knowledge-attitude-practice (behaviour), which means that changes in behaviour can be brought about by increasing knowledge about a particular food (Shepherd, 1990: 3).

Thus, a closer look at the theory of planned behaviour shows that an individual's attitude towards the behaviour is based on his or her belief of salient outcomes of the behaviour. These outcomes include behavioural outcomes (e.g. price of a food item), emotional outcomes (pleasantness of taste) and potential risks (will the food increase the chances of heart disease) (Conner, 1993: 28). According to this theory, individuals are likely to choose and consume a particular food if they believe that the consumption will lead to

specific positive outcomes and therefore, by changing the beliefs about the outcomes, changes in food choices can be influenced (Conner, 1993:29).

When considering the food itself, food choice consists of three aspects i.e. the food, the consumer and the context or situation in which it is consumed or the interaction with the food (Gains in MacFie & Thompson, 1994:51). Conner (1993:28) states that, when comparing diverse influences on food choices with the reasons people provide for consumption, the flavour or 'taste' of the food is a strong predictive positive factor, followed by satiety as a physiological factor and lastly benefits such as price and convenience have little or no effect. Men (husbands) have been found to value the taste of food as the most important determinant of food choice, while the nutritional contribution and the safety (safe for consumption) of the food are more important determinants of food choice by mothers of a household (Shepherd in McBride & MacFie, 1990:141).

All these theories relate to the purpose of this study which is to establish consumer taste preference for OFSP in order to meet the nutritional requirements of the consumers that are most in need of vitamin A in their diet (therefore a health benefit). It can, therefore, be predicted that, if the taste of OFSP surpasses that of WFSP, it could successfully be introduced into any community, in particular low income. Measuring the sensory properties of OFSP and determining the importance of these properties as a basis for predicting consumer acceptance is an essential component in the promotion of OFSP to South African consumers.

2.5.2. Food acceptance

Food acceptance refers to the palatability, hedonic tone, liking or disliking, food taste preference and pleasantness accompanied by the consumption of the foods (Meiselmann & MacFie, 1996:2). Food acceptance comprises a behavioural and attitudinal component (Randall & Sanjur, 1981: 151). Taste preferences in food often reflect a consumer's social and cultural origins, social ambitions as well as cultural capital acquired (Wright, Nancarrow & Kwok, 2001:355). From ancient days to the modern world of today, food and taste preferences have been closely linked to cultural development. Often, with affluence, consumers move from satisfying basic physiological needs to fulfilling social and psychological needs, shaped by the sub-cultures to which they belong (Wright *et al.*, 2001: 348-350). Meiselmann and Macfie (1996:3) show a

schematic model of the sensory basis of food acceptance, the stages, interactions and levels involved in the processing of sensory and perceptual information about food. Figure 2.1 is a simplified version of this model, and is included as it bears relevance to this study and the acceptability of OFSP.

Food preference refers to an expressed choice between two or more food items. Food preference techniques are used when the researcher wishes to look at the preference for one product directly against another product (Lawless & Heymann, 1998:430) and can also be defined as the degree of liking for a food product (Randall & Sanjur, 1981:151).

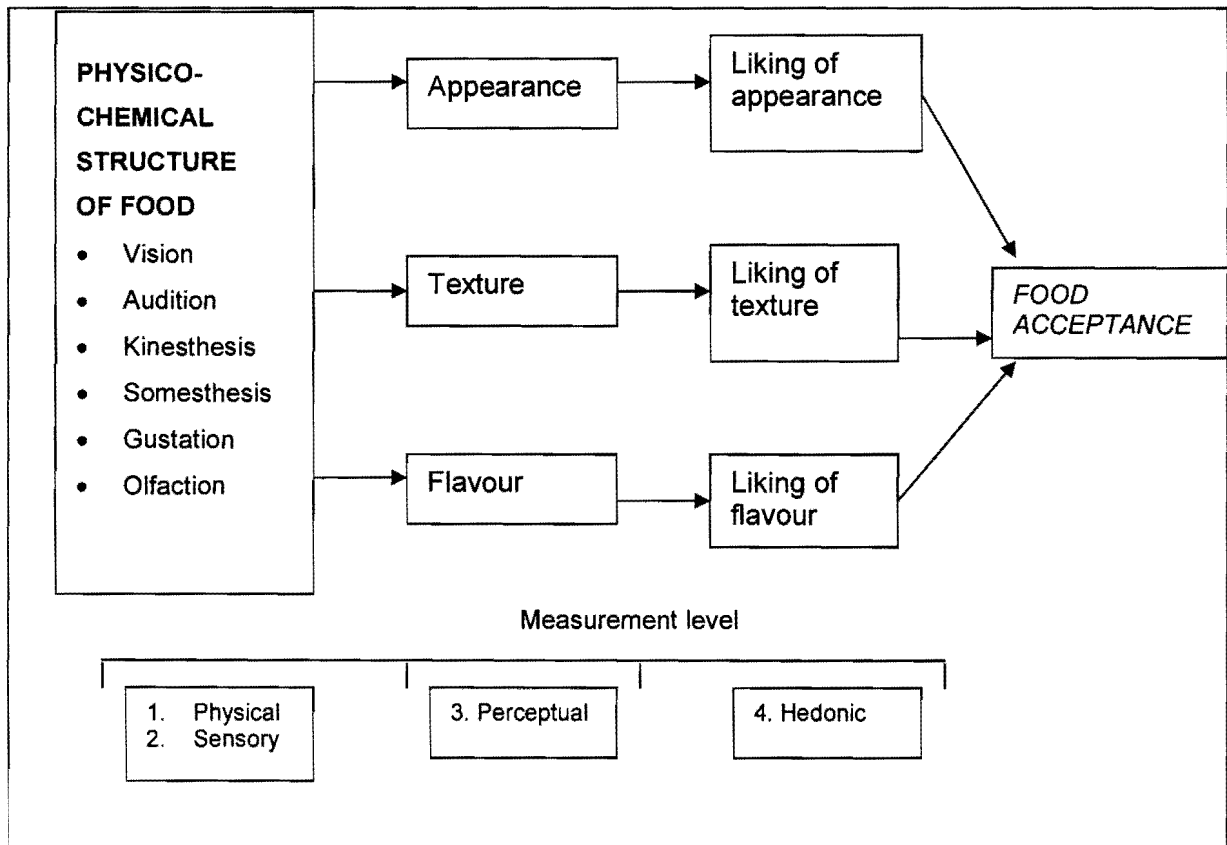


FIGURE 2.1: Schematic diagramme showing basic sensory, perceptual and hedonic stages involved in the processing of the structure of food, resulting in food acceptance (Meiselman & MacFie, 1996:3)

2.5.3. Focus group discussions - a brief overview

A focus group interview is a carefully planned session with 6-15 individuals and is designed to obtain perceptions in a defined area of interest in a permissive, non-threatening environment (Casey & Krueger in MacFie & Thompson, 1994: 77). It makes a valuable contribution towards understanding the attitudes and behaviour of consumers (Jenkins & Harrison, 1992:33). A skilled moderator conducts the interview and the discussions are relaxed and enjoyable for the participants. Focus group discussions are aimed at providing insights into how a product, service or opportunity is perceived. The moderator should be skilled to encourage participation by all the participants (Casey and Krueger in MacFie & Thompson, 1994: 77; Jenkins & Harrison, 1992:34). Caution should be taken to generalise the findings to the population at large as, even though respondents are recruited based on regular use of the product, it is not possible to ensure a representative sample of the public on all relevant demographic variables (Jenkins & Harrison, 1992:34). Limitations include the influence of dominant participants, limited exposure to the product, or it may not be used by all the participants (Lawless & Heymann, 1998: 521). Data is often complex to analyse and, although the group may provide rich dynamics, these may be difficult to interpret and therefore analysis takes time and thought. At least three groups should be conducted to balance idiosyncrasies amongst groups. Groups are often difficult to assemble and recruitment is time consuming (Casey and Krueger in MacFie & Thompson, 1994: 77). However, as markets become more complex and segmentation more important for success in the marketplace, focus group interviews will continue to dominate qualitative research (Jenkins & Harrison, 1992:36).

2.6 MOTIVATION FOR THE STUDY

Main thrusts were identified from the literature research and are discussed as separate bullet points:

- As consumption of OFSP improves the vitamin A status of children under the age of 10 years (Van Jaarsveld et al., 2005: 1080), role-players in food-based programmes in South Africa can promote the cultivation and use of OFSP in rural and urban communities in an effort to reduce malnutrition by increasing vitamin A intake. By

establishing the taste acceptability of beta-carotene rich OFSP in terms of its sensory properties amongst consumers of sweet potato and by determining the nutrient content of OFSP compared to that of WFSP, role-players in health and nutrition education could use such data to more effectively plan and implement food-based programmes.

- Consumer acceptability of OFSP among different socio-economic groups has not yet been established. Data reflecting its acceptability and preference based on taste, could be used by the ARC-Roodeplaat and similar organisations to motivate the production of OFSP for home consumption and also for the introduction of OFSP to the local fresh produce market, making it readily available to all consumers.
- Generally food composition data and specifically commodity data such as that which will be generated for OFSP is essential in nutritional research, for planning and assessing nutrition intervention studies, planning national food and nutrition policies and prescribing normal therapeutic and individual or institutional diets. Dietary intake is usually analyzed and recommendations are made by utilizing this information. Therefore the data will contribute to the South African food data base.

2.7 REFERENCES

BLACK, R.E., MORRIS, S.S. & BRYCE, J. 2003. Where and why are 10 million children dying every year? *Lancet*. 361: 2226-2234.

CASEY, M.A. & KRUEGER R.A. 1994. Focus group interviewing. In: MacFie, H.J.H. and Thompson, D.M.H. Measurement of food preferences. New York. Chapman and Hall.

CONNER, M. 1993. Understanding determinants in food choice. *Br Food J*, 95(9):27-31.

DEPARTMENT OF HEALTH. 2002. Regulations relating to the Fortification of Foodstuffs. <http://www.doh.gov.za/search/index.html>.

DE WAGT, A. 2001. Vitamin A deficiency control programs in Eastern and Southern Africa: A UNICEF perspective. *Food Nutr Bull.* 22(4): 352.

DOMOLA M.J. 2003. *Survey and characteristics of sweet potato viruses in South Africa*. M. Inst Agrar (Plant Protection). University of Pretoria.

FABER, M., LAURIE, S. & VENTER, S. 2006. *Home-gardens to address vitamin A deficiency in South Africa: A food-based approach*. Pretoria. CDP Printers.

FOOD AND AGRICULTURAL ORGANISATION OF THE UNITED NATIONS. 2007. FAO Statistics Division. <http://faostat.fao.org/site/336/DesktopDefault.aspx?PageID=336>.

GAINS, N. 1994. The repertory grid approach. *In* MacFie, H.J.H. & Thompson, D.M.H. *Measurement of food preferences*. New York. Chapman and Hall.

HAGENIMANA, V., LOW, J., ANYANGO, M., KURZ, K., GICHUKI, S.T. & KABIRA, J. 2001. Enhancing vitamin A intake in young children in western Kenya: Orange-fleshed sweet potatoes and women farmers can serve as key entry points. *Food Nutr Bull*, 22 (4):384.

JELLINEK, G. 1985. *Sensory evaluation of food, theory and practice*. Great Britain. Southampton. The Camelot Press.

JENKINS, M. & HARRISON, K.S. 1992. Focus Groups: a Discussion. *Br Food J*, 92 (9): 33-37.

LABADARIOS, D., STEYN, N., MAUNDER, E., MACINTYRE, U., SWART, R., GERICKE, G., DANNHAUSER, A., VOSTER, H.H. & NESAMVUNI, A.E. 2000. *The National Food Consumption Survey: Children aged 1-9 years, South Africa, 1999*. Stellenbosch.

LAURIE, S.M. & VAN DEN BERG, A.A. 2002. A review of recent progress in breeding Sweet potato in South Africa for resource-poor farmers. 12th Symposium of International Society of Tropical Root Crops (ISTRC). Potential of root crop for food end industrial purposes, 10-16 Sept 2000, Tsukuba, Japan. Edited by M. Nakatani and K Komaki, Cultio Corporation, Ibaraki, Japan.

LAURIE, S.M. 2004. Sweet potato cultivars. In: Niederwieser, J.G. *A guide to sweet potato production in South Africa*. ARC- Roodeplaat Vegetable and Ornamental Plant Institute. Pretoria. CDP Printers.

LAWLESS, H.T. & HEYMANN, H. 1998. *Sensory evaluation of food: Principles and Practices*. Gaithersburg. Maryland. Aspen.

LEA, P., NÆS, T. & RØDBOTTEN, M. 1998. *Analysis of variance for sensory data*. John Wiley and Sons. UK.

MEILGAARD, M., CIVILLE, G.V. & CARR, B.T. 1991. *Sensory evaluation techniques*. 2nd ed. CRC Press. New York.

MEISELMAN, H.L. & MACFIE, H.J.H. 1996. *Food choice acceptance and consumption*. London. Chapman and Hall.

MINDE, I.J., EWELL P.T. & TERI J.M. 1999. Contributions of cassava and sweet potato to food security and poverty alleviation in the SADC countries: current status and future prospects. In: Proceedings of the scientific workshop of SARRNET, Pamodzi Hotel, Lusaka, Zambia, 17 - 19 Aug 1998. Akoroda, M.O. and Teri, J.M. (Eds), pp. 169-182. Polygraphics Venture Limited, Ibadan, Nigeria.

MUKHALA, E. 2000. New sweet potato to reduce blindness in Africa. *Agricultural news*.11:9.

NATIONAL DEPARTMENT OF AGRICULTURE. 2001. Abstract Agricultural Statistics. Pretoria. South Africa.

NATIONAL DEPARTMENT OF AGRICULTURE. 2006. Statistics on Fresh Produce Markets report. (x): Table 4.

<http://www.nda.agric.za/publications/publications.asp?category=statistical+information>.

PARKER, R.S. 1996. Absorption, metabolism and transport of carotenoids. *FASEB J*. 10: 542-551.

PPECB. 2004. Export Directory. Helderberg. M-M Publishing. [http:// www.ppecb.com](http://www.ppecb.com).

RANDALL, E & SANJUR, D. 1981. Food preferences – their conceptualisation and relationship to consumption. *Ecol Food Nutr*, 11:151-161.

SAVAGE KING, F & BURGESS A. 2003. *Nutrition for developing Countries, 2nd Ed.* New York. Oxford University Press.

SHEPHERD, R. 1990. Attitudes and beliefs as determinants of food choice. In: McBride R.L. and MacFie H.J.H. 1990. *Psychological basis of sensory evaluation*. London. Blackie Academic.

SHEPHERD, R. & SPARKS, P. 1994. Modelling food choice. In MACFIE, H.J.H. & THOMPSON, D.M.H. 1994. *Sensory evaluation of food preferences*. New York. Chapman and Hall.

SOUTH AFRICAN VITAMIN A CONSULTATIVE GROUP. 1995. Anthropometric, vitamin A, iron and immunization coverage status in children ages 6-71 months in South Africa. *S Afr Med J*: 86:354-7. www.sahealthinfo.org/nutrition/vitA/htm.

VAN DEN BERG, A.A., LAURIE, S.M. & NIEDERWIESER, J.G. 2004. Harvest, storage and marketing. In: Nierderwieser, J.G. *A guide to sweet potato production in South Africa*. ARC- Roodeplaat Vegetable and Ornamental Plant Institute. CDP Printers. Pretoria.

VAN JAARSVELD, P.J., FABER, W.M., TANUMIHARDJO, S.A., NESTEL, P., LOMBARD, C.J. & BENADE, A.J.S. 2005. Beta-carotene rich orange-fleshed sweet potato improves the vitamin A status of primary school children assessed with the modified-relative-dose-response test. *Am J Clin Nutr*, 81: 1080-7.

VAN JAARSVELD, P.J., MARAIS, De Wet., HARMSE, E., LAURIE, S.M., NESTEL, P. & RODRIGUEZ-AMAYA, D.B. 2006. Retention of beta-carotene in boiled, mashed orange-fleshed sweet-potato. *J Food Compos Anal*, 19: 321-329.

VAN OIRSCHOT, Q.E.A., REES, D. & AKED, J. 2003. Sensory characteristics of five sweet potato cultivars during storage under tropical conditions. *Food Quality and Preference*, 14 (673-680).

VAN TRJIP, H.C.M. & SCHIFFERSTEIN, H.N.J. 1994. Sensory analysis in marketing practice: comparison and integration. *J Sensory Stud*, 2 (10): 127-147.

WHITNEY, E.N. & ROLFES, R.R. 2002. *Understanding nutrition*, 9th Ed. London. Wadsworth.

WOODS, M.P. 1998. Taste and flavour perception. *Proceedings of the nutrition society*, 57: 603 – 607.

WOOLFE, J.A. 1992. *Sweet potato, an untapped food resource*. Cambridge. University Press.

WRIGHT, T.L., NANCARROW, C., KWOK, P.M.H. 2001. Food taste preferences and cultural influences on consumption. *Br Food J*, 103 (5):348 –357.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

Following on the background information, aims and motivation of the study in Chapter 2, this chapter provides an overview of the research methodology followed in this study.

3.2 RESEARCH DESIGN

This research was of an explorative nature, therefore an open and flexible research strategy was applied and methods that lead to insights and comprehension were used (Babbie & Mouton, 2001:270). A quantitative research approach was followed to measure the sensory characteristics (aroma, flavour, texture and aftertaste) of sweet potatoes, acceptability of OFSP by consumers from different socio-economic groups and to measure the nutrient content of OFSP. A qualitative research technique i.e. focus group interviews, was applied in order to provide supportive information and validate findings of the consumer research through triangulation.

3.3 AIM OF THE STUDY

Broadly, this research study aimed to investigate the nutrient content and sensory characteristics of OFSP. Firstly, the study aimed to evaluate the nutrient content of different cultivars of OFSP. The findings were compared with existing data from Food Composition Tables of the Medical Research Council (Kruger, Sayed, Langenhoven & Holing, 1998) and the USDA Food Composition Tables (8th version, 1998) on the nutrient content of WFSP and carrots in order to establish the position of OFSP in alleviating vitamin A deficiency in South Africa. Secondly, the study aimed to determine and compare the sensory characteristics of different OFSP cultivars and WFSP. The final

aim was to subsequently determine the acceptability of the taste of OFSP among urban adult women and men of different socio-economic groups. From this broad aim, the following research questions were formulated.

3.3.1 Research questions

The main research question for this study was formulated as follows:

What is the nutrient and sensory quality of different cultivars OFSP as produced in South Africa?

This leads to the formulation of the sub-questions for the study

1. What is the nutrient content of raw and cooked OFSP?
2. Is there a difference in the nutrient content of different cultivars (Resisto, W119, Jewel and A15) cooked OFSP?
3. How does the descriptive sensory characteristics of Beauregard, Kano, W119, Resisto OFSP cultivars and Blesbok WFSP cultivar compare with each other?
4. Is there a difference in the taste preference for Resisto cultivar OFSP compared to Blesbok WFSP cultivar by urban adult consumers from different socio-economic groups, living in the greater Pretoria (*Tshwane Metropolitan*) area?

3.4 CONCEPTUAL FRAMEWORK

The broad conceptual framework for this research study on the sensory and nutrient content of sweet potato is presented in Figure 3.1.

The conceptual framework indicates the steps followed during the process of data collection to answer the research questions of this study. The design broadly outlines the steps and methods that were followed throughout the study.

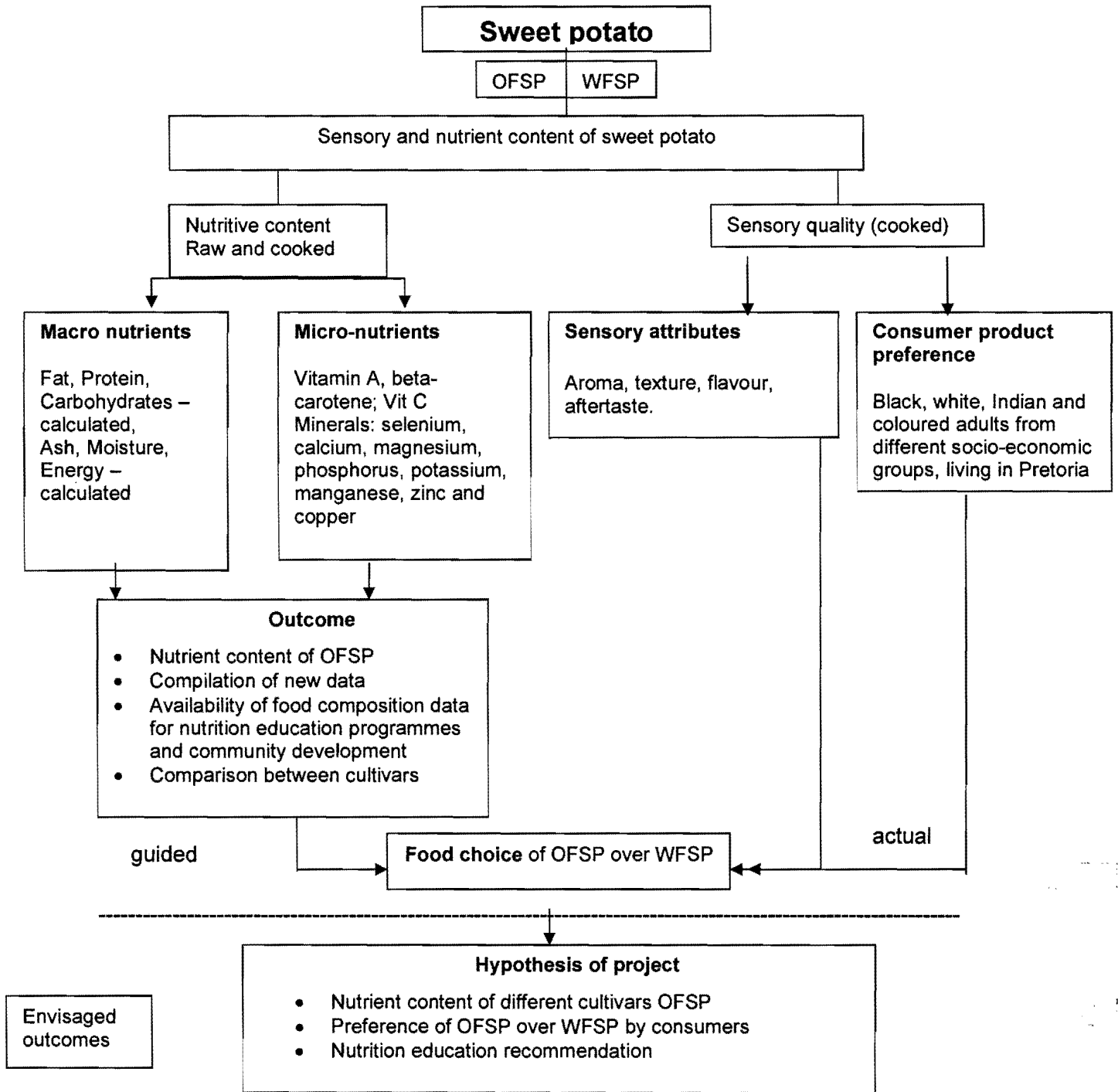


FIGURE 3.1: BROAD CONCEPTUAL FRAMEWORK

3.4.1 Conceptualisation

Nutrient analysis refers to the measurement of the nutrients within a food such as protein (N), moisture, fat, carbohydrates by difference, as well as mineral and vitamins (Greenfield & Southgate, 2003:97-99). The macro-nutrients measured in this study were the protein and fat. The carbohydrate content and energy values were calculated. The micro-nutrients (vitamins and minerals) analysed were the beta-carotene and vitamin C, selenium, calcium, magnesium, phosphorus, potassium, iron, manganese, zinc and copper content. The moisture and ash contents were also determined.

Chemical composition of the samples refers to the percentage water (moisture), fat, protein, (protein nitrogen (N) x conversion factor of x 6,25 = % protein) and ash (minerals) present in the OFSP cultivars. It was determined according to AOAC methods (2005) in a South African National Accreditation Services (SANAS) laboratory (the chemical analysis was performed on raw and cooked OFSP samples).

Descriptive sensory analysis refers to a series of sensory tests whereby a trained sensory panel rates specific attributes or intrinsic characteristics of a product on a scale of perceived intensities (Lawless & Heymann, 1998:806). An 8- point category rating scale was used in this project.

Consumer food acceptability refers to the consumption of food accompanied by pleasure. Therefore, food acceptance comprises a behavioural and attitudinal component (Randall & Sanjur, 1981:151). The behavioural component refers to the individual's attitude towards, for example, the taste of a product (Conner, 1993:28).

Food preference refers to an expressed choice between two or more food items. Food preference techniques are used when the researcher wishes to measure the preference of one product directly against another product (Lawless & Heymann, 1998:430).

Food choice refers to the set of conscious and unconscious decisions made by a person at the point of purchase or at the point of consumption (Hamilton, McIlveen & Strugnell 2000:113). Attitudes towards food choice can also be influenced by the knowledge about a food product which could affect the attitude which in turn could affect the behaviour related to the choice of food (Shepherd & Sparks in MacFie and Thomson,

1994:206). The consumer preference in this study was determined by making use of a 5-pt hedonic rating scale to measure consumer liking of OFSP and WFSP.

3.5 UNIT OF ANALYSIS

Sweet potato

Different cultivars of sweet potato were used as the unit of analysis of the nutrient content of sweet potatoes, the descriptive sensory evaluation and consumer acceptability tests.

Trained sensory panel

An experienced sensory panel consisting of 12 trained panel members was used to perform the descriptive sensory analysis of OFSP and WFSP in order to develop a flavour profile for each.

Consumer evaluation

The unit of analysis was black, white, coloured and Indian female and male adults from different socio-economic groups, who consume sweet potato and live in the greater Pretoria*(Tswane Metropolitan) area.

** Pretoria is part of the City of Tshwane which is 3200² km in size; population of 2.2 million; situated in the province of Gauteng, South Africa.*

3.6 MEASUREMENT PROTOCOL AND OPERATIONALISATION

Nutrient analysis

The ARC-Irene Analytical laboratory conducted the proximate analysis of four different cultivars i.e. Resisto, W119, Jewel, A15 plus one composite sample raw and cooked OFSP. (ARC- Irene Analytical Services is a South African National Accreditation Services (SANAS), accredited laboratory). The beta-carotene content of the four different OFSP cultivars was analysed by the Nutritional Intervention Research Unit of the Medical Research Council in Tygerberg. The mineral analysis was conducted by the

ARC-Institute for Soil, Climate and Water. Standardised analytical techniques were used for the analysis. The nutrient content of OFSP was compared with the nutrient content of WFSP and carrots. The nutrient contribution of OFSP to the Recommended Dietary Allowance (RDA) for children between the ages of four to eight years will be discussed (USDA, 1998)

Descriptive sensory analysis of sweet potato

Descriptors and definitions of the sensory characteristics of Resisto, Kano, W119 and Beauregard cultivars OFSP and Blesbok cultivar WFSP were developed and applied to measure the intensity of each sensory attribute in the different cultivars on an eight-point category rating scale. Experienced panellists were trained on the different types of sweet potatoes for four days (two hours per day), prior to being evaluated in individual sensory booths on four consecutive days. Sweet potato samples were evaluated under red light conditions in order to mask the colour difference that is characteristic of the different cultivars. One session per product was conducted per day in order to obtain four repetitions over four days which will provide statistically reliable results (Lea, Næs & Rødbotten, 1998:58).

Physical texture analysis

Physical texture analysis with the Instron Universal Testing Machine was performed on all sweet potato samples. After cooking, samples were cooled down at room temperature for at least 2-hours before shear force measurements. Cylindrical samples with a 12.5 mm core diameter were cored and sheared perpendicular to the fibre direction using a Warner Bratzler shear device mounted on a Universal Instron apparatus (6-8 cores / sample). The reported value in kg represents the average of the peak force measurements of each sample.

Consumer acceptability of Resisto cultivar OFSP vs. Blesbok cultivar WFSP

The first step in testing the consumer acceptability was to use the attributes of Resisto cultivar OFSP and Blesbok cultivar WFSP that were identified during the descriptive sensory analysis, to design a paired preference test in order to compare preference for OFSP (Resisto) to WFSP (Blesbok) on colour and taste. The outcomes of the consumer acceptability test were verified by conducting three focus group discussions with consumers from different socio-economic groups.

3.7 POPULATION AND SAMPLING

During this study, Resisto, Jewel, W119 and A15 OFSP cultivars were analysed for their nutrient content. The cultivars analysed for nutrient content differed from the cultivars included in the sensory evaluation due to the limited availability of different cultivars from different regions for nutritional analysis. Resisto, Kano, W119 and Beauregard OFSP cultivars and Blesbok WFSP cultivar were used as the unit of analysis for the quantitative descriptive analysis. The sensory evaluation required samples that were harvested from the same region on the same day in order to eliminate unnecessary variables that would influence the results. Resisto cultivar OFSP and Blesbok cultivar WFSP were used for the consumer evaluation.

Nutrient analysis

According to practicality and availability, four different cultivars plus one composite sample of OFSP were sampled from three different regions in South Africa. Sound sampling methods were applied, although in some cases the researcher did not have full control over the sampling methods and had to rely on the discretion of helpers in regions such as the Free State and Eastern Cape. However, all the samples were harvested at the end of the growing season, approximately four to five months after planting. Once harvested, samples were kept in basket-weave bags and stored in a cool room. Samples were prepared for nutrient analysis at the sensory laboratory of the ARC-Irene within five days after harvesting to be representative of commercial practice. All preparation procedures were monitored and recorded. Samples were weighed before and after preparation. Approximately 1.5 kg raw and cooked product per cultivar was prepared for analysis and each cultivar was treated separately. The raw and cooked samples were taken from different roots, as cutting the roots would have caused leaching of nutrients during cooking of samples. Table 3.1 presents the sampling plan and shows the number of units per cultivar from the different regions.

TABLE 3.1: Sampling plan to show the units per cultivar from the different regions

CULTIVAR	REGIONS	UNITS
Resisto	Gauteng, University of Pretoria vegetable gardens	30 units
W119	Gauteng, University of Pretoria vegetable gardens	20 units
Jewel	Gauteng, University of Pretoria vegetable gardens	20 units
	Free State, Fouriesburg	5 units
A15	Free State, Fouriesburg	5 units
Composite sample of 3 cultivars	Eastern Cape	5 units

Cooked samples were boiled in their skin in stainless steel saucepans with the lid on and 500 ml water was added to the saucepan and it was brought to boiling point at 95 °C. Water was replenished if required. Sweet potatoes were cooked until soft, which took approximately 40 min for a 250 – 300 g per sample. The sample size influenced the length of cooking time but, when the core temperature reached approximately 94 °C, the sweet potatoes were soft, which was tested by inserting a stainless steel probe. Samples were then cooled to room temperature and peeled (skin was easy to peel off / remove from cooked samples). The flesh was mashed with a fork, thoroughly mixed and 1 kg samples were packed in plastic bags and sealed. Samples were coded and dispatched on the same day to the analytical laboratory for freeze-drying, after which they were ground and then stored at -20 °C.

Approximately 1.5 kg raw OFSP of each cultivar was prepared by firstly weighing the raw samples, peeling and grating – using a stainless steel grater. Samples were grated medium to rough, by hand (approx 1 mm x 2 mm). Grated samples were thoroughly mixed and packed as 1 kg samples in plastic bags and sealed. Each sample was clearly coded and dispatched to the analytical laboratory for analyses, where the samples were freeze-dried and then stored at -20 °C.

Quantitative Descriptive Analysis

Twelve individuals previously trained in sensory analysis, were used to describe the complete profile of the sweet potatoes. Panel members were selected on their ability to provide similar responses to similar products on repeated occasions. The closer their responses were, the higher the degree of reliability, which gave confidence in the validity of the results. Panellists were also chosen for their smell acuity and interest in the project as well as being available for the entire study. This was followed by evaluation of the products in terms of its aroma, texture on appearance, texture on first bite, texture on mastication, flavour and aftertaste attributes. .

Consumer evaluation

The target population for this study was black, white, coloured and Indian female and male adults aged 20-60 years who consume sweet potato and lived in the greater Pretoria* area, in the proximity of Centurion. Income of the household, as an indicator of different socio-economic groups of consumers, was used to screen respondents. A household refers to a group of people living together and providing themselves jointly with food and / or other essentials for living (Census 2001: Census in brief / Statistics South Africa, 2003:vi). As mostly women produce and / or purchase sweet potato (Domola, 2003:49), 60 % of the sample consisted of women and 40 % of men. Women are decision makers regarding food choice for the household. Men were included in the study as they form part of a family and therefore play an important role in the acceptance and ultimate utilisation of the OFSP at household level.

Table 3.2 provides details of the total population of South Africa and Gauteng. Groups were selected based on the population criteria. As lower socio-economic groups are more likely to suffer from vitamin A deficiency, more respondents of lower socio economic backgrounds were included in the study.

TABLE 3:2: SAMPLING PLAN FOR THE CONSUMERS THAT PARTICIPATED IN THE STUDY (REFER GREYED AREA). (Census 2001: Census in brief / Statistics South Africa, 2003:6,7,8)

Population groups included in the study	Population of South Africa			Number of respondents for study			Actual % of each population group included in the study
	Total population in South Africa 44,8M	Total population Gauteng 8,8M	Total population Gauteng %	Total number of respondents included in the study	Female	Male	
Black	35.4	6 522 792	74	144	88	56	79
Coloured	3.98	337 974	3.7	2	1	1	1.1
Indian	1.12	218 015	2.2	2	1	1	1.1
White	4.3	1 758 398	20	34	33	1	19
Total				n =182	n = 123 (68 %)	n = 59 (32 %)	

The respondents were recruited from various farms, institutions and companies and included cleaners, farm-workers and management. At farms, the farm manager was contacted in advance and arrangements were made to conduct the research with the relevant farm workers. The farmer identified workers who were able to participate and any worker who consumed sweet potatoes was allowed to participate, including literate and illiterate workers. At offices, the researcher made contact with the relevant supervisor and arranged for a suitable time to conduct the research. All the requirements with regard to the research i.e. evaluation forms, cooked samples and serving utensils were transported to the research venue. Snowball sampling was applied which refers to the procedure where the target respondent indicates members of that population (friend, relatives, colleagues) as another possible participant (Babbie & Mouton, 2001:167). According to Jellinek (1985:28) in a hedonic test, 30-50 persons should participate. This study included 182 subjects as it was conducted over different population groups i.e. 123 females and 59 males (refer to table 3.1).

Table 3:3 summarises the selection criteria for the consumer acceptance testing.

TABLE 3:3: SELECTION CRITERIA FOR CONSUMERS

CRITERIA	MOTIVATION
<ul style="list-style-type: none"> Ethnicity and gender 	<p>Sweet potatoes in rural areas are primarily produced by women on the land given to them by their husbands. Husbands have some say in what is eaten by the members of the household and therefore should be included in the study.</p> <p>Sweet potatoes are consumed in rural and urban communities. urban white, black, coloured and Indian respondents were included in the study.</p>
<ul style="list-style-type: none"> Age Adults (aged between 20-65 years) 	<p>Women are the gatekeepers of the family and usually purchase food for the family. Sweet potatoes are consumed by all age groups, but adults are more likely to do the purchasing.</p>
<ul style="list-style-type: none"> Sweet potato consumption 	<p>Consumers must be users of sweet potatoes.</p>

Focus group discussion

A few focus group discussions were conducted and were only included to verify some of the findings of the consumer research. The target population for the focus group discussions was the same as for the consumer evaluation. Only three focus group discussions were conducted for the purposes of triangulation with results obtained in the consumer evaluation. With this qualitative technique, information was gathered that would otherwise not have been accessible such as preparation methods particular to a community or beliefs about the benefits of sweet potato by a specific community (Babbie & Mouton, 2001:292). Each focus group consisted of ten-twelve respondents from different socio-economic groups. Two of the focus groups were conducted with consumer groups (delegates) that were involved in a separate training course at the ARC-Irene. As these delegates fell within the target group for this study, the researcher arranged a suitable time to conduct the focus group discussions. This was a practical way to recruit respondents to participate in the preference test as well as the focus group discussion as the researcher was based at the ARC-Irene. The third focus group was conducted with white females that were recruited with the help of the trained sensory panel of the ARC-Irene. Each panel member recruited one friend who consumed sweet potato. However, panel members who were part of the descriptive analysis were not permitted to participate in the focus group discussion. The individuals were not evenly distributed.

3.8 DATA ANALYSIS

3.8.1 Nutrient analysis of OFSP

Methods of analysis

Various laboratories were tasked to analyse the nutrients present in OFSP. Table 3.4 summarises the analytical methods applied for nutrient analysis and lists the different laboratories used.

Table 3.4: SUMMARY OF THE ANALYTICAL METHODS USED FOR NUTRIENT ANALYSIS

Analysis	Method / technique	Institution / laboratory
Proximate analysis	AOAC 2005	ARC- Irene Analytical Services, South African National Accreditation Services (SANAS), accredited laboratory
Carbohydrates	Calculated 'by difference'	
Food energy content	Calculated	
Water soluble vitamins		ARC- Irene Analytical Services, SANAS accredited laboratory
Vitamin C	Liquid chromatograph	
Fat soluble vitamins		Nutritional Intervention research Unit of the Medical Research Council (MRC), Tygerberg
Beta Carotene	HPLC	
Minerals	ICP- emission spectrometer	ARC-Institute for Soil, Climate and Water

The results of the nutrient analysis of the different cultivars were entered on a spreadsheet using Microsoft Excel (2003). Data was statistically analysed by the ARC, Biometry Unit using GenStat for Windows (2003) statistical programme. A limited amount of data was available i.e. only 15 values which included 5 cultivars (W119, Jewel, Resisto, A15 and a Composite sample), three regions (Free-state, Eastern Cape and Gauteng) and two treatments (raw and cooked). Analysis of an unbalanced design using Genstat regression was applied.

The first regression analysis was applied to the overall raw and cooked values of all the OFSP cultivars. The tests that followed used the raw and cooked values for each cultivar as repetitions and the main effect of each sample was then tested separately for

cultivar and then region at a 5 % level of significance. If the sample main effect was significant, Fishers' protected t-test least significant difference (LSD)-test was applied to separate the sample means.

3.8.2 Quantitative descriptive analysis

Data obtained with Quantitative Descriptive Analysis (QDA) procedure was analysed by applying analysis of variance (ANOVA) statistical procedure, which was followed by multivariate statistical techniques i.e. correlation analysis and principal component analysis. All statistical analyses were done using GenStat for Windows (2003) statistical computer programme.

Analysis of Variance

Analysis of Variance (ANOVA) is one of the most common statistical procedures performed in descriptive analysis where more than two products are compared, using scaled responses (Lawless & Heymann, 1998: 701). ANOVA tests the hypothesis in so-called linear models which are based on comparing two variance estimates with each other (Lea *et al.*, 1998:23). It provides a sensitive tool for measuring whether variable treatments such as changes in processing, production or packaging have an effect on the sensory properties of the products. It examines variation between treatments, relative to variation within treatments. To achieve reliable results, a good experimental design, careful control and good testing practices are of utmost importance. ANOVA addresses multiple treatments to compare several means at one time and estimates the variance or squared deviation attributable to each factor, while also estimating the variance or squared deviation due to error. In ANOVA, a ratio of the factor variance is constructed to the error variance. This ratio follows the distribution of the F-statistic. If the F-ratio is significant for a given factor, it implies that at least one of the individual comparisons among means is significant for that factor. In other words, the F-ratio is a signal to noise (Lawless & Heymann, 1998: 701-3).

In this study, the different treatments referred to the five different cultivars i.e. Resisto, Kano, W119 and Beauregard OFSP cultivars and Blesbok WFSP cultivar.

Multivariate Analysis

Multivariate statistical methods refer to a method that is applied to data sets that contain both dependent and independent variables i.e. data sets in which one or more of the variables are special or of more interest relative to some others (Meilgaard, Civille & Carr, 1991: 276). The aim of multivariate statistical analysis is to extract information from a product attribute matrix and to present it in an understandable form. The sensory specialist is then able to detect broader patterns of interrelationships among products and among sensory characteristics than given by a univariate analysis (Lawless & Heymann, 1998: 586).

Correlation analysis

This is one of the simplest multivariate techniques and measures the strength of linear relationships between two variables. It can be used to identify groups of responses that vary in similar ways. The correlations indicate that an increase in a specific attribute will result in an increase in a correlating attribute e.g. flavour and aroma, or *visa versa*. Correlation analysis can also be used to determine the strength of the relationship of data arising from two different sources, for example consumer ratings and descriptive data from a trained panel. The strength of the relationship between two attributes is expressed in the correlation coefficient (r) (Meilgaard *et al.*, 1991:276).

Principal component analysis

Principal Component Analysis (PCA), a multivariate statistical technique, was applied to the data in order to identify the main variates that explained the data and, therefore, simplified the interpretation of the descriptive sensory data. The purpose of the PCA is to transform the set of original correlated descriptors into a new set of principal components, which are linear combinations that explain the greatest amount of observed variability in the data. It is possible to explain 75 – 90 % of the total variability in a data set containing 25 – 30 variables with as few as two to three principal components. PCA is a dimension-reducing technique, therefore descriptors are ranked so that the variation in the data-set explained by the successive principal components decreases (Van Marle, Van der Vuurst De Vries, Wilkinson & Yuksel, 1997: 82). Through PCA, the correlation structure of a group of multivariate observations is analysed and the axis along which maximum variability of the data occurs is identified and referred to as the first principal

component or PC1 (horizontal axis). The second principal component or PC2 (vertical axis) is the axis along which the greatest amount of the remaining variability lies subject to the constraint that the axes must be perpendicular (at right angles) to each other (Meilgaard *et al.*, 1991: 277).

3.8.3 Consumer evaluation

The consumer questionnaire i.e. paired preference test was analysed by applying a chi-square test, which was used to test the hypothesis of frequencies or occurrences (in other words - to determine the interaction between the taste and colour preferences) (O'Mahony, 1986:91). In a paired preference test, the probability of the selection of one specific product is one chance in two. The null hypothesis states that in the long run, when the underlying population does not have a preference for one product over another, each product will be picked an equal number of times – therefore the null hypothesis probability = 0.5 (O'Mahony, 1986:92). The paired preference test was two-tailed as, prior to the study, the researcher did not know which sample would be preferred by the respondents. Paired preference data may be analysed by either binomial, chi-square or normal distributions, respectively. All these analyses assume that the respondents were forced to make a choice and did not have the option of no-preference (Lawless & Heymann, 1998: 433-438).

Chi-square uses nominal data, which means that numbers in the scale represent nothing more than names. Certain conditions must apply when using a chi-square test such as each cell must be independent from each other. The expected frequencies should not be too small, for example, five is too small which means that frequencies in the cell cannot be normal (O'Mahony, 1986:99). For this reason, responses for the categories 'neither like nor dislike'; 'dislike a little' and 'dislike a lot' were grouped together.

Focus groups

The focus group were transcribed from the notes taken during the discussions and were summarised. The prompt list used during the discussions, guided the researcher to identify comments relative to the consumer taste test in order to establish commonalities between the consumer taste test and the focus group discussions. No particular statistical technique was applied to analyse the data.

3.9 QUALITY OF THE RESEARCH

3.9.1 Reliability

Reliability refers to the application of a particular technique that, when applied repeatedly to the same object, would provide the same results (Babbie & Mouton, 2001:119).

Nutrient analysis

As different cultivars from different regions were included in the nutrient analysis, particular care was taken in the coding of the samples to ensure that cultivars and regions were not confused. Samples were prepared according to a standardised method for sample preparation (Greenfield & Southgate, 2003: 79-82). The samples were clearly coded on the container and codes were recorded on a spreadsheet in Microsoft Excel, which accompanied all samples to the different laboratories. The proximate analyses were conducted by a South African National Accreditation Services (SANAS) accredited laboratory, and the remainder of the nutrients i.e. beta-carotene and minerals by experienced laboratory analysts in the industry i.e. Agricultural Research Institute for Soil, Climate and Water and the Medical Research Council, Tygerberg. Throughout the study, only validated methods were applied.

Quantitative Descriptive Analysis

Research design for QDA: In order to ensure that the study was reliable, a completely randomised block design was used for the descriptive sensory evaluation. Therefore, different sweet potatoes were served to the panel in a randomised order and the whole experiment was repeated for each assessor or panellist (Lea *et al.*, 1998:18). The panel had been trained according to the guidelines for training a descriptive sensory panel as described in Meilgaard *et al.* (1991:187-193).

Sensory testing environment – the sensory booths used were designed according to the American Society for Testing Materials (ASTM, 1998) guidelines. The sensory booths were in a quiet setting, air conditioned and no odours from food preparation were present.

Preparation procedures of samples used during the sensory evaluation were standardised prior to presentation to the trained panel for evaluation. The quality of the

samples served to the panel was controlled in that all the sweet potatoes were harvested on the same day, 4-5 months after planting from the same area i.e. ARC: Roodeplaas.

Consumer evaluation

Quantitative study: Sample preparation and serving procedures had been standardised and were applied throughout the study. The quality of the samples served to the participants was further controlled by ensuring that all the serving portion sizes and temperature were monitored and kept the same to all the participants.

Triangulation was applied during data collection, which is the use of multiple methods such as combining methods and investigators in the same study to overcome deficiencies from one investigator or method. In this study, selective focus groups were conducted to validate information gathered during consumer evaluation. More than one person was used to record data (such as fieldworkers / researcher) to reach consensus of the findings. The researcher also used assistants who were familiar with the type of research being conducted i.e. preference testing, in order to ensure that any gaps were identified and corrected. Triangulation is viewed as one of the best ways to enhance validity and reliability.

Extensive field notes enhance validity and reliability. During the focus groups discussions, the researcher took notes but also made use of two other observers to take notes, which were used to verify the data and findings by the researcher. Two sets of notes were kept of which one recorded information about the environment in which the study took place plus extensive observations. The other set of notes contained data regarding the researcher's theoretical memoranda and observation that could have contradicted or validated original theoretical ideas (Babbie & Mouton, 2001:275). The researcher checked the information gathered during the focus group interviews with the assistants who also took notes during the discussions.

3.9.2 Validity

Validity refers to whether a particular measure adequately reflects the concept's meaning, therefore, effectiveness of the measuring technique (Babbie & Mouton, 2001: 123).

Construct validity

Construct validity refers to the logical relationship between variables (Babbie & Mouton, 2001: 123). The literature study and conceptualisation provided a clear understanding of the concepts that were measured.

Content validity

Content validity refers to whether the measure covered that range of meanings within the concept i.e. was the complete spectrum covered. This involves the use of valid scales and valid instruments in order to achieve measurement validity. A standardised category scale was used for the sensory evaluation of the sweet potatoes (Lawless & Heyman, 1998:211; Stone & Sidel, 1993: 215) and four replications were applied during the sensory evaluation of the OFSP to ensure statistical reliability of the results.

The participants selected from the target market must be representative of the target population in order to achieve an unbiased sample (Mouton: 1998:10). A clear definition was supplied of the target population. The number of the different population groups used in this study i.e. White, Black, Indian and Coloured, were representative of the population of South Africa. In this study 182 participants participated in the study, ensuring an adequate sample size that contributed to its being representative and valid for a master's study.

Data analysis

All data was analysed by the ARC-Biometry unit, where a trained statistician guided the researcher with the statistical procedures as well as interpretation of the results. Interpretation of the results was again verified by the statistician in order to ensure that no incorrect inferences were made.

REFERENCES

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS INTERNATIONAL. 2005. Official methods of analysis of AOAC International. 18th Ed. Maryland, USA.

AMERICA SOCIETY FOR TESTING AND MATERIALS (ASTM). 1989. Standard definitions of terms relating to sensory evaluation of materials and products. *In Annual Book of ASTM Standards*. American Society for Testing and Materials, Philadelphia.

BABBIE, E. & MOUTON, J. 2001. *The practise of social research*. South African edition. New York. Wadsworth.

CONNER, M. 1993. Understanding determinants in food choice. *Br Food J*, 95(9):27-31.
DOMOLA M.J. 2003. *Survey and characteristics of sweet potato viruses in South Africa*. M. Inst Agrar (Plant Protection). University of Pretoria. pp. 46 -59

GENSTATS® for Windows® (7th Edition) – Introduction (Editor R.W. Payne), Published 2003 by VSN International, ISBN 1-904375-08-1.

GREENFIELD, H. & SOUTHGATE, D.A.T. 2003. *Food composition data. Production management and use*. Elsevier Science Publishers. Rome.

HAMILTON, J.A., MCLLVEEN & STRUGNELL, C. 2000. Educating young consumers – a food choice model. *J Consum Stud Home Econ*. 24(2) 113 – 123).

JELLINEK, G. (1985). *Sensory evaluation of food, theory and practice*. Great Britain. Southampton. The Camelot Press.

KRUGER, M., SAYED, M., LANGENHOVEN, M. & HOLING, F. 1998. *Composition of South African Foods: Vegetables and Fruit*. pp 36. UDMS, Cape Town.

LAWLESS, H.T. & HEYMANN, H. 1998. *Sensory evaluation of food: Principles and Practices*. Gaithersburg. Maryland. Aspen.

LEA, P., NÆS, T. & RØDBOTTEN, M. 1998. *Analysis of variance for sensory data*. John Wiley and Sons. UK.

MEILGAARD, M., CIVILLE, G.V. & CARR, B.T. 1991. *Sensory evaluation techniques*. 2nd ed. New York. CRC Press.

MOUTON, J. 1998. *Understanding social research*. Pretoria: Van Schaik.

O'MAHONY, M. 1986. *Sensory evaluation of food. Statistical Methods and Procedures*. pp 91, 92, 99,101. Marcel Dekker Inc.

RANDALL, E. & SANJUR, D. 1981. Food preferences – their conceptualisation and relationship to consumption. *Ecol Food Nutr* 11:151-161.

SHEPHERD, R. & SPARKS, P. 1994. Modelling food choice. In MacFie H.H & Thompson, D.M.H. 1994. *Sensory evaluation of food preferences*. New York. Chapman and Hall.

STATISTICS SOUTH AFRICA. 2003. *Census 2001: Census in brief*. Pretoria.

STONE, S. & SIDEL, J.L. 1993. *Sensory evaluation of food*. 2 ed. UK. p 111. Academic Press.

USDA-NCC. 1998. Dietary Reference Intake: Recommended Intakes for Individuals. National Academy of Sciences. Institute of Medicine. Food and Nutrition Board. (www.fnic.nal.usda.gov/nal_display/index.php?info_center).

USDA-NCC. 1998. Carotenoid Database for US Foods 1998. (www.nal.usda.gov/fnic/foodcomp/Data/car98/car98.html).

VAN MARLE, J.T., VAN DER VUURST DE VRIES, R., WILKINSON, E.C. & YUKSEL, D. 1997. Sensory evaluation of the texture of steam-cooked table potatoes. *Potato Research*. 40:79 –90.

CHAPTER 4

NUTRIENT CONTENT OF ORANGE-FLESHED SWEET POTATO

In this chapter the style and layout, as prescribed by the Journal in which the article will be published namely, Journal of Food Composition and Analysis, has been followed.

CS LEIGHTON¹, HC SCHÖNFELDT² and R KRUGER²

¹Agricultural Research Council, Irene (ARC-LBD), South Africa

²School of Agricultural and Food Sciences, University of Pretoria, South Africa

Abstract

The nutrient content of different cultivars orange-fleshed sweet potatoes (OFSP) from different regions in South Africa was evaluated. OFSP were analysed raw and cooked for comparative purposes. Cooked samples were prepared by boiling them in their skins until soft. Samples were cooled, peeled, mashed and thoroughly mixed in order to prepare an analytical sample. Raw samples were prepared by peeling the OFSP, grating and mixing it thoroughly. Proximate analyses (protein, fat, moisture and ash) and vitamin C were conducted by a SANAS accredited laboratory. Mineral analysis and beta carotene were analysed by other reputable laboratories. The results showed that a 100 g portion OFSP can provide up to 6528 µg beta-carotene, which is approximately 136 % of the RDA for pro-vitamin A carotenoids for children four to eight yrs. OFSP is also a valuable source of vitamin C, calcium, magnesium and zinc in the diet. A 100 g cooked OFSP can contribute up to 28 % of the vitamin C requirements of a child between the ages of four to eight years per day. It further contributes up to 13 % calcium, 15 % magnesium and 75.6 % zinc of their daily requirements.

Key words: Orange-fleshed sweet potatoes, nutrient content, beta-carotene, provitamin A carotenoids, retinol.

1. Introduction

The three most common forms of micro-nutrient deficiencies in the world (in order of prevalence) are nutritional anaemia, iodine deficiency disorders and vitamin A deficiency. Vitamin A deficiency has been recognised as a widespread problem affecting about 750 million people, almost all of whom are in developing countries. In sub-Saharan Africa, it is estimated that vitamin A deficiency contributes up to 25.1 % to child mortality due to related diseases such as malaria, diarrhoeal diseases, acute respiratory infections and vaccine preventable diseases (Black et al., 2003; Caulfield et al., 2004). Vitamin A is required in small amounts to ensure normal functioning of the immune system, the visual system as well as proper growth development (Savage King and Burgess, 2003).

By eliminating vitamin A deficiency, the mortality among school children can be reduced by as much as 35 – 50 % with an improvement in vitamin A status (Caulfield et al., 2004; Codjia, 2001). The introduction of vitamin A in the diet dramatically improves the chance of survival of deficient children between the ages of six months – six years, for example, the mortality risk from measles is reduced by approximately 50 % and from diarrhoea by approximately 40 % (Vitamin A Global Initiative, 1998). Vitamin A deficiency is caused by dietary patterns or intake of foods that provide too little bio-available vitamin A to support physiological needs under the prevailing circumstances. The provitamin A carotenoid content in foods, as well as the bioavailability thereof, are important determinants of the vitamin A status of an individual (Nestel and Nalubola, 2003a). The bioavailability of provitamin A from dark green leafy vegetables is low and research should be directed towards increasing the bioavailability of provitamin A carotenoids and their subsequent conversion to retinol (West et al., 2003). In developing countries, dietary vitamin A is mainly derived from plant foods such as carrots, spinach and pumpkin. A new addition is beta-carotene rich OFSP which is an excellent source of provitamin A (Van Jaarsveld et al., 2006). Regular intakes (100 g / day or half a cup) of OFSP provide recommended daily amounts for children under five years of age (400 µg RE) (Low et al., 2000).

The prevalence of vitamin A deficiency in South Africa was identified by The South African Vitamin A Consultative Group (SAVACG) in 1993. The SAVACG study

established that one in three children suffered from vitamin A deficiency and one in five children suffered from iron deficiency (SAVACG, 1995). From a National Food Consumption Survey (NFCS) that was conducted in South Africa (1999) among children between the ages of one to nine years, it was further observed that one out of two children had an intake of less than half of the recommended level for energy, vitamin A, vitamin C, riboflavin, niacin, vitamin B6, folate, calcium, iron and zinc. The nutrient intake of children living in rural areas was considerably lower than that of children living in urban areas. In addition, household food insecurity was associated with a considerably lower nutrient intake, specifically micronutrients. Stunting and underweight in children four to eight years, were found to be 21 % and 10 % respectively. This survey also identified maize meal, bread and sugar as the foods most widely consumed by the majority of South Africans (Labadarios et al., 2000). According to the NFCS, 83 % of the families interviewed (n=2812) procured potato or sweet potato and 82 % of the children consumed potato or sweet potato on a regular basis. However, in the 24h recall period, only 28 % of the children had consumed potato or sweet potato (Labadarios, 2000). The poor vitamin A status of people living in rural and urban areas in South Africa, requires strategies that are aimed at increasing production, availability, access and, subsequently, consumption of foods rich in vitamin A and provitamin A carotenoids.

Such strategies are:

- the fortification of food products consumed by infants and children (Vitamin A Global Initiative, 1998). In South Africa, products such as maize meal and bread (flour) are fortified,
- biofortification, which is a relatively new strategy and involves breeding of staple crops with increased vitamin A content (still in developmental phase) (Faber et al., 2006),
- food diversification to encourage increased vitamin A consumption (Faber et al., 2006), and
- food-based home-gardens to address vitamin A deficiency by increasing the availability of vitamin A through the planting of fruit and vegetables that are rich in beta-carotene such as mango, pumpkin, carrot, OFSP and green leafy vegetables. Only a few of these home-garden experiences have been evaluated as to their impact on vitamin A status, and have demonstrated a positive impact (Vitamin A

Global Initiative, 1998). This approach complements supplementation and fortification by providing a sustainable means to food diversification and, therefore, to improved nutrition (Faber et al., 2006).

In Kenya, similar approaches have been introduced since 1994 where vitamin A capsules were distributed to children and lactating women. In addition, food-based agricultural interventions were promoted and found to be successful in reducing sub-clinical vitamin A deficiencies while also complementing the supplementation programme. OFSP was used as the key entry point in improving vitamin A intake (Hagenimana et al., 2001).

In South Africa, in contrast, the fresh white-fleshed sweet potato (WFSP) is frequently consumed and, in some rural areas, cultivated by women as a food crop on small plots. It plays an important role as a food security crop in resource poor farming (Laurie in Niederwieser, 2004), however, WFSP has a very low beta-carotene content and cannot make any significant contribution to alleviating vitamin A deficiency (Hagenimana et al., 2001)

Different cultivars of OFSP have been cultivated as part of an effort to introduce vitamin A rich vegetables to people in rural areas. The Medical Research Council (MRC) of South Africa and the ARC promoted the production of beta-carotene rich fruits and vegetables. They have implemented a home-based food production programme in KwaZulu Natal in South Africa (Faber et al., 2002) The ARC has focussed research on identifying OFSP cultivars that will deliver a satisfactory yield, prove to be pest resistant and with good flavour characteristics that are acceptable to the African consumers (Laurie in Niederwieser, 2004). To date, the nutrient content of OFSP grown in South Africa has not yet been determined with the exception of the beta-carotene content. The content of provitamin A carotenoids in foods, as well as the bioavailability thereof, are important determinants of the vitamin A status of an individual (Nestel and Nalubola, 2003b). Vitamin A derived from plant food such as beta-carotene rich OFPS, is an excellent source of provitamin A (Van Jaarsveld et al., 2005).

The nutrient quality of sweet potatoes is influenced by growing conditions such as climatic factors, soil type, use and application methods of fertiliser (Thybo et al., 2001). Sweet potato is a hardy crop that is attacked by few pests and diseases, does not require high levels of input while also being more drought tolerant than other vegetable

crops. It offers flexibility in planting and harvesting times as it has a shorter growing cycle than other root crops, for example the average crop growth period for sweet potato is 140 days and for cassava, 330 days. Specific cultivars are also more suited to certain geographical areas (Van den Berg and Laurie, in Niederwieser, 2004).

Therefore, the aims of the study were, firstly, to determine the nutrient content of different cultivars of OFSP in order to obtain information with regard to the nutrients present in OFSP in South Africa and, secondly, to compare the nutrient content of different cultivars with each other.

2. Materials and Methods

2.1. Sampling of storage roots

Four different cultivars OFSP and one composite sample, cultivated by the Agricultural Research Council (ARC) – Roodeplaat, Gauteng, were sampled from three different geographical regions in South Africa. The cultivars included were Resisto, W119, Jewel, A15 and a composite sample that was drawn from the Eastern Cape (sampled on behalf of researcher and couriered to the researcher), Free State and Gauteng provinces in South Africa. Table 1 provides a layout of the sampling plan and shows the number of samples (units) drawn from each region.

Table 1
Number of units per OFSP cultivar selected for analyses

CULTIVAR	REGIONS	UNITS
Resisto	Gauteng	30
	University of Pretoria vegetable gardens	
W119	Gauteng	20
	University of Pretoria vegetable gardens	
Jewel	Gauteng	20
	University of Pretoria vegetable gardens	
	Free State Fouriesburg	
A15	Free State	5
	Fouriesburg	
Composite sample of 3 cultivars	Eastern Cape Lusikisiki	5

Units: 1 unit = 1 sweet potato

2.2. Preparation of samples

Sweet potatoes were analysed raw and cooked for comparison purposes. Raw sweet potatoes were washed, peeled and grated. Samples were grated by hand to a medium-rough size (approx 1 mm x 2 mm), using a stainless steel grater. Grated samples were thoroughly mixed and packed as 1 kg samples in plastic zip-lock bags.

Cooked samples were washed and boiled (boiling point of 95° C) in their skin in stainless steel saucepans with the lid on. Sweet potatoes were cooked whole to prevent leaching of nutrients into cooking water. Water (500 ml) was added to the saucepan and was replenished if required. Sweet potatoes were cooked until soft and a core temperature of 94° C was reached, which was tested by inserting a hand held digital stainless steel probe (Kane May C9003), equipped with a J-type thermocouple to record the internal temperature at the geometrical centre of the sweet potato. Samples were subsequently cooled to room temperature and peeled (skin was easy to peel off / remove from cooked samples). The flesh was mashed, thoroughly mixed and 1 kg samples were packed in plastic zip-lock bags. Raw and cooked samples were coded and dispatched on the same day to the ARC-Irene analytical laboratory for freeze-drying and grinding, after which it was stored at -20° C.

2.3. Methods of analysis

Various laboratories were tasked to analyse the nutrients present in OFSP. Table 2 summarises the analytical methods applied for nutrient analysis and lists the different laboratories used.

2.4. Comments on the sweet potatoes and collections sites

Vitamin A vegetable gardens have been implemented by the ARC-Roodeplaat in some rural areas in South Africa. The specific cultivar / s of the samples from Lusikisiki in the Eastern Cape was not identified and was, therefore, treated as a composite sample, which complicated the interpretation of the results. Sweet potatoes from Fouriesburg in the Free State were drawn by students and lecturers from the University of Pretoria. These sweet potatoes were grown under hardy conditions as people from the community had to walk a short distance to collect water for irrigation, which had to be

carried to the production site. The samples from Pretoria in Gauteng were drawn from vegetable gardens at the University of Pretoria. The planting of the sweet potatoes at this site was monitored by one of the co-authors on a regular basis. The plants received fertilizer and regular irrigation as water for irrigation purposes was readily available. All these factors had an influence on the nutrient content of the sweet potatoes, which makes the interpretation thereof difficult.

Table 2
Summary of the analytical methods used for nutrient analysis

Analysis	Method / technique	Institution / laboratory
Proximate analysis		
Protein	AOAC 2005	ARC- Irene Analytical Services, South African National Accreditation Services (SANAS), accredited laboratory
Fat	AOAC 2005	
Moisture	AOAC 2005	
Ash	AOAC 2005	
Carbohydrates	Calculated 'by difference'	
Food energy content	Calculated	
Water soluble vitamins		
Vitamin C	Liquid chromatograph	ARC- Irene Analytical Services, SANAS accredited laboratory
Fat soluble vitamins		
Beta Carotene	HPLC	Nutrition Intervention Research Unit of the Medical Research Council (MRC), Tygerberg
Minerals		
Selenium (Se) Calcium (Ca) Magnesium (mg) Phosphorus (P) Potassium (K) Iron (Fe) Manganese (Mn) Zinc (Zn) Copper (Cu)	ICP- emission spectrometer	ARC-Institute for Soil, Climate and Water

AOAC: Association of Official Analytical Chemists

2.5. Statistical analysis

The results of the nutrient analysis of the different cultivars were entered on a spreadsheet using Microsoft Excel (2003), using GenStat for Windows (2003) statistical programme. A limited amount of data was available i.e. only 15 values which included five cultivars (W119, Jewel, Resisto, A15 and a composite sample), three regions (Free State – Fouriesburg, Eastern Cape - Lusikisiki and Gauteng-Pretoria) and two treatments (raw and cooked). Therefore analysis for an unbalanced design was applied by using Genstat regression.

3. Results

Table 3 lists the nutrient values for raw and cooked OFSP of all the cultivars analysed. It was found that raw and cooked OFSP did not differ significantly from each other in the macro and micro nutrients. Therefore the tests that followed used the raw and cooked values for each cultivar as repetitions and the main effect of each sample was then tested separately for cultivar at a 5 % level of significance. If the sample main effect was significant, the Fishers' protected t-test least significant difference (LSD)-test was applied to separate the sample means. The first regression analysis was applied to the overall raw and cooked values of all the OFSP cultivars (refer table 3). These results showed that all the nutrients of the raw and cooked samples did not differ significantly from each other.

Table 3

Mean values for the nutrient content of raw and cooked OFSP including all the cultivars tested

Nutrients	Unit per 100g	p-value	All cultivars OFSP		OFSP ³ (US) Baked with skin, flesh only, USDA
			Raw ¹ (n = 6) (±) SEM	Cooked ² (n = 7) (±)SEM	
Macro-nutrients					
Ash	g	0.945	0.97± 0.047	0.97± 0.066	
Dry matter	g	0.964	21.1± 1.278	21.4± 0.911	20.71
Moisture	g	0.964	78.9± 1.278	79.0± 0.911	
Protein	g	0.912	1.30± 0.222	1.33± 0.195	1.7
Fat	g	0.578	0.24± 0.013	0.22± 0.029	0.1
Carbohydrate	g	Calculated	18.57	18.48	21.3
Energy	kJ	Calculated	343	341	446
Micro-nutrients					
Beta-carotene	µg	0.617	7128± 951.0	6528± 648.7	13 092
Vitamin C	mg	0.984	7.07± 1.555	7.10± 0.796	25
Selenium	µg	To small to analyse	<0.010	< 0.010	0.7
Calcium	mg	0.915	101± 8.091	103± 13.980	28
Magnesium	mg	0.941	19.3± 2.603	19.6± 1.913	20
Phosphorus	mg	0.681	57.7± 4.302	55.1± 4.120	55
Potassium	mg	0.426	324± 25.53	297± 22.87	348
Iron	mg	0.450	0.62± 0.119	0.71± 0.046	0.5
Manganese	mg	0.380	0.38± 0.204	0.18± 0.0417	0.56
Zinc	mg	0.805	3.68± 0.333	3.78± 0.222	0.29
Copper	mg	0.585	0.12± 0.047	0.096± 0.018	0.21

1. Mean raw values of OFSP, analysed in this study

2. Mean cooked values of OFSP, analysed in this study

3. Values for OFSP (USDA, 1998)

Means in same row are not significantly different at $p \leq 0.05$

Mean and standard deviation is based on 6 samples for raw OFSP and 7 samples for cooked OFSP (limited availability)

Energy and carbohydrate values were calculated (Greenfield and Southgate, 2003)

NOTE: Selenium

OFSP was analysed for selenium and results showed that OFSP did not contain significant amounts of selenium (< 0.01 mg / 100 g). Therefore it was not included in the statistical analysis and is not further discussed.

Comparing the mean values for cooked sweet potato as determined by this study with the values for OFSP from the United States (USDA, 1998), the latter have a slightly lower dry matter content and a higher carbohydrate and subsequently a higher energy value. Its beta-carotene value is almost double that of the beta-carotene value of the OFSP determined in the present study. The US vitamin C value is almost three times the value of the present study. Other differences were observed in the calcium and zinc values which were higher in the cooked OFSP analysed in this study. Differences could be attributed to, amongst others, the variation in the different cultivars evaluated, soil

composition, irrigation and fertilising applied. The comparative results of the nutrient analysis of different OFSP cultivars are summarized in Table 4. The values in Table 4 are average values for raw and cooked OFSP per cultivar (no significant difference was found for the raw and cooked values – refer Table 3).

Nutrient differences were observed in the different cultivars, particularly in the calcium and beta-carotene content of which the Resisto cultivar was the highest and differed significantly from the other three samples. W119 had the highest potassium and protein content and the lowest calcium and beta-carotene content. Furthermore it had the lowest dry matter content and therefore also the lowest carbohydrate and energy values. The calcium content of Jewel did not differ significantly from that of Resisto (which was the highest), and its potassium and protein content did not differ significantly from that of W119 (which was the highest in potassium). Resisto had the highest calcium, phosphorus and beta-carotene content. Its dry matter content did not differ significantly from that of the composite sample which had the highest dry matter content of the five samples. Resisto and the composite had the highest carbohydrate and energy content.

Table 4
Mean values for the nutrient content of different OFSP cultivars (mean of raw and cooked)

Nutrient	Unit Per 100g	p-value	cv %	SEM	W119 n = 2	Jewel n = 4	Resisto n = 2	A15 n = 2	Composite n = 3
Ash	g	0.001	5.90	0.057	1.20 ^a	0.98 ^b	1.04 ^b	0.97 ^b	0.77 ^c
Dry matter	g	0.060	6.45	1.421	16.8 ^a	20.9 ^b	23.1 ^{bc}	19.8 ^{ab}	23.6 ^c
Moisture	g	0.006	1.80	1.421	83.2 ^a	79.1 ^{bc}	76.9 ^{cd}	80.2 ^{ab}	76.4 ^d
Protein	g	0.032	25.91	0.341	2.02 ^a	1.40 ^{ab}	0.92 ^{bc}	0.70 ^c	1.42 ^{ab}
Fat	g	0.126	21.34	0.048	0.16	0.25	0.23	0.18	0.27
Carbohydrate	g		Calculated		13.4	18.2	20.9	17.9	21.1
Energy	kJ		Calculated		265	339	375	320	389
Beta-carotene	µg	0.004	10.87	742.4	4323 ^a	6853 ^b	9230 ^c	6880 ^b	-
Vitamin C	mg	0.915	47.08	3.33	5.91	6.37	8.56	7.45	7.580
Calcium	mg	0.007	15.64	15.95	65.5 ^a	115 ^{cd}	143 ^d	105 ^{bc}	80.0 ^{ab}
Magnesium	mg	0.028	18.56	3.61	18.5 ^a	19.2 ^a	16.0 ^b	13.5 ^a	26.7 ^b
Phosphorus	mg	0.001	5.63	3.17	57.5 ^a	57.5 ^a	71.5 ^b	60.5 ^a	41.0 ^c
Potassium	mg	0.003	9.24	28.63	362 ^a	324 ^a	328 ^a	348 ^a	219 ^b
Iron	mg	0.640	33.83	0.227	0.64	0.71	0.45	0.74	0.75
Manganese	mg	0.270	115.84	0.318	0.14	0.14	0.15	0.77	0.30
Zinc	mg	0.289	16.70	0.623	4.18	3.96	3.95	2.85	3.57
Copper	mg	0.645	85.18	0.089	0.02	0.11	0.15	0.11	0.13

Means in row with different superscript (a,b and c) represent significant difference ($P \leq 0.05$)

Means in same row followed by the same letter are not significantly different at $P \leq 0.05$

Means in same row not followed by a letter = no significant difference $P \geq 0.05$

CV – coefficient variation

SEM – standard error of means

Table 5 presents the results of the beta-carotene analysis for the different OFSP cultivars as obtained from the Nutritional Intervention Research Unit of the MRC, and is included merely for interest to the reader, as average values for the beta-carotene content of the different cultivars are used in the discussion.

Table 5: Beta-carotene content of different cultivars OFSP.

Source	Variety	Beta carotene content µg / 100 g raw root	Beta carotene content µg / 100 g cooked root	Vitamin A value RAE / 100 g cooked root ¹
Van Jaarsveld, (2003)	Resisto cultivar	N/a	9 980	832
Sight and Life (2004). New vitamin A tables	Not specified	N/a	5065	422
Present study	W119 Gauteng	4212,20	4433,09	369
Present study	Jewel Free State	7168,70	6119,10	510
Present study	Jewel Gauteng	7653,70	6472,10	539
Present study	Resisto Gauteng	10112,21	8346,93	696
Present study	A15 Free-State	6492,40	7268,35	606

¹Conversion factor 12 µg beta-carotene to 1 µg retinol

Table 6 lists the RDA for children between the ages of four to eight years, the values for OFSP as determined by the USDA (1998) and the values for WFSP and carrots as determined by the South African Department of Health (Kruger et al., 1998).

Table 6

RDA for children between the ages of four to eight years and nutrient values for other vegetable sources with high beta-carotene content

NUTRIENT	UNIT	RDA ¹ Children 4-8 years	OFSP (SA) ² Boiled in skin, mashed, flesh only	WFSP ³ Boiled without skin, flesh only	CARROTS ³ Boiled, flesh and skin
Dry matter			21.43	18.2	10.3
Protein	g	24	1.33	1	0.9
Fat	g	-	0.22	0.1	0.1
CHO	g	-	18.48	15.1	5.3
Energy	kJ	7560	341	311	162
Beta-carotene	µg	*4800	6528	20	17 280
Vitamin C	mg	25	7.10	7	4
Se	mg	30	< 0.1	0.5	0.7
Ca	mg	800	103	9	31
Mg	mg	130	20	13	11
P	mg	500	54	22	29
K	mg	-	297	189	156
Fe	mg	10	0.71	0.3	0.6
Mn	mg	1.5	0.18	60	150
Zn	mg	5	3.78	0.12	0.39
Cu	mg	440	0.09	0.08	0.03

1 RDA for children aged 4-8 years (Whitney and Rolfes, 2002)

*Vitamin A = 400µg/day (1 RAE = 12µg beta-carotene) (Whitney and Rolfes, 2002: 360)

2 Mean values for OFSP as determined in this study (refer Table 3)

3 Values for WFSP and carrots (Kruger et al., 1998)

4. Discussion

4.1. Nutrient content of OFSP

The dry matter of OFSP evaluated in this study was 21.4 % (refer to cooked OFSP in Table 3), however, according to Woolfe (1992), the average dry matter content of sweet potatoes is around 30 %. Although, the dry matter content of sweet potatoes is relatively low in comparison with other roots and tubers (Woolfe, 1992), sweet potatoes generally have a higher dry matter content than potatoes (19.6 %) (Kruger et al., 1998) and therefore a higher starch content (Garrow and James, 1998; Laurie in Niederwieser, 2004). Sweet potato dry matter consists of approximately 70 % starch, 10 % total sugars, 5 % total protein, 1 % fat, 3 % ash, 10 % total fibre and < 1 % vitamins, organic acids and other components in low concentrations (Woolfe, 1992). Dry matter content can vary widely depending on the cultivar, geographical area, climate, day length, soil type, incidence of pests and disease and cultivation practices (Garrow and James, 1998; Woolfe, 1992).

Dry matter in potatoes is known to decrease with increasing nitrogen supply, especially when a high nitrogen-fertilised crop is defoliated before physiological tuber maturity (Thybo et al., 2001). The lower moisture content indicates a higher dry matter content and therefore more carbohydrates and subsequently a higher energy value.

OFSP is an excellent source of energy (341 kJ / 100 g), which compares well with WFSP (311 kJ / 100 g), potato (318 kJ / 100 g) (Kruger et.,1998) and maize porridge (318 kJ / 100 g) (Woolfe, 1992). A 100 g portion of cooked OFSP, maize porridge or potato provide approximately 4.5 % of the daily energy requirements of children between the ages of four to eight years, WFSP provides 4 % and carrots only 2 %. The energy value is dependent on the type of cultivar and the time of harvest (stage of ripening). The energy value was calculated from the carbohydrate, protein and fat content present in the sweet potato (Greenfield and Southgate, 2003). The carbohydrate content of cooked OFSP analysed in this study (18.48 g / 100 g) is comparable to other starches such as maize porridge (15.6 g / 100 g) and potato (18.5 g / 100 g) Woolfe (1992). The protein content of sweet potatoes was relatively low (1.3 g / 100 g), but comparable with other vegetable sources.

Although the beta-carotene content of OFSP may differ between different cultivars, it remains an excellent source of beta-carotene when compared to many other commonly consumed vegetables. The average beta-carotene content of a 100 g cooked portion OFSP can provide up to 6528 µg / 100 g beta-carotene, which is approximately 136 % of the RDA for children between the ages of 4 - 8 years (refer to Table 6). Spinach contributes 7.1 % of the RDA for children aged 4 - 8 years. Carrots, on the other hand, provide substantial amounts of beta-carotene (17280 µg / 100 g) and almost half the amount of energy per 100 g portion compared to sweet potato (carrot 162 kJ / 100 g) (Kruger et.,1998).

According to Garrow and James (1998), sweet potato has little protein with somewhat higher values for its vitamin C content, which agrees with the results of this study. Woolfe (1992) reported values of 30 mg / 100 g vitamin C for sweet potatoes, which is substantially higher than the OFSP analysed in this study (7.1 mg / 100 g). However, the vitamin C content of WFSP published in the Food Composition Tables (Kruger et al., 1998) compared well with the vitamin C content of the OFSP analysed. OFSP can contribute up to 28 % of the vitamin C requirements of a child between the ages of four

to eight years per day with the consumption of a 100 g portion cooked OFSP, which is the same contribution as that of WFSP (28 %) and carrots providing 16 % (4 mg / 100 g) (refer to Table 5). The vitamin C present in OFSP could aid the absorption of the haeme-iron in the body (Savage King and Burgess, 2003), when consumed in the same meal.

The iron from plant matter is non-haeme (therefore limited absorption) (Savage King and Burgess, 2003) but, in many cases, may be the only iron available in the diet of people living in rural areas.. When comparing the contribution of iron to the diet of children between the ages of four to eight years, OFSP contributes approximately 7.1 % (0.71 mg / 100 g) iron, a 100 g portion of WFSP approximately 3 % (0.3 mg / 100 g) and carrots approximately 6 % (0.6 mg / 100 g). A 100 g portion cooked OFSP further contributes 75.6 % (3.78 mg / 100 g) of zinc to the RDA of children below the age of 8 years, which is similar to that of carrots and four times the contribution of WFSP (0.12 mg / 100 g). .

OFSP contains substantially more calcium than WFSP and carrots, and makes a significant contribution of almost 13 % (103 mg / 100 g) to the daily requirements of calcium for children aged four to eight years, whereas WFSP provides only 1.13 % (9 mg / 100 g) and carrots almost 4 % (31 mg / 100 g) (Kruger et al., 1998). The magnesium content of OFSP is approximate 60 % more than that of WFSP. A 100 g cooked portion of OFSP can contribute 15 % (19.6 g / 100 g) of the daily requirements of magnesium and WFSP contributes 10 % (13 mg / 100 g) and carrots 8.5 % (11 mg / 100 g) for children aged four to eight years. Although no RDA is available for potassium requirements of children between the ages of four to eight years, a 100 g cooked portion of OFSP contains 297 mg potassium. In 1989 the minimum requirements of potassium of 2000 mg / day for adults was established (USDA 1998). Its main function in the body is to maintain normal fluid and electrolyte balance and symptoms of a deficiency include muscular weakness (Whitney and Rolfes, 2002). According to the DRI (Dietary Reference Intake) tables of 2004, the Adequate Intake (AI) for potassium is 3.1 g / day for children between the ages of four to eight years (USDA, 1998). The DRI is a collective name for a set of at least four nutrient-based reference values and includes among other, the RDA (Recommended Dietary Allowance and AI (Adequate Intake) (USDA, 1998).

4.2. Nutrient content of different OFSP cultivars

In this study different cultivars were sampled from various regions in South Africa to compare nutrient differences that may exist between them. However, the different cultivars tested were not available from each of the three different regions from where OFSP were sampled and are therefore not discussed according to regions. Therefore, no assumptions in terms of cultivar adaptability to the specific region could be made (refer Table 1). To date, no South African data is available to compare the nutrient content of OFSP per cultivar or per region.

The dry matter content (DM) differed significantly between the different cultivars. The DM of Resisto and the composite sample was the highest. The beta-carotene content differed significantly among the four cultivars analysed i.e. W119, Jewel, Resisto and A15 (the composite sample was not analysed for beta-carotene content). The beta-carotene content of the cooked OFSP ranged from 4323 to 9230 $\mu\text{g} / 100 \text{ g}$ (refer Table 4). Resisto had the highest beta-carotene content, which differed significantly from the other three samples. Although significant differences were found in the beta-carotene content of the different cultivars, OFSP generally has a high beta-carotene content in all the cultivars and could make a significant contribution to vitamin A in the diet. The variation in beta-carotene content is not only cultivar specific and natural variations can occur within the same cultivar. Van Jaarsveld et al. (2006) found natural variations in beta-carotene content ranging from 13200 – 19400 $\mu\text{g} / 100 \text{ g}$ in OFSP taken from the same harvest batch.

The beta-carotene content of the cultivars analysed agreed with values reported in the literature. Van Jaarsveld et al. (2005) determined the beta-carotene content of Resisto cultivar OFSP that was grown by the Vegetable and Ornamental Plant Institute of the ARC-Roodeplaat in Pretoria, as having a beta-carotene content of 9980 $\mu\text{g} / 100\text{g}$ (± 1167) in the cooked root. The beta-carotene content of the Resisto cultivar OFSP analysed was 9230 $\mu\text{g} / 100\text{g}$. In addition, the colour of the OFSP is a direct indication of the carotenoid content - the darker the orange colour, the higher the beta-carotene content. Therefore, colour intensity may be used as an indication of provitamin A level in sweet potatoes (Hagenimana et al., 2001). Resisto had the darkest orange colour as well as the highest beta-carotene content of the four varieties analysed.

Losses of carotenoids can occur during processing through physical removal e.g. peeling, geometrical isomerisation and enzymatic or non-enzymatic oxidation (Rodriguez-Amaya, 2002). In the present study, the raw samples were peeled and then grated, which could have caused losses of carotenoids. An increase of the beta-carotene content was observed between the raw sample of the W119 cultivar (4212 µg / 100 g) and cooked sample (4433 µg / 100 g) (refer Table 5). However, no particular significance should be attributed to the increase as it is unlikely to be true. Often such results could be artefacts of the analytical calculation procedures; loss of carotenoids in the fresh sample due to enzymatic activity or unaccounted loss of water and leaching of soluble solids during processing (Rodriguez-Amaya, 2002).

The differences in the nutrient content of the different OFSP cultivars could be attributed to the geographical area and cultivation processes, which were not measured in this study. Negligible differences were observed in the Jewel cultivar, which was sampled from two different regions i.e. Pretoria and Fouriesburg i.e. Jewel sampled from Pretoria (7654 µg / 100 g) and Jewel sampled from Fouriesburg (7168 µg / 100 g). At Pretoria, fertilizer and adequate water was administered to the vegetables, whereas no information with regard to the growing conditions in the Free State was available. The use of some fertilizer with adequate irrigation would influence the nutrient content of OFSP especially with regard to the mineral content. The highest yield and best quality sweet potatoes is achieved where sweet potato plants are established in moist soil and sufficient irrigation is available for the crop through the growing season (Alleman in Niederwieser, 2004). However, in rural areas such as the Free State, all these factors are not always in place, which affects the nutrient content of the sweet potato and, in this study, very little information was available about the growing condition in all of the regions, except for Pretoria.

5. Conclusion

The NFCS identified inadequate daily intake levels for energy, vitamin A, vitamin C, riboflavin, niacin, vitamin B6, folate, calcium, iron and zinc of children between one to nine years of age (Labadarios et al., 2000). In terms of these nutrients, OFSP can contribute energy, beta-carotene, vitamin C, calcium, iron and zinc to the diet. When ranking the different cultivars according to their contribution of these nutrients, Resisto cultivar contributes the most energy, beta-carotene, vitamin C and calcium while A15

contributes the most iron and W119 the most zinc. Although no significant differences were found in the zinc content of the different cultivars tested, the zinc content ranged from 2.85 mg / 100 g – 4.18 mg / 100 g. The RDA for children between the ages of four to eight years is 5 mg of which the zinc content of W119 contributes 83.6 %. The average contribution of OFSP analysed in this study is 75.6 % of zinc to the diet of children of this age. Therefore, although the beta-carotene content of W119 was significantly less than that of Resisto, it still contributes 90 % of the RDA for children between the ages of four to eight years. Its contribution to the zinc intake is of great importance as zinc supports the work of proteins (DNA and RNA) in the body and assists in the immune function as well as growth development (Whitney and Rolfes, 2002: 438).

Sweet potato plays an important role as a household food security crop in resource-poor farming where sweet potato is grown in home-gardens for food supply as well as for income (Domola, 2003: 49, 50). It can make a substantial contribution to the energy and nutrient intake of poorer communities.

6. Recommendations

Specific cultivars perform better in certain regions than others, and the cultivar that provides the highest yield in a certain region should be promoted for commercial production. However, for home-gardens Resisto OFSP has the highest beta-carotene content and should therefore be recommended, providing it is suitable for the selected region and its environmental factors. It is recommended that further studies on the nutrient content of OFSP should focus on a sampling plan that would provide a representative sample from each plot in each region for analysis purposes, in order to obtain values specific to each cultivar and region.

ACKNOWLEDGEMENTS

ARC-Roodeplaat for financial support for analysis: S Laurie

ARC-Biometry for statistical analysis: M. Smith and L. Morey

ARC-Irene staff for preparation of samples: J. van Niekerk and E. Visser

REFERENCES

Alleman, J. 2004. Fertilisation, Irrigation and Weed Control. In: Niederwieser, J.G. *A guide to sweet potato production in South Africa*. ARC- Roodeplaat Vegetable and Ornamental Plant Institute. pp 28. Pretoria. CDP Printers.

Association of Official Analytical Chemists International (AOAC). 2005. Official methods of analysis of AOAC International. 18th Ed. Maryland, USA.

Black, R.E., Morris, S.S. and Bryce, J. 2003. Where and why are 10 million children dying every year? *Lancet*. 361: 2226-2234.

Caulfield, L.E., de Onis, M., Blössner, M and Black, R.E. 2004. Under-nutrition as an underlying cause of child deaths associated with diarrhoea, pneumonia, malaria and measles. *Am J Clin Nutr* 2004. 80: 193-198.

Codjia, G. 2001. Food Sources of vitamin A and provitamin A specific to Africa: An FAO Perspective. *Food Nutr Bull*. (vol 22) nr 4: 3457-359.

Domola M.J. 2003. *Survey and characteristics of sweet potato viruses in South Africa*. M. Inst Agrar (Plant Protection). University of Pretoria.

Erhardt, J. 2004. Printed version of the new vitamin A table. *Sight and Life*. 1:32.

Faber, M., Laurie, S. and Venter, S. 2006. *Home-gardens to address vitamin A deficiency in South Africa: A food-based approach*. Pretoria. CDP Printers. pp 14.

Faber, M., Venter S.L. and Benade A.J.S. 2002. Increased vitamin A in children aged 2-5 years through targeted home-gardens in a rural South African community. *Publ Health Nutr*, 5(1): 11-16.

Garrow, J.S. and James, W.P.T. 1998. *Human nutrition and dietetics*. China. Churchill Livingstone.

Genstats® for Windows® (7th Edition) – Introduction (Editor R.W. Payne), Published 2003 by VSN International, ISBN 1-904375-08-1.

Greenfield H. and Southgate D.A.T. 2003. *Food composition data. Production management and use.* pp 168, 169 Elsevier Science Publishers. Rome.

Hagenimana, V., Low, J., Anyango, M., Kurz, K., Gichuki, S.T. and Kabira, J. 2001. Enhancing vitamin A intake in young children in western Kenya: orange-fleshed sweet potato and women farmers can serve as key entry points. *Food Nutr Bull.*22 (4). 376 – 387.

Kruger, M., Sayed, M., Langenhoven, M. and Holing, F. 1998. *Composition of South African Foods: Vegetables and Fruit.* pp 36. UDMS, Cape Town.

Labadarios, D., Steyn, N., Maunder, E., MacIntyre, U., Swart, R., Gericke, G., Dannhauser, A., Voster, H.H. and Nesamvuni, A.E. 2000. *The National Food Consumption Survey: Children aged 1-9 years, South Africa, 1999.* Stellenbosch.

Laurie, S.M. 2004. Sweet potato cultivars. In: Niederwieser, J.G. *A guide to sweet potato production in South Africa.* ARC-Roodeplaat Vegetable and Ornamental Plant Institute. pp 2-5 and 57-65. Pretoria. CDP Printers.

Laurie, S.M. and Niederwieser, J.G. 2004. The sweet potato plant. In: Niederwieser, J.G. *A guide to sweet potato production in South Africa.* ARC- Roodeplaat Vegetable and Ornamental Plant Institute. pp 13-14. Pretoria. CDP Printers.

Low, J., Uaiene, R., Andrade, M.I. and Howard, J. 2000. Orange-fleshed sweet potato: Promising partnerships for assuring the integration of nutritional concerns into agricultural research and extensions. Research Results from the Department of Policy Analysis, MARD-Directorate of Economics. 20E:1-6.

Nestel, P. and Nalubola, R. 2003_b. Beta-carotene in fruits is more bioavailable than that in vegetables. ILSI Human Nutrition Institute. Washington.

Nestel, P. and Nalubola, R. 2003_a. The amount of bioavailability of provitamin A carotenoids in plant foods vary widely. ILSI Human Nutrition Institute. Washington.

Rodriguez-Amaya D.B. 2002. Effects of processing and storage on food carotenoids. *Newsletter, Sight and Life*. 3: 25 – 35.

Savage King, F and Burgess A. 2003. *Nutrition for developing Countries, 2nd Ed.* New York. Oxford University Press. pp 37, 255.

Thybo, A.K., Mølgaard J.P. and Kidmose, U. 2001. Effect of different organic growing conditions on the quality of cooked potatoes. *J Sci Food Agr*. 82: 12 –18.

USDA-NCC. 1998. Dietary Reference Intake: Recommended Intakes for Individuals. National Academy of Sciences. Institute of Medicine. Food and Nutrition Board. (www.fnict.nal.usda.gov/nal_display/index.php?info_center).

Van Den Berg, A.A. and Laurie S.M., 2004. Cultivation. In: Niederwieser, J.G. *A guide to sweet potato production in South Africa*. ARC- Roodeplaat Vegetable and Ornamental Plant Institute. pp 13-14. Pretoria. CDP Printers. pp 15-26.

Van Jaarsveld, P.J., Marais, De Wet., Harmse, E., Laurie, S.M., Nestel, P. and Rodriguez-Amaya, D.B. 2006. Retention of beta-carotene in boiled, mashed orange-fleshed sweet-potato. *J Food Compos Anal*. 19: 321-329.

Van Jaarsveld, P.J., Faber, W.M., Tanumihardjo, S.A., Nestel, P., Lombard, C.J. and Benade, A.J.S. 2005. Beta-carotene rich orange-fleshed sweet potato improves the vitamin A status of primary school children assessed with the modified-relative-dose-response test. *Am J Clin Nutr*. 81: 1080-7.

Vitamin A Global Initiative. 1998. A strategy for Acceleration of Progress in Combating Vitamin A Deficiency, Consensus of an Informal Technical Consultation. New York. UNICEF. <http://www.unicef.org/search.php?q=Vitamin+A+Global+Initiative>. pp 8.

West, C.E., Eilander, A., Van Lieshout, M. 2003. Consequences of revised estimates of carotenoid bioefficacy for dietary control of vitamin A deficiency in developing countries. American Society for Nutritional Services. Proceeding of the XX International Vitamin A Consultative Group Meeting. *J Nutr*. 133. 2917 and 2920S – 2926S.

Whitney, E.N., Rolfes, R.R. 2002. *Understanding nutrition, 9th Ed.* pp1. London. Wadsworth.

Woolfe, J.A. 1992. *Sweet potato, an untapped food resource.* Cambridge. University Press.

CHAPTER 5

QUANTITATIVE DESCRIPTIVE SENSORY ANALYSIS OF FIVE DIFFERENT CULTIVARS OF SWEET POTATO

In this chapter the style and layout, as prescribed by the Journal in which the article will be published namely, *Journal of Sensory Studies*, has been followed.

CS LEIGHTON¹, HC SCHÖNFELDT² and R KRUGER²

¹Agricultural Research Council, Irene (ARC-LBD), South Africa

²School of Agricultural and Food Sciences, University of Pretoria, South Africa

ABSTRACT

A trained sensory panel was used to establish terminology for describing the sensory attributes of different cultivars orange-fleshed sweet potato (OFSP) and white-fleshed sweet potato WFSP. Quantitative Descriptive Analysis (QDA) was applied to evaluate the samples in terms of the aroma, texture, flavour and aftertaste attributes. Thirteen attributes were identified. Principal Component Analysis (PCA) was applied to identify any factors differentiating between the sweet potato cultivars. The findings indicated that the main differences were in PC1 the flavour and density and adhesive textural characteristics and in PC2, the grainy and firm textural characteristics of the different cultivars. OFSP displayed a more dense and pasty texture, which was most intense in the Resisto cultivar. W119 had a more grainy texture when compared to the other cultivars tested. WFSP was more moist and fibrous. Therefore, OFSP differed in colour, was sweeter and displayed flavour characteristics of yellow-vegetables (such as butternut and pumpkin) when compared to WFSP.

Key words: Sensory analysis, quantitative descriptive analysis, orange-fleshed sweet potato, trained panel, PCA, texture, flavour.

INTRODUCTION

Sweet potato is an important food crop in many parts of the world. Good yields are obtained when conditions such as rain, soil and climatic conditions are optimal. The storage roots contain large quantities of energy and substantial amounts of some vitamins and minerals (Laurie in Niederwieser 2004). Currently, most South African cultivars have a white to light creamy-yellow flesh colour and the OFSP is relatively unknown. The Agricultural Research Council (ARC)-Roodeplaat Vegetable and Ornamental Plant Institute has a comprehensive sweet potato breeding programme which includes WFSP and OFSP. To date, at least 22 cultivars have been released by the programme and more cultivars will be released in the future. Beta-carotene rich OFSP is being introduced in South Africa and is becoming an important food crop in sub-Saharan Africa. It plays a significant role in resource-poor farming as a food security crop (Laurie and Niederwieser in Niederwieser 2004), especially for its contribution to vitamin A intake. It is estimated that, in sub-Saharan Africa, vitamin A deficiency contributes up to 25.1 % to child mortality due to related diseases such as malaria, diarrhoeal diseases, acute respiratory infections, vaccine preventable diseases as well as low weight-for age (Black *et al.* 2003; Caulfield *et al.* 2004). OFSP has been successfully introduced into gardening projects in South Africa such as the Ndunakazi project in KwaZulu Natal, which showed success in improving vitamin A intake (Faber *et al.* 2002_b) and, ultimately, the vitamin A status (Faber *et al.* 2002_a) of children in population groups at risk of vitamin A deficiency.

However, little or no work has been done to determine the sensory acceptability of new cultivars that have shown potential for release to farmers and secondary nurseries in order for OFSP to be produced for the commercial market. Different cultivars OFSP are planted in various regions and cultivar differences in flavour and texture may influence the taste acceptability. QDA can be used to measure significant differences between sensory descriptors / attributes for the flavour and textural components of white and orange-fleshed sweet potatoes, as well as between different cultivars OFSP.

Descriptive analysis has successfully been used to obtain detailed descriptions of the aroma, flavour and oral texture of foods and beverages. Samples are evaluated for a number of attributes by a trained panel (Lea *et al.* 1998). This provides an objective measure of the sensory quality of food products (Alvarez and Blanco 2000). The sensory profiles or pictures obtained can be used in product development and

manufacturing and is of particular use to nutritionists and food scientists who are interested in the development of food and beverage products (Woods 1998). These include activities such as the development of standards for quality control purposes, to document product attributes before consumer testing to help select attributes for inclusion in the consumer questionnaire, to help explain results of consumer tests, as well as tracking sensory changes and reformulation of existing products due to ingredient changes (Meilgaard *et al.* 1991; Lawless and Heymann 1998).

Developing a lexicon for sensory testing of a product is a critical step in the research process. QDA is a time-consuming process. However, when applied to promising cultivars before release to nurseries or farmers it can provide invaluable information regarding potential rejects and reasons for rejection by consumers (Van Oirschot *et al.* 2002). Obviously many other factors also determine the success of a new cultivar in the market place such as the dry matter content (texture), the yield (economic factor) or pest resistance. Product expectation generated by marketing messages through the media or packaging could further influence the success of a product in the market place (Wright *et al.* 2001).

The aims of this study were two pronged; firstly to establish defined terminology for describing the sensory attributes (textural, aroma, flavour and aftertaste) of OFSP and, secondly, to compare the sensory profiles of the different cultivars OFSP with each other as well as with WFSP.

MATERIALS AND METHODS

Sample selection

Five sweet potato cultivars were included in the project. Beauregard, Kano, W119 and Resisto cultivars OFSP and Blesbok cultivar WFSP were selected for the study at the request of the ARC-Roodeplaat. They required the analysis of various cultivars OFSP in terms of its sensory characteristics as well as consumer acceptability, as compared to WFSP in order to be able to identify promising cultivars that are acceptable in taste to the South African consumer. Cultivars were selected as follow: Resisto cultivar OFSP was included in the study because it has the highest beta-carotene level of the cultivars introduced in South Africa. Resisto was previously used in a clinical trial by Van

Jaarsveld *et al.* (2005) where it showed that beta-carotene rich OFSP contributed to the intake of vitamin A carotenoids by children, and has the potential to limit vitamin A deficiency in developing countries. Beauregard cultivar OFSP was included in the study as it has been identified for commercialization in South Africa. Kano and W119 cultivars OFSP were included as they have shown potential in terms of yield, taste and pest resistance. Blesbok cultivar WFSP has a cream flesh colour and a purple skin (Laurie in Niederwieser 2004) and is one of the most commonly consumed WFSP that is freely available on the market.

The sweet potatoes were harvested at the ARC-Roodeplaat and transported on the same day to the sensory laboratory of the ARC-Irene where they were stored in a cool room. They were harvested at the end of the growing season (July 2006). As sweet potatoes vary in size and shape, samples that were similar in shape and weight were selected for the study. The average weight of the raw samples ranged between 250 – 350 g each and each day approximately 800 g of the different cultivars was cooked (3-4 sweet potatoes). The training of panellists commenced three days after harvesting and the final sensory evaluation in the booths took place immediately after a four-day training session. All the samples received the same treatment for storage and cooking throughout the project.

Selection of trained panel

Ten trained and experienced panel members were selected to participate in the development of sensory profiles for the five different cultivars of sweet potato. They were chosen based on their ability to provide similar responses to similar products on repeated occasions, smell acuity, interest in the project and availability for the duration of the study. In order to ensure that panellists were not influenced in any way, no information with regard to the nature of the samples was provided. Panellists were reminded not to use perfumed cosmetics and to avoid exposure to foods and/or fragrances at least 30 minutes before evaluation sessions.

Training sessions

Panellists were exposed to two-hour training sessions on four consecutive days in order to develop a clear definition for each attribute identified for the different cultivars. Panellists each received a representative sample of the sweet potatoes and were trained to increase their sensitivity and ability to discriminate between the sensory attributes of the different cultivars. Descriptors and definitions (lexicon) of the characteristics of five different sweet potato cultivars were developed by the panellists. Reference books were used to guide the researcher to formulate suitable definitions for each attribute (Civille and Lyon 1996; Thybo and Martins 1998)

Scaling and score sheet

An eight-point category scale was used to measure the intensity of each sensory attribute (aroma, texture, flavour and aftertaste) for the different sweet potato cultivars. One (1) on the category scale denoted the least intense condition (e.g. no sweet potato aroma) and eight (8) denoted the most intense condition (e.g. extremely intense sweet potato aroma (refer Table 2).

Sample preparation

The sweet potatoes were first washed and then scrubbed to remove any soil or dirt present and then placed into 2L stainless steel saucepans, covered with 1-1.3 L boiling water and boiled in their skins. Sweet potatoes were boiled for approximately 45 minutes with a lid on the saucepan to prevent excessive moisture loss. The water was replenished when required to ensure that it covered the sweet potatoes. It was observed that the cooking time varied slightly between the different cultivars. The sweet potatoes were cooked until soft and a core temperature of 94° C was reached, which was tested by inserting a hand held digital stainless steel probe (Kane May C9003), equipped with a J-type thermocouple to record the internal temperature at the geometrical centre of the sweet potato. Sweet potatoes were removed from the saucepan and allowed to cool slightly before being used for sensory evaluation.

Serving procedure

Figure 1 is a graphical representation of the sweet potato sample as served to the panel. A portion of the sweet potato in the skin was served to the panel members for evaluation. Sweet potatoes were sliced into 20 mm slices and halved to form small half circle portions weighing approximately 40 g each. Each portion was wrapped in aluminium foil with the shiny side in, and coded with a random three-digit code. Samples were placed in heated glass containers and kept warm at 60 °C in calibrated Miele ovens for 2-3 minutes before serving to the panel. The serving temperature was 40 °C. One cultivar was served at a time.

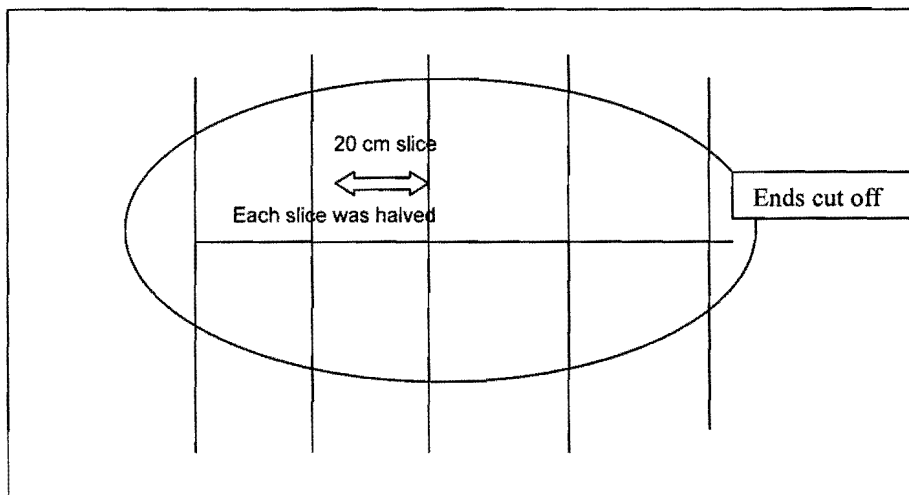


FIGURE 1: Graphical presentation of the serving procedure of the sweet potato

When served to the panel, a coded sample was placed on a heated side plate and served on a white plastic tray. Care was taken to ensure uniformity of each sample (volume served and serving temperature) and of each replication of the different samples. Samples were randomised to exclude any bias due to the position effect. A score sheet for the evaluation accompanied the sample. Panel members were provided with water at room temperature, which served as palate cleansers in between evaluation sessions.

All samples were evaluated by the trained panel according to the methods described in the Annual Book of the American Society for Testing and Materials Standards (ASTM 1989). The sensory analysis facilities were constructed according to ASTM design guidelines for sensory facilities, with all the elements necessary for an efficient sensory

programme. Samples were evaluated daily for four consecutive days under red light conditions in order to mask any differences in the colour of the different sweet potato cultivars.

Shear values

The remaining sweet potato samples were cooled in an air conditioned sensory laboratory to an internal temperature of 17-18 °C and then cored. Sweet potatoes were sliced in half and eight cylindrical cores with a diameter of 12.7 mm were removed from the sweet potatoes – four from the left half of the sweet potato and four from the right half of the sweet potato. One shear value for each core was obtained using an Instron Universal Testing Machine (Model 4301) (Instron Corporation, 1990), with a Warner Bratzler shear device mounted on a Universal Instron apparatus. The reported value in kilograms represented the average peak force measurement.

Statistical analysis: testing for differences between means

A randomized complete block design with four replications was used to determine the descriptive attributes ($p \leq 0.05$) for the different sweet potato cultivars (aroma, flavour, aftertaste and textural). Four repetitions were applied, which ensured further reliability of the results (Stone and Sidel 1993). The significance of all the sensory attributes measured for each sweet potato sample was tested by means of factorial analysis of variance (ANOVA), which tested the main effect of the sample, panellists, as well as the sample-by-panellist interactions at a 5 % level of significance. If the sample main effect was significant, Fisher's protected t-test least significant difference (LSD) was applied to separate the sample means.

Statistical Analysis: testing for significant correlation

Correlation matrices of the sensory and quality data were performed in order to identify correlations between sensory parameters and quality. The correlation coefficient, also known as Pearson's coefficient of correlation or the product moment correlation coefficient, is a measure of the linear relationship between two random variates. Note that this only shows the extent to which two variates are linearly related and does not imply any causal relationship between them.

Generally, a coefficient of about ± 0.7 or more is regarded as indicating fairly strong correlation, and in the region of ± 0.9 it indicates very strong correlation. In the region of ± 0.5 the correlation is moderate, and in the range -0.3 to $+0.3$ it is weak (Rayner, 1969).

The descriptive data was further analysed using PCA to identify any factors differentiating the sweet potato cultivars. All statistical analyses were done using GenStat for Windows (2003) statistical computer programme.

RESULTS AND DISCUSSION

Weight gain of samples during cooking

The sweet potatoes were weighed before and after cooking. It was found that sweet potatoes increased in weight during cooking, although no significant differences were found for the amount of weight gained between the different cultivars (Table 1). The increase in weight could be due to the fact that a moist heat cooking method was applied and that the sweet potatoes absorbed moisture (being starch based) during the cooking period. Starch granules in the raw state are hard, closely packed, microscopic agglomerations of starch molecules, which give a chalky mouth-feeling when chewed out of the cells. During cooking the starch granules start to soften at about $66\text{ }^{\circ}\text{C}$ (it varies from plant to plant), and moisture is absorbed which disrupts their compact structure and the granules swell up to many times their original weight (McGee 2004).

TABLE 1.
WEIGHT GAIN OF SWEET POTATOES DURING COOKING

Weight gained during cooking	Unit	Beauregard	Kano	W119	Resisto	Blesbok
	%	6.8 %	3.1 %	6.1 %	6.1 %	4.9 %

Lexicon development

The final list of descriptive attributes, as developed by the trained panel, encompassed the aroma, texture on appearance and in the mouth, flavour and aftertaste attributes. Reference books and food samples were used as reference guides to develop the lexicon. For each of these attributes a clear definition was developed as presented in Table 2.

TABLE 2.
LEXICON FOR DESCRIPTIVE SENSORY ANALYSIS OF FIVE DIFFERENT SWEET POTATO CULTIVARS

ATTRIBUTE	DESCRIPTION
AROMA	
Earthy	Aromatic notes associated with damp soil, wet foliage or slightly undercooked potatoes.
Sweet potato	Aromatic associated with cooked sweet potato, typical of WFSP.
Burn	An aromatic associated with vegetables that were burnt while cooking.
TEXTURE - initial impression: Squeeze sweet potato lightly between fingers holding it on the skin side.	
Moistness	Hold sample between forefingers and evaluate the amount of wetness / juiciness released by the sample which is visible when squeezing sample <u>lightly</u> .
Firm	Degree to which the sample retains its shape after lightly squeezing it.
First bite	
Denseness	The solidness / compactness of the sample.
Moistness	The amount of moistness / wetness of the sample in the mouth.
Mastication	
Fibre	Using a fork, gently break piece off sweet potato to observe fibres and then evaluate the amount of stringy fibres perceived in the mouth.
Adhesive (Stickiness / pasty)	The amount to which the sample sticks to any of the mouth surfaces such as teeth, gums or palate and is perceived as pasty.
Grainy	Use the tongue to press the sweet potato on to the palate. Degree to which surface is uneven, amount of graininess or roughness of particles on chewing.
FLAVOUR	
Vegetable sweet	Taste characteristics of sweet vegetable varieties such as sweetcorn, sweet potato, butternut or sweet carrots.
Sweet potato	Flavour notes associated with the taste of cooked white-fleshed sweet potatoes.
Yellow vegetables (Butternut, carrots, pumpkin)	Taste associated with yellow starchy vegetables such as butternut, pumpkin, carrots and to a lesser degree squash.
AFTER-TASTE	
Sweet	An aftertaste that leaves a sweetness on the tongue and in the mouth that is pleasant.

Descriptive analysis

The descriptive attribute intensity means (n=40) for the five different sweet potato cultivars are listed in Table 3. OFSP differed from WFSP in that it had an earthy aroma and a less intense sweet potato aroma. The earthy aroma was associated with aroma

notes of damp soil and slightly undercooked potatoes. The sweet potato aroma and flavour of Blesbok WFSP was typical of sweet potatoes commonly consumed in South Africa. OFSP was found to be sweeter with flavour characteristics of yellow vegetables such as butternut, pumpkin and carrots when compared to WFSP. Resisto cultivar OFSP had the most intense yellow vegetable flavour, vegetables sweet flavour and sweet aftertaste. W119 had a slight burnt aroma, which was associated with vegetables that were burnt whilst cooking (this particular aroma was almost undetectable in the other four cultivars tested).

Textural differences were found among the different sweet potato cultivars. W119 had a firm texture on appearance and was dense and slightly pasty on mastication. It had the most intense grainy texture of the five cultivars tested and was not very moist. The OFSP cultivars had a less moist texture on appearance and first bite, whereas WFSP had the most moist and fibrous texture of the five cultivars tested. OFSP was characterised by a denser and more adhesive texture than that of WFSP. Resisto cultivar had the most adhesive or pasty texture which referred to the amount the sweet potato flesh stuck to any surface of the mouth. A grainy texture was identified in W119, which referred to the amount of graininess or roughness of particles on chewing. Although the orange colour of the different cultivars was not measured, colour differences were observed with Resisto cultivar that had the darkest orange colour, which is an indication of high beta-carotene content.

TABLE 3
LEAST SQUARE MEAN VALUES FOR THE SENSORY ANALYSIS OF FIVE SWEET POTATO CULTIVARS AND THE SHEAR FORCE MEASURE (n = 40)

Sensory attribute	p-value	OFSP Cultivars				
		Beauregard	Kano	W119	Resisto	Blesbok
AROMA						
Earthy	0.005	3.600 ^a	3.750 ^a	3.800 ^a	3.925 ^a	2.825 ^b
		±1.221	±1.474	±1.497	±1.969	±1.533
Sweet potato	< 0.001	4.800 ^b	4.675 ^b	3.925 ^d	4.050 ^{cd}	5.875 ^a
		±1.241	±1.302	±0.892	±1.433	±1.189
Burnt	< 0.001	1.775 ^b	1.795 ^b	2.850 ^a	1.975 ^b	1.100 ^c
		±0.846	±1.009	±2.438	±1.051	±0.092
TEXTURE						
Moistness (visible on surface)	< 0.001	4.925 ^b	5.000 ^b	3.400 ^c	3.525 ^c	6.125 ^a
		±1.610	±1.333	±1.426	±1.281	±0.625
Firm (retain shape)	0.008	5.100 ^{ab}	4.475 ^c	5.375 ^a	4.675 ^b	4.625 ^{bc}
		±0.862	±1.384	±1.574	±1.353	±0.753
First bite						
Denseness	< 0.001	4.550 ^a	4.275 ^{bc}	5.150 ^a	5.150 ^a	3.800 ^c
		±1.228	±1.281	±1.310	±0.644	±1.446
Moistness	< 0.001	4.700 ^b	4.475 ^b	3.200 ^c	3.325 ^c	5.525 ^a
		±1.190	±0.974	±1.241	±0.994	±0.871
Mastication						
Fibres (with fork)	0.010	4.550 ^b	4.200 ^b	4.575 ^b	4.100 ^b	5.225 ^a
		±0.818	±1.908	±1.122	±1.477	±0.897
Adhesive (pasty)	< 0.001	3.725 ^b	4.100 ^b	4.175 ^b	5.275 ^a	2.850 ^c
		±1.538	±1.426	±1.892	±0.922	±1.362
Grainy (tongue on palate)	< 0.001	3.650 ^{bc}	3.525 ^{bc}	4.575 ^a	3.275 ^c	3.925 ^b
		±1.618	±1.281	±0.763	±1.794	±1.046
FLAVOUR						
Vegetable sweet	< 0.001	4.564 ^b	4.825 ^b	4.650 ^b	5.425 ^a	3.875 ^c
		±1.042	±1.174	±1.054	±1.174	±0.830
Sweet potato	0.002	4.692 ^b	4.725 ^b	4.125 ^b	4.650 ^b	5.625 ^a
		±1.219	±1.384	±1.189	±1.567	±1.215
Yellow vegetables (butternut/pumpkin/carrot)	< 0.001	3.750 ^a	4.125 ^a	3.925 ^a	4.325 ^a	1.600 ^b
		±1.885	±2.215	±1.815	±2.174	±0.554
AFTERTASTE						
Vegetable sweet	< 0.001	4.750 ^b	4.925 ^b	4.925 ^b	5.500 ^a	4.025 ^c
		±1.218	±1.353	±0.738	±0.923	±0.846
Shear force measurement (kg)	0.449	0.355	0.373	0.369	0.364	0.343

Means in row with different superscript (a, b and c) represent significant difference ($p \leq 0.05$)

Means in same row followed by the same letter are not significantly different at $p \leq 0.05$ (Fisher's protected t-test LSD)

Means in same row not followed by a letter = no significant difference $p \leq 0.05$

Standard Deviation (\pm)

Intensities measured on an 8-point scale with 1 = least intense and 8 = extremely intense

Shear force

No significant differences were found for the shear force measurement of the different sweet potato cultivars. The average measure was 0.35 kg

CORRELATION ANALYSIS

The sensory aroma, texture, flavour and aftertaste parameters of the sweet potato cultivars have significant correlation coefficients among themselves as shown in Table 4. Only attributes with correlation coefficient $r > 0.8$ are reported. Generally, a coefficient of about ± 0.7 or more is regarded as indicating fairly strong correlation, and in the region of ± 0.9 it indicates very strong correlation. In the region of ± 0.5 the correlation is moderate, and in the range -0.3 to $+0.3$ it is weak (Rayner 1969). For example, if $r = 0.5$, even if statistically significant, the $R^2 = 25\%$. This indicates that 25% of the variation between the observations is accounted for by the relationship between the two variates, but 75% variation remains unexplained (personal consultation with statistician)

The earthy aroma correlated positively with the vegetable sweet and yellow vegetable flavour attributes. This agreed with the results obtained from the ANOVA, as OFSP scored higher values for the earthy, yellow vegetable and vegetable sweet attributes as well as having a stronger earthy aroma than WFSP. With regard to the texture of sweet potatoes, the moist texture attributes correlated negatively with the dense texture attributes as well as with the shear force measurement of the sweet potatoes. Blesbok cultivar WFSP scored higher values for the moistness attribute in appearance and on first bite, whereas OFSP scored lower values for moistness but higher values for denseness. Resisto and W119 cultivars OFSP had the highest value for denseness.

Principal component analysis

PCA was performed to illustrate graphically (Figures 2 and 3) the correlation ratings given to the different descriptors. In PCA, all attributes were taken and it was applied on the mean values of each individual attribute per sweet potato cultivar as obtained from sensory analysis (aroma, texture, flavour and aftertaste). Figure 2 graphically represents the position of the different sweet potato cultivars relative to the attributes

that were rated the most intense in each cultivar. Figure 3 graphically represents the PCA loadings of the attributes and is an indication of the correlation structure of the sensory attributes.

TABLE 4
CORRELATION COEFFICIENTS AMONG SENSORY ATTRIBUTES

	Earthy Ar	SP Ar	Burn Ar	Moist Ap	Firm Ap	Dense FB	Moist FB	Fibre Mas	Adhes Mas	Grainy Mas	Vegsweet FI	SPato FI	Yellow veg FI	Instron
Correlation matrix														
Earthy Ar	1													
SP Ar	-0.945	1												
Burn Ar	-	-0.891	1											
Moist Ap	-	0.974	-0.883	1										
Firm Ap	-	-	-	-	1									
Dense FB	-	-0.955	-	-0.989	-	1								
Moist FB	-	0.971	-0.882	0.994	-	-0.967	1							
Fibre Mas	-0.93	-	-	-	-	-	-	1						
Adhes Mas	0.886	-	-	-0.849	-	0.836	-	-0.892	1					
Grainy Mas	-	-	-	-	-	-	-	-	-	1				
Vegsweet FI	0.904	-	-	-	-	-	-	-0.948	0.986	-	1			
SP FI	-0.885	0.938	-0.952	0.878	-	-0.864	-	-	-	-	-	1		
Yellow veg FI	0.991	-0.896	-	-	-	-	-	-0.949	0.851	-	0.89	-	1	
Veg-sweet At	0.943	-0.892	-	-0.85	-	0.843	-	-0.937	0.987	-	0.991	-	0.922	1
Instron			0.826	-	-	-	-	-	-	-	-	-	-	-

SP = sweet potato; Veg = vegetable; Adhes = adhesive; Ar = aroma; Ap = appearance; FB = first bite; Mas = mastication; FI = flavour; At = aftertaste

Correlation coefficients > 0.878 are significant at $p \leq 0.05$; coefficients of > 0.959 are significant at $P \leq 0.01$;

Coefficients > 0.991 are significant at $p \leq 0.001$; - = not significant

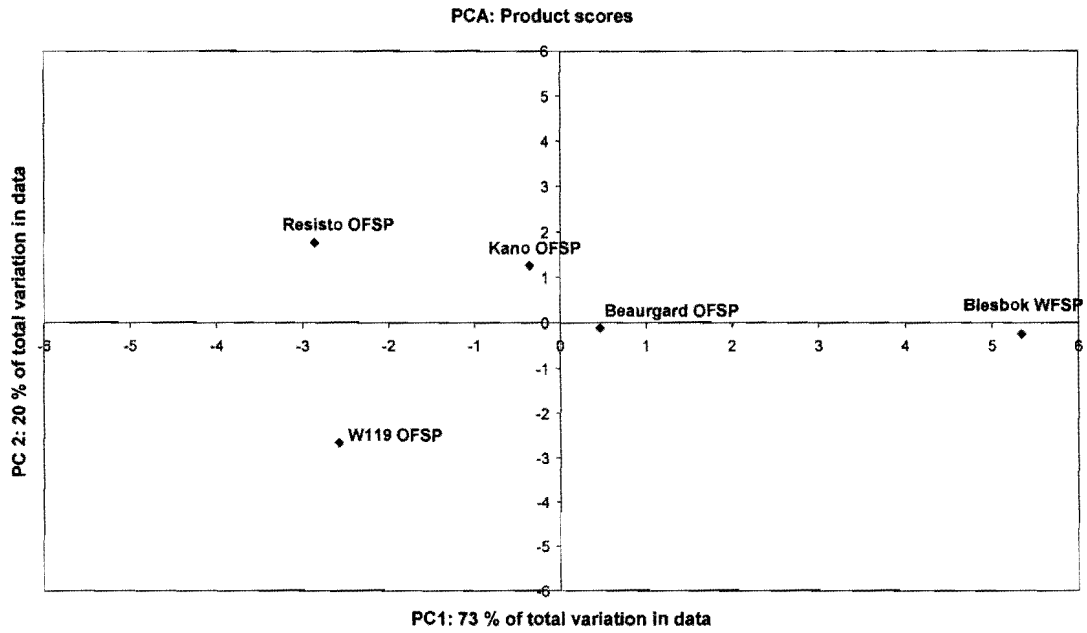


FIGURE 2. Graphical representation of the position of each sweet potato cultivar in relation to the PC-scores of each cultivar

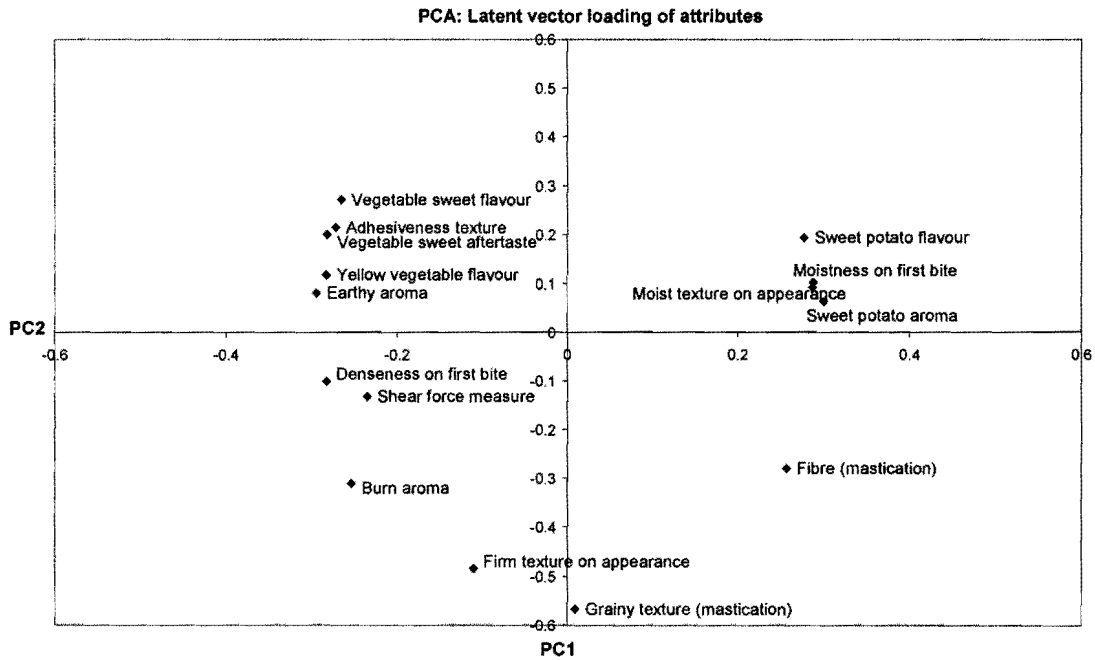


FIGURE 3: Graphical presentation of the main attributes identified in the PCA that discriminated between the sweet potato cultivars

The first two principal components explained 94.9 % of the total variance. The first principal component (PC 1) accounted for 72.9 % of the total variation in the data. It was characterised by the sweet potato aroma, sweet potato flavour, moist texture on appearance and moist texture on first bite with positive loadings, while the earthy aroma, yellow vegetable flavour, vegetable sweet aftertaste, dense and adhesive texture attributes displayed a negative loading. In Figure 1 the PCI (x-axis) shows that Resisto and W119 cultivars OFSP (left of graph) contrasted with the Blesbok cultivar WFSP (right of graph) the strongest with the regard to the attributes identified in PC1.

For the second principal component (PC 2), the grainy texture on chewing and the firm texture on appearance, showed a negative loading. PC2 (y-axis) showed that W119 cultivar OFSP contrasted with Resisto and Kano cultivars.

To summarise - reading Figures 2 and 3 adjacent to each other, clearly shows that in PC1 Resisto cultivar OFSP was mainly associated with the vegetable sweet and yellow vegetable flavour attributes and textural attributes such as intense adhesiveness / pasty texture and low moisture texture attributes; whereas Blesbok cultivar WFSP was mainly associated with the sweet potato flavour attributes as well as with the moist texture attributes. In PC 2, W119 cultivar OFSP was mainly associated with the firm and grainy texture attributes which scored lower values in Resisto cultivar OFSP.

DISCUSSION

Cooked sweet potatoes are not a uniform product. OFSP and WFSP exhibited a great deal of diversity with regard to flavour and texture attributes. A study conducted by Van Oirschot *et al.* (2002), evaluated the sensory characteristics of different cultivars OFSP when stored under tropical conditions. They found that the main characteristics that discriminated between the different cultivars were primarily related to the different textural components.

Prior to this study, very little research had been done to determine the flavour profile of sweet potatoes (Woolfe 1992; Van Oirschot *et al.* 2002). Woolfe (1992) reported on information regarding the flavour profile of sweet potatoes in that the sweetness of sweet potatoes was largely due to the presence of different carbohydrates i.e. maltose, glucose, sucrose and fructose. This causes the sweetness to vary among different cultivars due to

the combination of the different carbohydrate fractions to the total sugar (Woolfe 1992). In this study, OFSP was found to have a more intense vegetable-sweet flavour when compared to WFSP and Resisto OFSP was found to be most intense in this attribute.

Texture plays an important role in the overall acceptance and eating quality of sweet potatoes. The correlation of dry matter content with texture attributes has been studied before and it was found that the dry matter could be correlated to some degree with the texture of potatoes, although this fact is not very clear (Van Marle *et al.* 1997). The dry matter content of OFSP ($\pm 20\%$ (USDA 1998)) was somewhat higher than that of WFSP (18.2% (Kruger *et al.* 1998)) (cultivar unspecified). The higher dry matter content of OFSP could have contributed to its being less moist on appearance, more dense and pasty (adhesive) than the WFSP. The slightly lower dry matter content of WFSP could explain the higher watery appearance (moisture content) of the cooked WFSP when evaluated in the foil by the trained panel. WFSP had a more moist appearance and a moist texture on first bite and appeared less firm than OFSP. The method of cooking used in the preparation of sweet potatoes could influence the dry matter content, as it was found that water evaporation during steaming increased the dry matter content of cooked samples over a range of cultivars tested by Truong *et al.* (1997).

Blesbok cultivar WFSP had a higher fibre content than OFSP cultivars. The dietary fibre content in sweet potato roots varies between different cultivars. In some cultivars the fibre content can be so high that the sweet potato is unusable directly as human food and is directed toward industrial processing. However, the dietary fibre in sweet potato is similar to some other roots and tubers, although is much higher than food such as cooked rice (Woolfe 1992).

The grainy texture attribute differed significantly between the different cultivars and W119 cultivar OFSP scored the highest value for grainy texture, followed by Blesbok WFSP and then the other three OFSP cultivars. OFSP appeared less moist and more firm which correlated with its having a more dense and pasty texture. Pasty texture referred to the degree to which sweet potato stuck to mouth surfaces when chewed. WFSP scored lower values for its dense and adhesive texture attributes.

Although textural differences were found by the trained sensory panel, the results of the shear force resistance for cooked sweet potatoes showed no significant difference between the different cultivars tested. However, PCA found negative correlations between the moistness texture attributes such as moistness on appearance and moistness on first

bite with the shear force measurement (refer to Figure 3). This agrees with the results obtained from the ANOVA in that Blesbok cultivar WFSP had the lowest value for the shear force measurement (refer to Table 2, although not significant) and the highest value for the moistness on appearance as well as moistness on first bite. These findings are different to the results obtained by Truong *et al.* (1997) who found significantly different values for compressive strain and stress at failure, between cultivars. A reduction in both shear strain and stress values was observed in all steamed cultivars compared to the values for raw sweet potatoes. This could be explained by the magnitude in which starch and cell wall substances degrade during cooking, which impacts on different textural properties among sweet potato cultivars. Therefore, compression or shear force measurement on raw samples may not be an accurate prediction of the textural characteristics of sweet potatoes (Truong *et al.* 1997).

CONCLUSION

The sensory profiles of the different sweet potato cultivars showed that the OFSP differed from WFSP in that it had a more intense earthy aroma and a less intense sweet potato aroma. OFSP overall was sweeter and had characteristics similar to that of yellow-vegetables such as butternut, pumpkin and carrots. The texture of OFSP was less moist and less fibrous than WFSP. OFSP displayed a more dense and pasty texture, which was most intense in the Resisto cultivar. W119 had more grainy texture when compared to the other OFSP cultivars tested. The firm appearance of OFSP sweet potatoes also varied between the different OFSP cultivars and Beauregard and Kano had the most firm appearance. Although the orange colour of the different cultivars was not measured, colour differences were observed and the Resisto cultivar had the darkest orange colour.

The PCA showed that in PC1, the Resisto and W119 cultivars OFSP contrasted with the Blesbok cultivar WFSP the strongest. Resisto was mostly associated with the sweet and yellow vegetable flavour attributes, intense adhesiveness / pasty and low moisture texture attributes; whereas Blesbok cultivar WFSP was mostly associated with the typical sweet potato flavour attributes as well as the moist texture attributes. In PC 2, Resisto contrasted with W119 the strongest. W119 cultivar OFSP was mostly associated with firm and grainy texture attributes which scored lower values in Resisto cultivar OFSP.

RECOMMENDATIONS

As a follow-up study, the sensory profiles of different OFSP breeding crops should be determined at different stages of storage. The benefits of improved disease resistance and superior yields may not override unacceptable sensory qualities. Such a study would identify off flavours that may develop during storage and which may result in consumers rejecting such a cultivar once it has been introduced into the market place. Consumer studies could be conducted to determine the acceptability of different cultivars OFSP and other yellow vegetables such as butternut and pumpkin. Specific gravity and dry matter should be determined and correlated as it impacts on the moisture and density properties of the cultivar.

ACKNOWLEDGEMENTS

ARC-Roodeplaat for financial support for analysis: S Laurie

ARC-Biometry for statistical analysis: M. Smith and L. Morey

ARC-Irene staff for preparation of samples: J. van Niekerk and E. Visser

REFERENCES

ALVAREZ, P. and BLANCO, M. 2000. Reliability of the sensory analysis data of a panel of tasters. *J Sci Food Agr.* 80: 409-418.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM). 1989. Standard definitions of terms relating to sensory evaluation of materials and products. *In Annual Book of ASTM Standards.* American Society for Testing and Materials, Philadelphia.

BLACK, R.E., MORRIS, S.S. and BRYCE, J. 2003. Where and why are 10 million children dying every year? *Lancet.* 361: 2226-2234.

CAULFIELD, L.E., DE ONIS, M., BLÖSSNER, M. and BLACK, R.E. 2004. Under-nutrition as an underlying cause of child deaths associated with diarrhoea, pneumonia, malaria and measles. *Am J Clin Nutr* 2004. 80: 193-198.

CIVILLE, G.V. and LYON, B.G. 1996. *Aroma and flavour lexicon for sensory evaluation.* ASTM. West Conshohocken.

FABER, M., PHUNGULA, M.A.S., VENTER, S.L., DHANSAY, M.A. and BENADÉ, A.J.S. 2002_a. Home gardens focussing on the production of yellow and dark-green leafy vegetables increase the serum retinol concentration of 2-5-y-old children in South Africa. *Am J Clin Nutr*: 76:1049-54.

FABER, M., VENTER S.L. and BENADE A.J.S. 2002_b. Increased vitamin A in children aged 2-5 years through targeted home-gardens in a rural South African community. *Publ Health Nutr*. 5(1): 11-16.

GENSTATS® for Windows® (7th Edition) – Introduction (Editor R.W. Payne), Published 2003 by VSN International, ISBN 1-904375-08-1.

INSTRON. 1990. Series IX Automated Materials Testing System: Operating Instruction manual. Instron Corporation, Issue B: November.

KRUGER, M., SAYED, M., LANGENHOVEN, M. AND HOLING, F. 1998. *Composition of South African Foods: Vegetables and Fruit*. pp 36. UDMS, Cape Town.

LAURIE, S.M. 2004. Sweet potato in Perspective. In: Niederwieser, J.G. *A guide to sweet potato production in South Africa*. ARC- Roodeplaat Vegetable and Ornamental Plant Institute. Pretoria. p 5. CDP Printers.

LAURIE, S.M. and NIEDERWIESER, J.G. 2004. The sweet potato plant. In: Niederwieser, J.G. *A guide to sweet potato production in South Africa*. ARC-Roodeplaat Vegetable and Ornamental Plant Institute. Pretoria. p 2. CDP Printers.

LAWLESS, H.T. and HEYMANN, H. 1998. *Sensory evaluation of food: Principles and Practices*. p 351. Gaithersburg. Maryland. Aspen.

LEA, P., NÆS, T. and RØDBOTTEN, M. 1998. *Analysis of variance for sensory data*. p 4. John Wiley and Sons. UK.

McGEE, H. 2004. *McGee on Food and Cooking. An encyclopaedia of kitchen science, history and culture*. p 283. Hodger and Stoughton.

MEILGAARD, M., CIVILLE, G.V. and CARR, B.T. 1991. *Sensory evaluation techniques*. 2nd ed. p 188. New York. CRC Press.

RAYNER, A.A. 1969. A first course in Biometry for agriculture students. University of Natal Press, Pietermaritzburg.

SNEDECOR, G.W. and COCHRAN, W.G. 1980. *Statistical methods* (7th Ed.). Iowa State University Press.

SOUTH AFRICAN VITAMIN A CONSULTATIVE GROUP. 1995. Anthropometric, vitamin A, iron and immunization coverage status in children ages 6-71 months in South Africa. *S Afr Med J*: 86:354-7. www.sahealthinfo.org/nutrition/vitA/htm.

STONE, S. and SIDEL, J.L. 1993. *Sensory evaluation of food*. 2 ed. UK. p 111. Academic Press.

THYBO, A.K. and MARTENS, M. 1998. development of a sensory texture profile of cooked potatoes by Multivariate data analysis. *J Sensory Stud*. 29: 453-468.

TRUONG, V.D., WALTER, W.M. and HAMANN, D.D. 1997. Relationship between instrumental and sensory parameters of cooked sweet potato textures. *Journal of Texture*. 28. 163-185.

VAN OIRSCHOT, Q.E.A., REES, D and AKED, J. 2002. Sensory characteristics of five sweet potato cultivars during storage under tropical conditions. *Food Quality and Preference* 14: 673-680.

VAN JAARVELD, P.J., FABER, W.M., TANUMIHARDJO, S.A., NESTEL, P., LOMBARD, C.J. and BENADE, A.J.S. 2005. Beta-carotene rich orange-fleshed sweet potato improves the vitamin A status of primary school children assessed with the modified-relative-dose-response test. *Am J Clin Nutr*. 81:1080-7.

VAN MARLE, J.T., VAN DER VUURST DE VRIES, R., WILKINSON, E.C. and YUKSEL, D. 1997. Sensory evaluation of the texture of steam-cooked table potatoes. *Potato Research*. 40: 79 –90.

WOODS, M.P. 1998. Taste and flavour perception. *Proceedings of the nutrition society*. 57: 603 – 607.

WOOLFE, J.A. 1992. *Sweet potato, an untapped food resource*. p 57, 142-143, 605. Cambridge. University Press.

WRIGHT, T.L., NANCARROW, C. and KWOK, P.M.H. 2001. Food taste preferences and cultural influences on consumption. *Br Food J*. 103 (5):348 –357.

CHAPTER 6

CONSUMER TASTE PREFERENCES FOR SWEET POTATO

In this chapter the style and layout, as prescribed by the Journal in which the article will be published namely, Development Southern Africa, has been followed.

CS LEIGHTON¹, HC SCHÖNFELDT² and R KRUGER²

¹Agricultural Research Council, Irene (ARC-LBD), South Africa

²School of Agricultural and Food Sciences, University of Pretoria, South Africa

ABSTRACT

The objective of this study was to report on the consumer taste preference for sweet potato. The intrinsic characteristics, as related to the sensory attributes of white-fleshed sweet potato (WFSP) are known, but that of orange-fleshed sweet potato (OFSP) is still relatively unknown. OFSP contains high levels of beta-carotene as opposed to WFSP, and has the potential to alleviate vitamin A deficiency in individuals at risk. OFSP is grown in home gardens as a food-based approach to address vitamin A deficiency. Consumer preference (n=180) for OFSP and WFSP was measured by means of a paired preference test. Focus group interviews were used to verify the results. The paired preference test was analysed by applying chi-square to test the hypothesis of frequencies or occurrences. A preference for OFSP was found as, overall, 85 % of respondents preferred the taste of OFSP, 53 % liked the orange colour a lot as opposed to 24 % that liked the colour a little. The majority of the consumers indicated a willingness to purchase OFSP, if not available in home gardens.

1. INTRODUCTION

The introduction and acceptance of beta-carotene rich OFSP as an alternative to white-fleshed sweet potato (WFSP), plays an important role in improving the intake of vitamin A by communities at risk of vitamin A deficiencies and related diseases (Faber Laurie & Venter, 2006:13). Vitamin A deficiency has been shown as a most serious health problem in South Africa and sub-Saharan Africa (Black, Morris & Bryce, 2003:2227). Different strategies have been applied to improve vitamin A intake of communities at risk of vitamin A deficiency (Vitamin A Global Initiative, 1998:8). These strategies include supplementation whereby children under the age of five years and lactating mothers are provided with vitamin A capsules; the fortification of commonly consumed staple foods in South Africa such as bread and maize flour; biofortification, which is a relatively new strategy and involves breeding of staple crops with increased vitamin A content (still in a developmental phase) and lastly, food diversification to encourage increased vitamin A consumption of foods naturally high in beta-carotene. Food diversification as a means to address vitamin A deficiency, refers to improving the availability, access and consumption of vitamin A rich foods which could be achieved through home gardens where vitamin A rich vegetables are planted (Faber, et al. 2006:14).

Home gardens is a food-based approach to address vitamin A deficiency by increasing the availability of thereof through the planting of fruit and vegetables that are rich in pro-vitamin A beta-carotene such as mango, pumpkin, carrot, OFSP and green leafy vegetables. Vegetable home gardens provide households with direct access to a variety of vitamin A-rich foods as well as other important nutrients (Savage King & Burgess, 2003:37). Although the best sources of vitamin A are from animal origin, they are expensive and often out of reach of families of poor communities to consume on a regular basis (Faber et al. 2006:37).

An important function of the introduction of new products into the market place is the ability to understand the needs of the present and future consumers in order to identify products with attributes that are desired by the targeted consumers. In most sub-Saharan African countries, only WFSP is available, which has a light creamy coloured flesh and contains very little or no beta-carotene (Laurie in Niederwieser, 2004:59). Sweet potato originally comes from the Central or South American lowlands and was known as *batatas*. It was introduced into Africa by the Portuguese from the Atlantic coast regions of mid-latitude America (Woolfe, 1992:2). OFSP is rich in beta-carotene, but is still relatively unknown. According to Mukhala (2000:9), scientists have spent

more than 10 years selecting OFSP cultivars that could meet the taste preferences of African consumers, as well as nutrient and energy requirements of African and sub-Saharan African people.

As WFSP is frequently consumed and grown by many women (Mukhala, 2000:9), consumers are familiar with the intrinsic characteristic of sweet potato which refers to the physical and sensory characteristics of the product (Van Trijp & Schifferstein 1994: 130). In Kenya, women grow sweet potatoes on small plots of land of which most are harvested for home consumption and surplus sweet potatoes are sold for income (Hagenimana, Low, Anyango, Kurz, Gichuki & Kabira, 2001:377). The success of OFSP lies in the acceptability of the taste by consumers of sweet potato. In a study conducted in 1956 by Van Riter (Randall & Sanjur, 1981:155), the acceptability of a selection of vegetables was measured by 'plate-waste' i.e. the amount left over on the plate after consumption. It was found that the acceptability of the vegetables was closely associated with the familiarity with the vegetables.

In food consumption and food choice, the characteristics of the individual who is making the decisions, need to be considered. Differences in food preferences exist between male and female, and females have been found to have a greater acuity in detecting the four basic tastes i.e. sweet, sour, salt and bitter. Women also seem to be familiar with a greater variety of different foods, which could be due to more frequent interaction with family and friends and exchange of recipes and foods, all which may influence preferences and choices of foods (Randall & Sanjur, 1981:151).

Consumers often have limited vocabulary when it comes to describing a product and their perceptions of the product. By including a scale as part of the evaluation, they are guided with the evaluation process (Greenhoff & MacFie in MacFie and Thompson, 1994: 137). Paired preference tests have been found to be reliable when used with illiterate and semi-illiterate consumers. In a paired preference test, respondents receive two coded samples and are requested to identify the sample that is preferred (Lawless & Heymann, 1998:430). The test forces a choice to be made between the two products (Meilgaard, Civille & Carr, 1991:210).

In addition to quantitative consumer research, focus group interviews, which is a qualitative method of investigation, makes a valuable contribution towards understanding the attitudes and behaviour of consumers (Jenkins & Harrison, 1992:34). A focus group interview is a carefully planned session with 6-15 individuals and is designed to obtain

perceptions in a defined area of interest in a permissive, non-threatening environment (Casey & Krueger in MacFie and Thompson, 1994). A skilled moderator conducts the interview and the discussions are relaxed and enjoyable for the participants. Focus group discussions are aimed at providing insights into how a product, service or opportunity is perceived. The moderator should encourage participation by all the participants (Casey & Krueger in MacFie and Thompson, 1994; Jenkins & Harrison, 1992:77).

Caution should be taken to generalise the findings of focus-group interviews to the population at large as, although respondents are recruited based on regular use of the product, it is not possible to ensure a representative sample of the public on all relevant demographic variables (Jenkins & Harrison, 1992:34:35). Limitations of focus group interviews include the influence of dominant participants, limited exposure and use of the product by all the participants (Lawless & Heymann, 1998:521). Data is often difficult to analyse and, although the group may provide rich dynamics, these may be difficult to interpret and, therefore, analysis takes time and thought. At least three focus groups should be conducted to balance idiosyncrasies amongst groups. Groups are often difficult to assemble and recruitment is time consuming (Casey & Krueger in MacFie and Thompson, 1994:77). However, as markets become more complex and segmentation more important for success in the marketplace, focus group interviews will continue to dominate qualitative research (Jenkins & Harrison, 1992:34).

The aim of the study was to establish, by means of consumer preference testing, whether consumers of sweet potato would accept OFSP and, if so, prefer it to WFSP, in order that it could become part of the food based strategy to increase the availability of OFSP and subsequently the consumption of vitamin A in communities at risk of vitamin A deficiency.

2. MATERIALS AND METHODS

2.1 Sample selection

Resisto cultivar OFSP and Blesbok cultivar WFSP were used for the consumer preference test. Resisto cultivar OFSP was selected for the study because it was the only cultivar available from the ARC at the time of the test. The Resisto has a purple skin and dark orange flesh colour. Blesbok cultivar WFSP was included as it is one of

the most commonly consumed WFSP that is freely available on the South African market. Blesbok has a cream flesh colour with a purple skin (Laurie in Niederwieser 2004:60). The sweet potatoes were harvested on the same day from the ARC-Roodeplaat and transported to the sensory laboratory of the ARC-Irene where they were stored in a cool room. Sweet potatoes were harvested at the end of the growing season in June 2005. All the samples received the same treatment for storage and cooking throughout the project.

2.2 Consumer selection for paired preference test

The target population for this study was black, white, coloured and Indian male and female adults who lived in the Pretoria* area and consumed sweet potato (refer table 1). The selection of the number of respondents per population group was based on the population criteria for South Africa. Income of the household was used as an indicator of different socio-economic groups of the respondents.

* Pretoria is part of the City of Tshwane which is 3200² km in size; population of 2.2 million; situated in the province of Gauteng, South Africa.

TABLE 1: SOUTH AFRICAN AND GAUTENG POPULATION CRITERIA RELEVANT TO THE RESPONDENTS USED FOR THIS STUDY (Census in Brief / Statistics South Africa, 2003:6.8.10)

	Black	Coloured	Indian	White	Total
Total population in South Africa: 44.8M	35.4m	3.98m	1.12m	4.3m	
Total population Gauteng: 8.8M	6 522 792m	337 974m	218 015m	1 758 398m	
Total population: Gauteng %	74 %	3.7	2.2	20	
Number of respondents included in the study	144	2	2	34	n = 182 (100%)
Female	88	1	1	33	n = 123 (68%)
Male	56	1	1	1	n = 59 (32%)
Actual % of each population group included in the study	79	1.1	1.1	19	

Men were included in the population sample as generally they are part of the family and play an important role in the acceptance of food (OFSP). The percentage consumers selected from different population groups was based on the demographics of the population of South Africa. In order to get a representative sample, the respondents

were recruited from various farms, institutions and companies around Pretoria including cleaners, farm-workers and management staff. As limited funds were available, a convenient sampling approach was followed.

2.3 Consumer selection for focus group interviews

Three focus group interviews were conducted in order to validate results obtained from the quantitative consumer test. The participants of two focus groups consisted of black urban African consumers of sweet potato and the third group consisted of white urban females who consumed sweet potato on a regular basis (Table 2). No focus group discussions were conducted with coloured or Indian consumers as they were not available and only made up a small percentage of the selected respondents.

Prior to evaluating the test samples, consumers were requested to provide demographical information i.e. their name, age, area where they lived as well as indicate their income. All this served as an indication of each respondent's socio-economic status.

TABLE 2: SUMMARY OF PARTICIPANTS IN DIFFERENT FOCUS GROUP INTERVIEWS

Participants in focus group	Number	Age	Demographics
Black male and female	15	24+	4 th year part time students at the University of Pretoria and working in Pretoria.
Black females	11	40+	Teachers in peri-urban communities in greater Pretoria area and were part-time students at UNISA.
White females	12	35+	All married with children. Some had a part-time job and all lived in the Centurion area.

2.4 Consumer questionnaire

The paired preference test questionnaire was developed according to the guidelines in Lawless & Heymann (1998:430). A 5-point hedonic scale with smiling faces was used to evaluate the colour acceptability of the sweet potatoes as the some of the respondents had limited vocabulary skills, specifically the farm-workers (refer addendum B).

A prompt list was developed by the researcher / moderator and used as a guideline for discussion during the focus group discussions. Each focus group followed after a sweet

potato tasting session. The discussions lasted approximately 60 minutes and were conducted by the researcher (as moderator) and two assistants (colleagues) who took notes during each discussion, which was then transcribed by the researcher. Participants were informed that the subject of the discussion was sweet potatoes but not specifically OFSP.

2.5. Sample preparation and serving procedures

The sweet potatoes were prepared at the sensory laboratory of the ARC-Irene. Sweet potatoes were washed to remove any soil or dirt present, placed into 2 litre stainless saucepans and boiled in their skin in 500 ml boiling water for approximately 45 minutes. The water was replenished when required to ensure that it covered the sweet potatoes. Sweet potatoes were cooked until soft and a core temperature of 94° C was reached, which was tested by inserting a hand held digital stainless steel probe (Kane May C9003), equipped with a J-type thermocouple to record the internal temperature at the geometrical centre of the sweet potato. Sweet potatoes were removed from the saucepan and allowed to cool slightly before being used for evaluation.

A portion of the sweet potato, in the skin, was served to the consumers for evaluation. Sweet potatoes were sliced into 30 mm slices and halved to form small half circle portions weighing approximately 50 g each. Each portion was wrapped in aluminium foil with the shiny side in, and coded with a three-digit code. Samples were placed in foil containers and kept warm in insulated cooler bags during transport to different venues. The serving temperature was approximately 40 °C.

Each respondent was presented with a small polystyrene tray that held two coded samples. Care was taken to ensure uniformity of each sample (volume served and serving temperature) for every respondent. All samples were randomised to exclude any bias due to the position effect. Water at room temperature was served in cups as palate cleansers before each taste session.

Groups of up to 10 respondents participated in each evaluation session. Groups were interviewed at their place of work e.g. farm or office where a separate room was prepared for respondents to feel relaxed and comfortable. The researcher explained the evaluation procedures to the respondents and an interpreter was provided if required. Each research assistant was appointed to three respondents at a time to ensure that the

respondents understood the questionnaire and were able to complete it correctly. After completion of the questionnaire, respondents were rewarded with 1 kg sweet potatoes WFSP and OFSP.

2.6. Statistical analysis

Consumer paired preference test

The paired preference test was analysed by applying chi-square to test the hypothesis of frequencies or occurrences (to determine the interaction between the taste and colour preferences) (O'Mahony, 1986:91). In a paired preference test, the probability of the selection of one specific product is one chance in two. The null hypothesis states that, in the long run, when the underlying population does not have a preference for one product over another, each product will be picked an equal number of times – therefore the null hypothesis probability = 0.5 (O'Mahony, 1986:92). Row by column (2x2) χ^2 was performed on the consumer preferences data. Yates's correction for 2x2 tables was applied (O'Mahony, 1986:92).

Chi-square uses nominal data, which means numbers in the scale represent nothing more than names. Certain conditions must apply when using a chi-square test such as each cell must be independent from the other and the expected frequencies should not be too small, for example 5 is too small, which means that frequencies in the cell cannot be normal (O'Mahony, 1986:99). In this study the expected frequencies were < 5 (colour preference) for the responses in the categories 'neither like nor dislike; dislike a little; dislike a lot, on the scale and were therefore grouped together (refer table 3).

Focus group discussions

The focus group were transcribed from the notes taken during the discussions and were summarised. Comments made by participants were included in each summary to give an accurate reflection of the attitudes and opinions expressed. In order to use the information from the discussions to verify the consumer quantitative data, comments that related to the consumer tests were highlighted i.e. comments on colour preference, taste preference and purchase intent. No particular statistical technique was applied to analyse the data.

3. RESULTS

Table 3 summarises the results obtained from the chi-square test which showed the observed frequencies of the colour and taste preferences (e.g. how many respondents liked OFSP as well as the orange colour).

3.1. Taste preference

One hundred and eighty respondents indicated their preference for the taste of sweet potatoes. The results showed that 85 % respondents preferred the taste of OFSP to that of WFSP, which was preferred by 15 % respondents (refer table 3).

TABLE 3: OBSERVED FREQUENCIES OF CONSUMERS' (n=180) TASTE PREFERENCE AND COLOUR ACCEPTANCE

Preference of orange colour	Preferred taste of OFSP	Preferred taste of WFSP	Total of colour preference
Like it a lot	91 (95 %)	5 (5 %)	96 (53 %)
Like it a little	33 (75 %)	11 (25 %)	44 (24 %)
*Neither like nor dislike; dislike a little; dislike a lot.	29 (73 %)	11(27 %)	40 (22 %)
Total of taste preference	153 (85 %)	27 (15 %)	180 (100 %)

Row by column (2x2) χ^2 was performed on the consumer preferences and whether they preferred the orange colour of OFSP. Yates's correction for 2x2 tables was applied (O'Mahony, 1986:92)

3.2. Colour preferences: Interaction between product preference (taste) and colour acceptance

A total of 96 consumers liked the colour a lot, of which 95 % respondents also preferred the taste of OFSP and 5 % the taste of WFSP. Frequencies were significantly different. Of the respondents, 44 liked the colour of OFSP 'a little', of which 75 % preferred the taste of the OFSP and 25 % the taste of WFSP. Forty respondents fell into the third category i.e. 'neither liked' or 'disliked the colour', 'disliked the colour a little to a lot', (refer addendum B). However, 72.5 % preferred the taste of the OFSP and 27.5 % the taste of WFSP.

3.3. Product preference and purchase intent

In order to find out if respondents would be willing to buy OFSP if available at the local market, the consumer evaluation form included a question accordingly. Table 4 summarises the results obtained from the chi-square performed on consumer preference for sweet potato and willingness to buy. The majority of the consumers (86 %) indicated that they will be willing to buy OFSP (refer table 4). From these results it can be concluded that the taste and colour of OFSP are acceptable by consumers of sweet potato and that it has potential to be successful in the marketplace.

TABLE 4: SUMMARY OF CONSUMER PREFERENCE FOR SWEET POTATO AND WILLINGNESS TO BUY OFSP (n=182)

Willingness to buy OFSP	Preferred taste of OFSP	Preferred taste of WFSP	Total (will buy)
Will buy OFSP	150 (95 %)	7 (4.5 %)	157 (86.3 %)
Will not buy OFSP	1 (10 %)	9 (90 %)	10 (5.5 %)
Might buy OFSP.	4 (27 %)	11 (73 %)	15 (8.2 %)
Total (taste preference)	155 (85 %)	27 (15 %)	182 (100 %)

Row by column (2x2) χ^2 was performed on the consumer preferences and whether they would buy OFSP. Yates's correction for 2x2 tables was applied (O'Mahony 1986:101)

3.4. Focus Group Discussions

The focus group discussions were transcribed from notes taken during the discussions. Black participants were more likely to consume sweet potato 1-2 times per week when in season. Respondents indicated that all the members of the family consumed sweet potato, although the men did not enjoy it as often as the women. Where garden space was available, the women liked to grow their own sweet potatoes. Sweet potatoes were also bought from the market, local supermarkets or street vendors. Family members in rural areas grew sweet potato to sell to others or to give to friends and family when visiting one another. In cases where sweet potatoes were grown at home, they were kept for up to one week after harvesting, before cooking. According to some of the respondents, sweet potatoes were sweeter if kept for a short period after harvesting.

Respondents reported that in some cases sweet potatoes (which were WFSP) were boiled in the skin or placed into hot coals. When cooled, the skin was removed and the sweet potato was eaten whole or mashed. The mashed sweet potato was eaten warm but in many cases the sweet potato was eaten cold, or eaten the following day with tea or milk. Some respondents said they preferred to eat sweet potatoes cold, as when

eaten hot or immediately after being cooked, it was perceived to cause flatulence, a perception more common among men.

The white participants, who were of a higher socio-economic group, viewed OFSP as a new vegetable that could add variety to the diet. They were keen to develop recipes or different uses for OFSP as opposed to seeing it as an important source of vitamin A, energy and an opportunity to grow it in their own garden. The health benefits of the OFSP were of interest to them.

The majority of respondents had not been exposed to OFSP prior to participating in the taste test that preceded the interview, although one respondent had seen OFSP in the Mpumalanga area. All the respondents liked the sweet flavour and smooth texture of Resisto cultivar OFSP and found the colour attractive. Although the orange colour was favoured, concerns were raised about the deep orange colour of Resisto cultivar OFSP and a few participants thought it may be genetically modified, in which case they would be less willing to buy OFSP.

According to most respondents, sweet potatoes were perceived as being good for you while also being cost effective, a good source of energy and a vegetable that could be produced on a small piece of land. It was explained to the respondents that OFSP was rich in beta-carotene and the benefits of consuming beta-carotene was highlighted. When told that Resisto cultivar OFSP had high beta-carotene content and WFSP contained almost no beta-carotene, the respondents indicated that they would purchase OFSP if it was available at their local shops or market. Some of the respondents were concerned as to whether they would be able to identify OFSP from WFSP by the colour of the skin and others about the cost / price of the OFSP. Most respondents were prepared to pay a little more as it was more nutritious. Some respondents indicated that they would like to grow their own OFSP.

4. DISCUSSION

Literature states that flavour and taste are predictive characteristics of food that could influence consumption, while factors such as satiety and price, are less important (Conner, 1992:28). Resisto cultivar OFSP was readily accepted in taste and colour by the majority of consumers who participated in the study. These findings agree with the findings of Van Jaarsveld, Faber, Tanumihardjo, Nestel, Lombard & Benade (2005:1084)

in a study where Resisto cultivar OFSP was fed to children between the ages of 5-10 years for 53 days as part of a nutrition intervention programme and the participants reported that they liked the taste of the OFSP.

Taste is not the only characteristic that determines the success of a product. Other factors such as smell, appearance, marketing messages by media (e.g. nutritional education on beta-carotene) and even origin of country i.e. culture, could influence the acceptability of OFSP among different target consumers (Wright, Nancarrow & Kwok, 2001: 348,355). Consumer belief that consumption of a specific food could lead to a positive outcome (Conner, 1992:28), could infer that consumers who are aware of the health benefits of OFSP, may purchase it more willingly, which was confirmed by the findings of the focus group interviews. Consumers largely base their choice behaviour on their product preferences and factors such as availability and price may interfere with the relation between preference and choice (Van Trijp & Schifferstein ,1994:129).

5. CONCLUSION

OFSP was preferred by the majority of the respondents and therefore it can be concluded that OFSP has potential to be readily accepted on taste and colour. The focus group discussions verified the findings of the consumer taste test in that participants expressed a positive attitude towards the colour and taste of OFSP. However, the perception that emerged from the focus group discussions, that the dark orange colour of Resisto OFSP could be due to genetic modification, is a concern that should be taken cognisance of when marketing and educating OFSP to the target market. Although genetic engineering (GM) in the field of food production is both beneficial and advantageous, public concerns about the safety of consumption as well as environmental concerns are steadily increasing (Arvanitoyannis & Krystallis 2005:343).

6. RECOMMENDATION

Although OFSP is relatively unknown to the South African consumer, familiarity with a specific vegetable influences consumption as was found by Van Riter in 1956 (Randall & Sanjur, 1981: 155). With adequate education and awareness making by retailers, OFSP has the potential to be successful in the market place providing the price is acceptable and affordable to those communities that are most in need of vitamin A in their diet.

WFSP has been commonly known for many years as a vegetable that is freely available, cheap and frequently consumed by many consumers. Therefore, in marketing terms, the introduction of OFSP could be seen as an 'extension to a range' of an existing vegetable. Furthermore, through interaction with family and friends, the message that OFSP is more nutritious, may influence consumer attitude and consumption of OFSP.

Investigating the consumption of sweet potato among men is recommended for a follow-up study. This study focussed largely on women who were found to be positive about OFSP and keen to grow it for home consumption. The preference for the dry matter content of OFSP among different cultural groups varies and is further recommended for another study. In a study that determined the selection criteria for eating quality in steamed sweet potatoes, it was found that the acceptability ranking of sweet potato roots varied according to the nationality of the sensory panel member. Therefore the potential of OFSP lies in the selection of cultivars that are acceptable to different cultural groups. Different OFSP cultivar should be evaluated for eating quality in the country or region where it will be introduced. The method of preparation of OFSP specific to the culture, could be used for the organoleptic evaluation (Villareal, Tsou, Lai & Chiu,1979:32), which then identifies true acceptance of the product. Health messages on OFSP should be part of the communication campaign, when OFSP is launched into the market place.

ACKNOWLEDGEMENTS

ARC-Roodeplaat for financial support for analysis: S Laurie

ARC-Biometry for statistical analysis: M. Smith and L. Morey

ARC-Irene staff for preparation of samples: J. van Niekerk and E. Visser

REFERENCES

ARVANITOYANNIS, IS & KRYSTALLIS, A, 2005. Consumers' beliefs, attitudes and intentions towards genetically modified foods, based on the 'perceived safety vs. benefits' perspective. *Int J Food Sci Tech.* 40: 343-360.

BLACK, RE, MORRIS, SS & BRYCE, J, 2003. Where and why are 10 million children dying every year? *Lancet.* 361: 2226-2234.

CASEY, MA & KRUEGER RA, 1994. Focus group interviewing. *In*: MacFie, H.J.H. and Thompson, D.M.H. *Measurement of food preferences*. New York. Chapman and Hall.

CONNER, M, 1993. Understanding determinants in food choice. *Br Food J.* 95(9):27-31.

FABER, M, LAURIE, S & VENTER, S, 2006. Home-gardens to address vitamin A deficiency in South Africa: A food-based approach. Pretoria. CDP Printers.

GREENHOFF, K & MACFIE, HJH, 1994. Preference mapping in practice. *In*: MacFie, HJH and Thompson, DMH. *Measurement of food preferences*. New York. Chapman and Hall.

HAGENIMANA, V, LOW, J, ANYANGO, M, KURZ, K, GICHUKI, ST & KABIRA, J, 2001. Enhancing vitamin A intake in young children in western Kenya: orange-fleshed sweet potato and women farmers can serve as key entry points. *Food Nutr Bull.* 22 (4). 376 – 387.

JENKINS, M & HARRISON, KS, 1992. Focus Groups: a Discussion. *Br Food J.* 92 (9): 33-37.

LAWLESS, HT & HEYMANN, H, 1998. *Sensory evaluation of food: Principles and Practices*. pp 431, 521. Gaithersburg. Maryland. Aspen.

LAURIE, SM, 2004. Sweet potato cultivars. *In*: Niederwieser, J.G. *A guide to sweet potato production in South Africa*. ARC- Roodeplaat Vegetable and Ornamental Plant Institute. Pretoria. CDP Printers.

MEILGAARD, M, CIVILLE, GV & CARR, BT, 1991. *Sensory evaluation techniques*. 2nd ed. New York. CRC Press.

MUKHALA, E, 2000. New sweet potato to reduce blindness in Africa. *Agricultural News*. 11:9, 29.

O'MAHONY, M, 1986. *Sensory evaluation of food. Statistical Methods and Procedures*. Marcel Dekker Inc.

RANDALL, E & SANJUR, D, 1981. Food preferences – their conceptualisation and relationship to consumption. *Ecol Food Nutr.* 11:151-161.

SAVAGE KING, F & BURGESS, A, 2003. *Nutrition for developing Countries, 2nd Ed.* New York. Oxford University Press.

STATISTICS SOUTH AFRICA, 2003. *Census 2001: Census in brief.* Pretoria.

VAN JAARVELD, PJ, FABER, WM, TANUMIHARDJO, SA, NESTEL, P, LOMBARD, CJ & BENADE, AJS, 2005. Beta-carotene rich orange-fleshed sweet potato improves the vitamin A status of primary school children assessed with the modified-relative-dose-response test. *Am J Clin Nutr.* 81: 1080-7

VAN TRJIP, HCM & SCHIFFERSTEIN, HNJ, 1994. Sensory analysis in marketing practice: comparison and integration. *J Sensory Stud.* 2 (10): 127-147.

VILLAREAL, RL, TSOU, SC, LAI, SH & CHIU, SL, 1979. Selection criteria for eating quality in steamed sweet potato roots. *Journal of the American Society of Horticultural Science.* 104 (1): 31 – 33.

VITAMIN A GLOBAL INITIATIVE, 1998. A strategy for Acceleration of Progress in Combating Vitamin A Deficiency, Consensus of an Informal Technical Consultation. New York. UNICEF. <http://www.unicef.org/search.php?q=Vitamin+A+Global+Initiative>.

WOOLFE, JA, 1992. *Sweet potato, an untapped food resource.* Cambridge. University Press.

WRIGHT, TL, NANCARROW, C & KWOK, PMH, 2001. Food taste preferences and cultural influences on consumption. *Br Food J.* 103 (5): 348 –357.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 INTRODUCTION

OFSP is a new exciting root vegetable in South Africa that is rich in beta-carotene, has an orange colour and is tasty. The main findings of the study are presented according to the three aims of the research project. This study firstly aimed to examine the nutrient content of orange fleshed sweet potato (OFSP) in South Africa, by analysing four different cultivars OFSP and one composite sample. The second aim was to establish the sensory characteristics of OFSP by developing sensory profiles for four OFSP cultivars and one white-fleshed sweet potato (WFSP) cultivar by making use of a trained sensory panel. The third aim of the study was to determine consumer acceptability of OFSP with 182 consumers of different socio-economic levels living in Pretoria (Tswane Metropolitan area). The conclusion and recommendations of the study will follow after the main findings. All three aims were addressed and achieved.

7.2 MAIN FINDINGS

The main findings are discussed according to the research questions presented in chapter 3.

Nutrient content of OFSP

1. What is the nutrient content of raw and cooked OFSP?

Different cultivars OFSP were analysed for their nutrient content with regard to macro-nutrient and micro-nutrient content. A 100 g portion of cooked OFSP can provide up to 6528 µg beta-carotene, which is approximately 136 % of the RDA for vitamin A for children four to eight years. OFSP is also a valuable source of vitamin C, calcium,

magnesium and zinc. A 100 g cooked OFSP can contribute up to 28 % of the vitamin C requirements of a child between the ages of four to eight years per day. It further contributes up to 13 % of the daily requirements for calcium, 15 % magnesium and 75.6 % zinc.

Nutrient differences between cultivars

1. Is there a difference in the nutrient content of different cultivars (Resisto, W119, Jewel and A15) cooked OFSP?

Differences were found in the nutrient content of the different cultivars, especially with reference to the dry matter (DM), beta-carotene and calcium content. The DM content differed between the different cultivars. It was observed that cultivars with a higher DM content had somewhat higher nutrient content values, for example, the Resisto cultivar had a DM content of 23.08 g / 100 g (highest) and W119 a DM content of 16.76 g / 100 g (lowest). Breeding programmes often screen new crops for high DM content, as a high DM is associated with higher yields in terms of energy per area. A high DM in potatoes is assumed to give a floury texture (Van Oirschot, Rees and Aked, 2003:679), which was not the case with sweet potato, as the Resisto cultivar, which had a high DM content and a low moisture content, was not described as having a floury texture. The Resisto cultivar also had the highest calcium, phosphorus and beta-carotene content. Although differences were found in the beta-carotene content of the different OFSP cultivars, it remains an excellent source of beta-carotene, while WFSP is almost void of beta-carotene.

Sensory analysis of different sweet potato cultivars

3. How does the descriptive sensory characteristics of Beauregard, Kano, W119, Resisto OFSP cultivars and Blesbok WFSP cultivar compare with each other?

The sensory profiles of the different sweet potato cultivars showed that the OFSP differed from WFSP in that it had a more intense earthy aroma and a less intense sweet potato aroma. OFSP overall was sweeter and had characteristics similar to that of yellow-vegetables such as butternut, pumpkin and carrots. The texture of OFSP was less moist and less fibrous than WFSP. OFSP displayed a more dense and pasty texture, which was most intense in the Resisto cultivar. W119 had more grainy texture when compared to the

other OFSP cultivars tested. The firm appearance of OFSP sweet potatoes also varied between the different OFSP cultivars and Beauregard and Kano had the most firm appearance. Although the orange colour of the different cultivars was not measured, colour differences were observed and the Resisto cultivar had the darkest orange colour.

The PCA showed that in PC1, the Resisto and W119 cultivars OFSP contrasted with the Blesbok cultivar WFSP the strongest. Resisto was mostly associated with the sweet and yellow vegetable flavour attributes, intense adhesiveness / pasty and low moisture texture attributes; whereas Blesbok cultivar WFSP was mostly associated with the typical sweet potato flavour attributes as well as the moist texture attributes. In PC 2, Resisto contrasted with W119 the strongest. W119 cultivar OFSP was mostly associated with firm and grainy texture attributes which scored lower values in Resisto cultivar OFSP.

Consumer preference test

4. Is there a difference in the taste preference for Resisto cultivar OFSP compared to Blesbok WFSP cultivar by urban adult consumers from different socio-economic groups, living in the greater Pretoria (*Tshwane Metropolitan*) area

The results from the consumer acceptability test showed a preference for OFSP. Overall 85 % of the respondents preferred the taste of OFSP, 53 % liked the orange colour a lot while 24 % liked the colour a little and the remainder 22 % displayed a negative attitude towards the orange colour. Furthermore, 86% of the respondents indicated a willingness to purchase OFSP.

The focus group discussions, which were only included in the study to verify the results obtained from the consumer test, also showed that respondents preferred OFSP and it was further revealed that sweet potato is consumed differently by different cultural groups. However, after providing information regarding the health benefits of the beta-carotene present in OFSP, respondents showed a greater interest in OFSP and a willingness to purchase it.

7.3 CONCLUSIONS

In this study, each specific research area, as presented in the conceptual framework in Chapter 3, provided different insights with regard to the role of OFSP in the diet. OFSP

contributes a variety of nutrients that are essential for everybody but specifically for people who suffer from malnutrition. OFSP can become one of the most important sources of vitamin A in rural communities, where vegetable gardens are developed. A newly created awareness within communities about the health benefits of consuming beta-carotene rich fruits and vegetables will not only introduce variety in the diet, but result in a significant increase in vitamin A intake and subsequently reduce vitamin A deficiency. In addition, the production of OFSP has the potential for income generation and therefore social upliftment of these households and, in the long term, the community as a whole (Faber, Phungula, Venter, Dhansay, Benade, 2002:1050).

The quantitative descriptive analysis measured significant differences between different cultivars with respect to a range of sensory descriptors including textural and flavour components. The main differences were found in the sweet flavour and texture attributes. New emerging cultivars can be profiled using the lexicon that was developed in this study to identify textural and taste differences among different cultivars. In addition, these findings have important implications for overall consumer acceptability of the different cultivars and can be used in future studies to profile new emerging cultivars

The results of the consumer tests revealed readily acceptance of the taste and colour of OFSP when compared to WFSP by both female and male respondents. Overall 83% of the males and 87% of the females who participated in the study preferred OFSP to WFSP. The information generated from the focus group interviews agreed with the findings of the consumer questionnaire and the knowledge that OFSP was more nutritious than WFSP, had a positive effect on the acceptability of OFSP. Therefore, OFSP has the potential to be successful in the marketplace.

7.4 LIMITATIONS OF THE STUDY

Shortcomings of the present study, with regard to the nutrient analysis of sweet potato, were that limited samples of each cultivar from the different regions were available for nutrient analysis. Although comparing the nutrient content of cultivars from different regions, was not an aim of the study, the limited available sample restricted the interpretation of the results. Cultivation procedures have an effect on the sweet potato character during the sweet potato root-shaping period (Chun-Sheng, 1985:1; Laurie in Niederwieser, 2004:3). Comparing such effects could provide insights on cultivation procedures for optimum yield.

Secondly, the consumer test could have provided more insights into taste and textural preferences of different OFSP cultivars by including more cultivars in this test. During the focus group discussions, more information with regard to cultural preferences for sweet potato as well as preparation methods could have been obtained, plus uses of OFSP and whether OFSP would be treated that same way as WFSP or similar to pumpkin or butternut.

7.5 RECOMMENDATIONS

OFSP can be regarded as a nutritious food product that could be easy to grow, is pest resistant and some cultivars deliver adequate yields in selected regions. The data on the nutrient content of OFSP, now available from the present study, can provide a valuable guideline for nutritionists who are involved in community health to calculate adequate nutrient intakes. The following are recommendations for future studies:

- From the sensory profiles of OFSP and WFSP, it was observed that differences were found mostly in sweetness and texture. As the texture of different cultivars plays an important role in the taste acceptability of root vegetables such as potatoes and sweet potatoes, it is recommended that more cultivars are evaluated for their textural qualities.
- The sensory profiles of cultivars that deliver a good yield are pest resistant and that show potential for introduction to farmers and secondary nurseries, should be analysed at different stages of the shelf-life under different storage conditions.
- Consumer preference impacts upon the acceptance of new sweet potato crops released by breeding programmes. Benefits such as superior yield and improved disease resistance may not override unacceptable sensory factors (Van Oirschot, Rees & Aked, 2003:679). The variation in preferences between consumer groups and the use of sensory evaluation in crop breeding programmes is very valuable. This approach provides invaluable information about potential rejects and the reason for the rejection of new crops. Although according to Laurie (in Niederwieser, 2004:57), cultivars with a high dry matter content of > 30% are preferred by the South African consumer, it is culture specific. Villareal, Tsou, Lai and Chiu (1979:32) found that the acceptance of sweet potatoes was ranked according to the nationality of the panel member and suggested that the eating quality of sweet potato roots should be

evaluated in the specific country where the selected cultivar will be introduced for adoption. The acceptability of textural differences that exist between promising cultivars should be tested with consumers in the different regions where OFSP are cultivated in order to identify cultural differences with regard to the texture of sweet potatoes.

- The 'willingness to buy' needs to be tested with actual prices for the different products that are available at different outlets e.g. retailers or street vendors. The consumer questionnaire only asked whether consumers would be willing to buy OFSP and no price structure was provided. It is further recommended that a more representative sampling approach is followed with a consumer study that would be representative of the whole of South Africa. Such a study would be able to measure frequency of purchase of sweet potato, consumption thereof as well as establishing where OFSP could fit into the daily diet.
- The key constraint in introducing a new variety is the availability of adequate amounts of planting material (Low, Osman and Zano, 2005:1,2). In order to convince producers and consumers to accept something to which they are not accustomed such as OFSP, creating of a demand and awareness is an integral part of the variety introduction strategy (Low *et al.*, 2005:1). Communities can be made aware of OFSP through promotional messages through radio programmes, hats and T-shirts that carry the message of OFSP and vitamin A.
- Behaviours regarding child feeding practices and diversification of household diet, should be addressed by nutritionists or agricultural extension officers in communities at risk of vitamin A deficiency. Households should be encouraged to produce a surplus of sweet potato so that there is sufficient for home consumption and for selling purposes.

7.6 THOUGHTS TO TAKE HOME: SWEET POTATO FROM A MARKETING PERSPECTIVE

Many different sweet potato cultivars are found in the world and cultivar preferences and requirements also differ among people in the world. In South Africa, promising cultivars for the delivery of carotenoids to alleviate vitamin A deficiency are evaluated in trials at target sites, after which recommendations are made, based on adaptability and, at a later stage, taste acceptability by the particular community. Once a cultivar has been

identified as suitable for a certain region, stock plants from the virus-tested glass house collection of the ARC are established in nurseries in the target areas. Cuttings of the new cultivars are distributed from the primary nurseries to secondary nurseries as well as to resource poor farmers, where training is conducted in the cultivation and multiplication of sweet potato (Laurie in Niederwieser: 2004:59-62).

In addition, the South African Food Based Dietary Guidelines (FBDG) Work Group was mandated in 1997 to develop new guidelines for South Africa. A final set of FBDG for healthy South Africans, seven years and older, were approved and adopted as national guidelines for South Africa by the National Department of Health, on 9/05/2003 (Marais, 2006:S17). One of these guidelines is: 'Eat plenty of vegetable and fruit every day' and is motivated by reviewing the evidence that these foods contribute valuable nutrients to the diet. Although OFSP is relatively unknown, it will gain popularity due to its vitamin A content and contribution to various other nutrients such as vitamin C, calcium and zinc as should be strongly promoted for home-based vegetable gardens as part of the National Health strategy of the Department of Health and home-based vegetable gardens of the Department of Agriculture.

An important function of marketing is to understand the present and future needs of potential customers for a certain product and to use such information to identify new products or product concepts with optimum attributes that are desired by the target consumer (Zigmund & d'Amico, 2002:43). The taste of a product primarily determines its acceptance by consumers. If a product does not deliver on taste, regardless of the health benefits, its future success cannot be guaranteed. It is therefore important to position the product correctly in the market place.

When introducing a product into the market place, there are five stages in the process from primary production to consumption of food products that should be taken into consideration when planning to launch a new product such as a new variety of vegetable (Van Trjip and Schifferstein, 1994:130). These include the following:

- Ingredients or product (stage 1): Although OFSP is a new cultivar that is still relatively unknown in South Africa, it is an extension of a range of an existing product / vegetable variety i.e. white-fleshed sweet potatoes. The product is therefore not completely new to consumers, and acceptance could be more ready as consumers may be willing to try it as an alternative to WFSP, especially if its appearance is not completely foreign.

- Intrinsic product characteristics (stage 2): This refers to the physical, chemical and microbiological analyses as well as the sensory analyses plus the extrinsic product characteristics. The descriptive sensory evaluation of OFSP found it to be a sweeter vegetable than WFSP. The nutritional analysis found that OFSP is rich in beta-carotene plus it makes a significant contribution to the energy intake of children between the ages of four to eight years (4.5% / 100g portion). In addition, a 100g cooked portion (half cup) further provides up 28 % vitamin C, 13 % calcium, 15 % magnesium as well as 7 % iron and 75.6 % zinc to the diet of this age group.
- Attitude and perception (stage 3) of the consumer towards the new product and consumer preference (stage 4). The consumer evaluation indicated an overwhelming acceptance of the taste and colour of Resisto cultivar OFSP. However, the negative perceptions that emerged from the focus group interviews that the dark orange colour of Resisto OFSP could be due to genetic modification is a concern that should be taken cognisance of when marketing and educating OFSP to the consumer. Although genetic engineering (GM) in the field of food production is both beneficial and advantageous, public concerns about the safety of consumption as well as environmental concerns are steadily increasing (Arvanitoyannis and Krystallis, 2005: 343).
- Choice (stage 5) of the product. Price influences food choice. Economic conditions largely dictate how households allocate their food budget. It was found that consumers are more likely to adjust purchases to price changes within a major food group than to those between major food groups (Smallwood, Blaylock and Zeller, 1981: 75). In the present study, 86 % of the participants indicated that they would be willing to buy OFSP. However, willingness to buy a product is a complex issue and is influenced by many factors such as income, size of the family, cultural background and education (Smallwood *et al.*, 1981:75), and cannot be determined by asking consumers only one question that related to this issue. Although the intrinsic and extrinsic characteristics as well as consumer perception and preference were tested, the 'product choice' needs to be addressed with the introduction of OFSP into the marketplace.

7.5 REFERENCES

ARVANITOYANNIS, I.S. & KRYSTALLIS, A. 2005. Consumers' beliefs, attitudes and intentions towards genetically modified foods, based on the 'perceived safety vs benefits' perspective. *Int J Food Sci Tech.* 40: 343-360.

CHUN-SHEN, X. 1985. *Effect of irrigation and compost on root shapes of sweet potatoes.* [http://www.arc-avrdoc.org/pdf_files/Xiechunsheng\(4-N\).pdf](http://www.arc-avrdoc.org/pdf_files/Xiechunsheng(4-N).pdf).

FABER, M., PHUNGULA, M.A.S., VENTER, S.L., DHANSAY, M.A. & BENADE, A.J.S. (2002). Home gardens focussing on the production of yellow and dark-green leafy vegetables increase the serum retinol concentration of 2-5 year old children in South Africa. *American Journal of Clinical Nutrition.* 76:1049-54.

LAURIE, S.M. 2004. Sweet potato in perspective. In: Niederwieser, J.G. *A guide to sweet potato production in South Africa.* ARC- Roodeplaat Vegetable and Ornamental Plant Institute. Pretoria. CDP Printers.

LOW, J.W., OSMAN, N. & ZANO, F. 2005. Ensuring supply and creating demand for beta-carotene rich sweet potato. Proceedings for the 18th International Congress of Nutrition. Durban, South Africa.

MARAIS, D. 2006. Using the food based dietary guidelines as a tool for nutrition through the life cycle. Proceedings of the 21st Biennial congress of the Nutrition society of South Africa and the 9th Biennial congress of the Association of Dietetics of South Africa, incorporating the SAAFoST one-day Workshop. 24-27 September 2006, Port Elizabeth, Eastern Cape. Supplement, S1-S28.

SMALLWOOD, D., BLAYLOCK, J. & ZELLER, J. 1981. Factors influencing food choice. *National Food Review.* Spring. 75 –77.

VAN OIRSCHOT, Q.E.A., REES, D. & AKED, J. 2003: Sensory characteristics of five sweet potato cultivars and their changes during storage under tropical conditions. *Food Quality and Preference.* 14: 673-680.

VAN TRJIP, H.C.M. & SCHIFFERSTEIN, H.N.J. 1994. Sensory analysis in marketing practice: comparison and integration. *J Sensory Stud,* 2 (10): 127-147.

VILLAREAL, R.L., TSOU, S.C., LAI, S.H. & CHIU, S.L. 1979. Selection criteria for eating quality in steamed sweet potato roots. *Journal of the American Society of Horticultural Science*. 104 (1): 31 – 33.

ZIGMUND, W.G. & d'AMICO, M. 2002. *Effective Marketing: Creating and Keeping Customers in a e-commerce World*. USA. Thompson Learning, South Western.



ADDENDUM A:

QUANTITATIVE DESCRIPTIVE ANALYSIS, SENSORY EVALUATION FORM

Sensory evaluation of sweet potatoes

2 – 8 June 2006

Name:..... Date..... Code.....

AROMA	None	Hint	Slight	Weak	Moderate	High	Very High	Extremely
Earthy	1	2	3	4	5	6	7	8
Sweet potato	1	2	3	4	5	6	7	8
Burn	1	2	3	4	5	6	7	8
TEXTURE	None	Hint	Slight	Weak	Moderate	High	Very High	Extremely
Initial impression: squeeze sweet potato between fingers, holding it on the skin side								
Moistness (visible on surface)	1	2	3	4	5	6	7	8
Firm (retain shape)	1	2	3	4	5	6	7	8
First bite	1	2	3	4	5	6	7	8
Denseness	1	2	3	4	5	6	7	8
Moistness	1	2	3	4	5	6	7	8
Mastication								
Fibres (with fork)	1	2	3	4	5	6	7	8
Adhesive (pasty)	1	2	3	4	5	6	7	8
Grainy (tongue on palate)	1	2	3	4	5	6	7	8
FLAVOUR	None	Hint	Slight	Weak	Moderate	High	Very High	Extremely
Vegetable sweet	1	2	3	4	5	6	7	8
Sweet potato	1	2	3	4	5	6	7	8
Yellow vegetables (butternut/pumpkin/carrot)	1	2	3	4	5	6	7	8
AFTER-TASTE	None	Hint	Slight	Weak	Moderate	High	Very High	Extremely
Vegetable sweet	1	2	3	4	5	6	7	8

Comments:

ADDENDUM B: CONSUMER QUESTIONNAIRE

Evaluation form for sweet potatoes.

Date:.....

Name:.....

Age:.....

Which town do you live in?.....

Income	1000 - 2500	2500 - 4000	4000 - 6000	6000 +
√ the appropriate block				

1. COLOUR: Do you like the colour of the orange-fleshed sweet potato?

Place a √ in box in the appropriate block.



Like a lot



Like a little



Neither like
nor dislike



Dislike a little



Dislike a lot

2. TASTE: Please taste the product on the **left first**. You must taste **both** products. Which **one** do you prefer? Please choose one. Place a √ in the box above the number you prefer.

471

863

3. PURCHASE INTENT: Will you **buy** the orange-fleshed sweet potato?

Please √ appropriate block



Yes



No

Thank you for participating

ADDENDUM C: PHOTO GALLERY

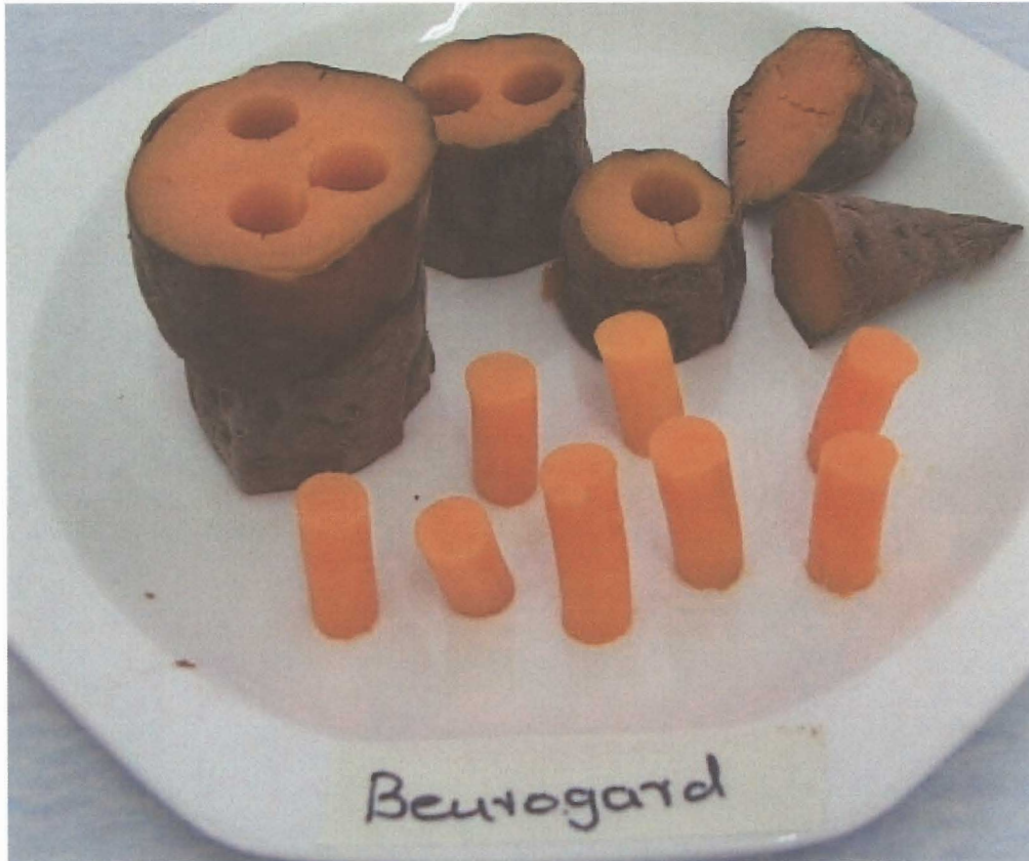
Cultivars tested



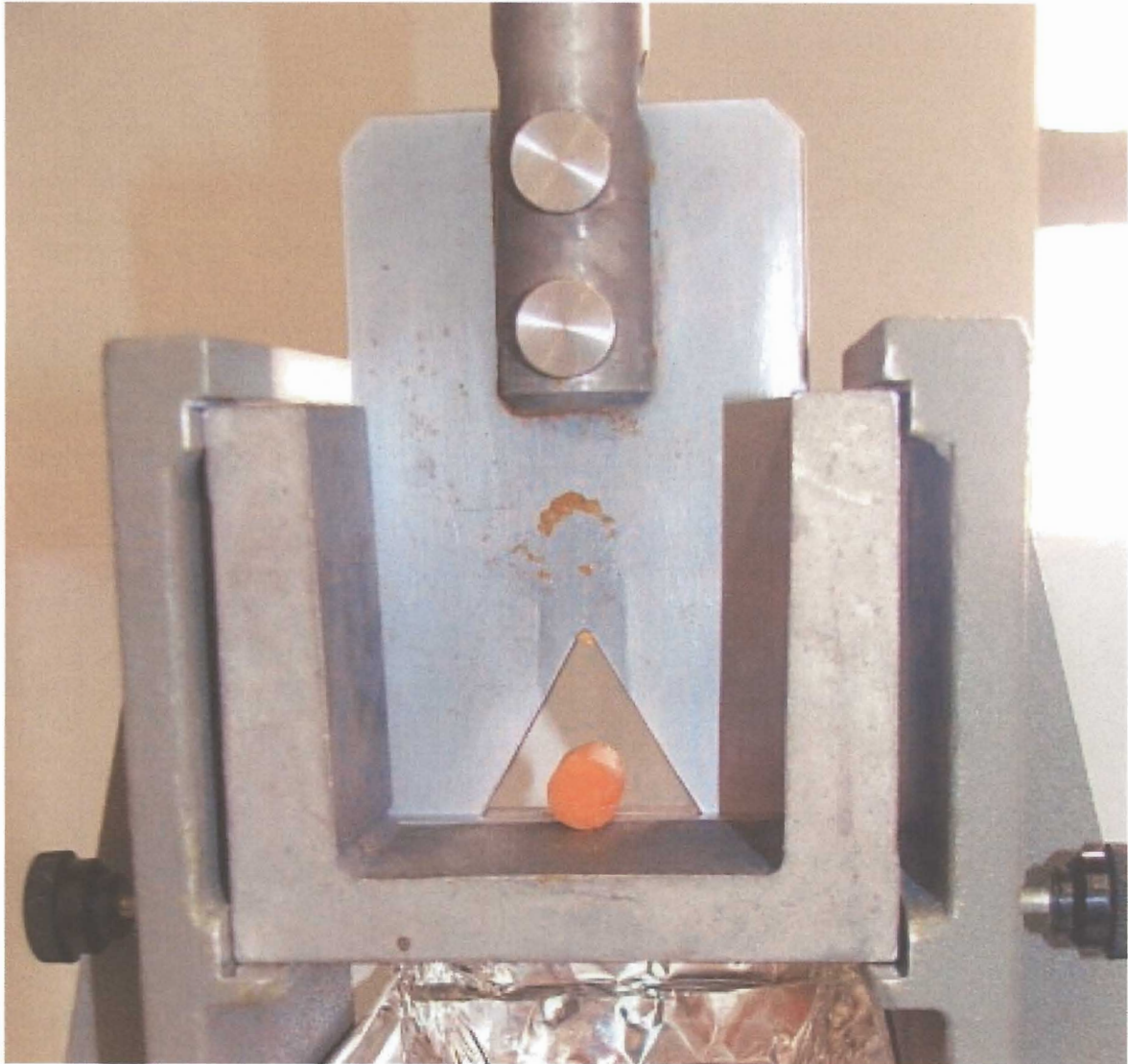




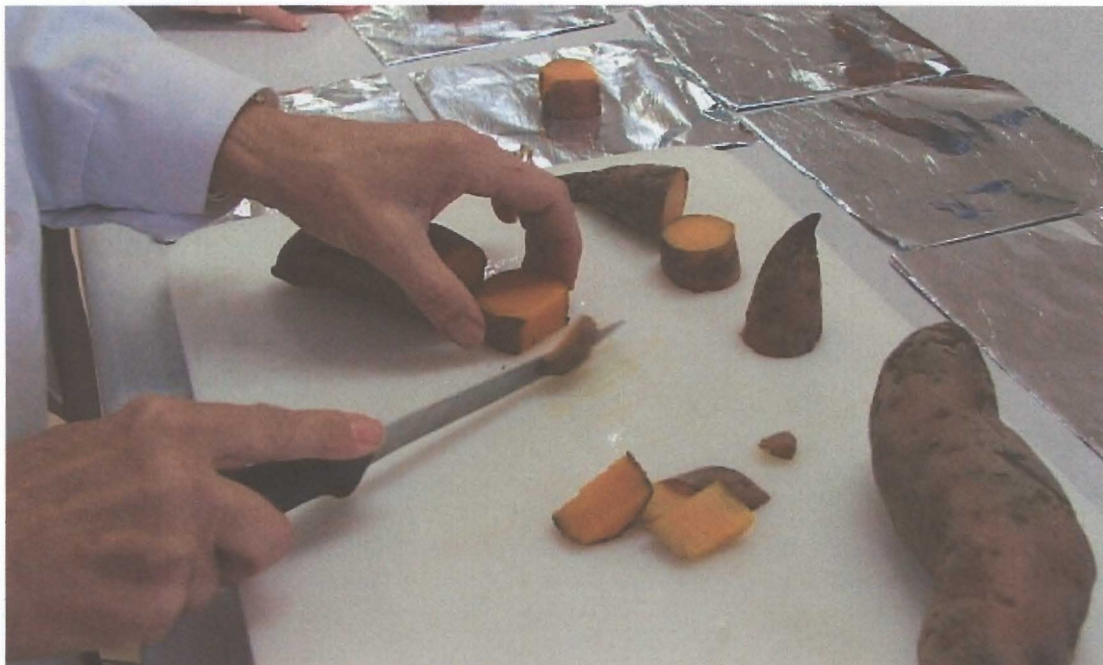
Sample preparation for Instron

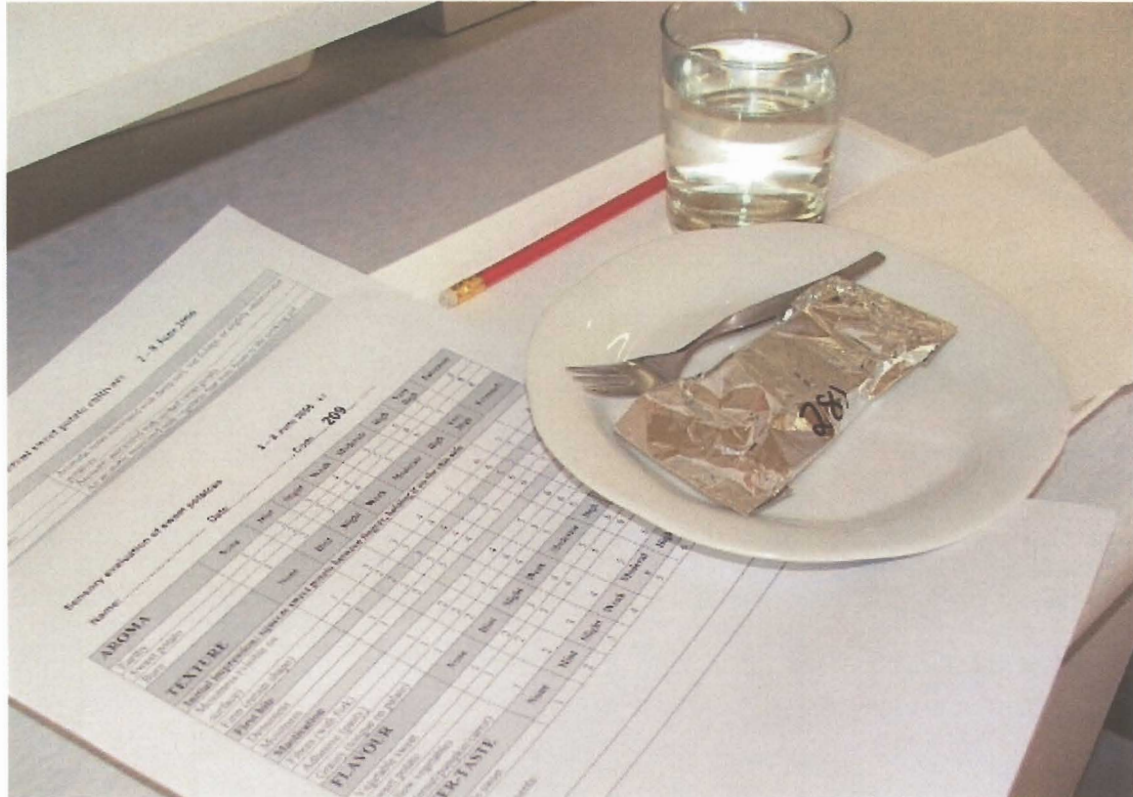


Instron is used measure shear force of sweet potatoes



Panel training, sample preparation and serving of sweet potatoes for sensory evaluation.







OFSP at ARC-Roodeplaat



