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.

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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
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CULTIVAR	REGIONS	UNITS
Resisto	Gauteng University of Pretoria vegetable gardens	30
W119	Gauteng University of Pretoria vegetable gardens	20
Jewel	Gauteng University of Pretoria vegetable gardens	20
	Free State Fouriesburg	5
A15	Free State Fouriesburg	5
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 is 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)	ICP- emission spectrometer	ARC-Institute for Soil, Climate and Water
Calcium (Ca)		
Magnesium (mg)		
Phosphorus (P)		
Potassium (K)		
Iron (Fe)		
Manganese (Mn)		
Zinc (Zn)		
Copper (Cu)		

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

			All cultivars OFSP		
Nutrients	Unit per 100g	p-value	Raw[1] (n = 6) (±) SEM	Cooked[2] (n = 7) (±)SEM	OFSP[3] (US) Baked with skin, flesh only, USDA
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^{a}	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

[1]Conversion 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.,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 µg / 100 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 µg / 100 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 µg / 100g (± 1167) in the cooked root. The beta-carotene content of the Resisto cultivar OFSP analysed was 9230 µg / 100g. 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 attributes 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

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