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PROXIMATE COMPOSITION AND VITAMIN A CONTRIBUTION OF BIOFORTIFIED ORANGE FLESHED SWEET POTATO VALUE ADDED PRODUCTS

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ABSTRACT

Orange fleshed sweet potato (OFSP) is rich in provitamin A carotenoids and can thus be utilized to tackle Vitamin A deficiency (VAD) in Sub-Saharan Africa (SSA). Puree with high amounts of β-carotene processed from OFSP roots is currently being incorporated in baked products such as bread, cakes, biscuits, and buns. The objective of this study was to evaluate the nutritional composition of OFSP puree supplemented food products, that is, bread, buns, flakes, cakes, biscuits, muffins, soft cookies, golden biscuits and whole wheat flour bread. The composite products made from OFSP puree were analyzed for β-carotene content and proximate analysis. The highest concentration of β-carotene (19.86 mg/100g) was obtained in OFSP flakes. The concentration in buns with 20% puree was 0.58 mg/100g, while bread with 35% puree had a concentration of 3.02 mg/100g. Biscuits, cookies and cakes with high puree of 40% had β-carotene concentrations of 2.39, 1.83, and 2.30 mg/100g respectively. These concentrations are lower than in bread with 35% puree, and we see different proportions of ingredients and other factors such as cooking method, duration of cooking also play a major role in the final β-carotene concentration of the products. The total Retinol Activity Equivalents (RAE) for the OFSP products were significantly different with bread (35% puree) having a higher concentration of 216.67 µg/100g and OFSP buns (20% puree) having a lower concentration of 41.19 µg/100g. Orange fleshed sweet potato flakes had the highest concentration of 1443.2 µg/100g and whole wheat flour bread having the least of 6.9 µg/100g. The moisture content, total ash, crude fiber, crude fat, crude protein, and carbohydrate content of the OFSP products varied between 2.4-29.7%, 0.7-2.4%, 1.0-4.5%, 0.7-18.1%, 5.1-7.9% and 50.7-83.7%, respectively. The findings of this study show that different proportions of OFSP puree: wheat flour is not the only determinant on the final β-carotene concentration of the different OFSP products, the type and quantity of ingredients used, cooking time and method also contribute to the VA content. Diversification of OFSP food products helps increase its consumption and its added value.

Key words: Beta-carotene, Orange fleshed sweet potato, puree, Sweet potato, Vitamin A

INTRODUCTION

China is currently the top producer of sweet potatoes globally, followed by Nigeria and Tanzania, Indonesia, and Uganda [1]. Sweet potato is the most abundantly grown root crop in sub-Saharan Africa, covering around 2.9 million hectares with an estimated production of 12.6 million tons of roots in 2007 [2]. Sweet potato is considered as a food security crop because of its low input requirements and high yields in different climatic conditions [2]. As a food security crop, it can be harvested at the point of demand, hence contributing to a reliable source of food and revenue to farmers who are frequently susceptible to regular crop damage [3]. It is a good source of important nutrients such as vitamins and minerals. Orange fleshed sweet potato (OFSP) is rich in β-carotene, hence considered as a significant dietary source of Vitamin A (VA) [4]. Vitamin A deficiency (VAD) remains a serious public health problem in the developing world [5]. Preschool children and pregnant women suffer the most widespread and severe effects of VAD such as blindness in children and severe infections like diarrhoeal disease and measles [6]. It has a characteristic sweet taste and an attractive, eye-pleasing orange color to children, in comparison with white-fleshed sweet potato; hence it has demonstrated a potential role to tackle calorific and VAD malnutrition problems of children under five years, pregnant women and lactating mothers in targeted communities [7].

Its roots are processed into puree (soft, creamy thick paste) for use as an ingredient in foods. Processing of OFSP puree involves grading of OFSP roots, washing, peeling, steaming, cooling and size reduction, pureeing and preservative addition, vacuum packaging in plastic bags, and storage at very low temperatures [8]. The puree is an economically viable ingredient for enhancing VA in baked and fried products [9]. Puree production and its use as a functional ingredient in food processing has been done for over three decades in the United States [10]. Puree has been used locally at domestic levels and in industrial production of baked products [11]. In Rwanda, OFSP puree business is on the rise and research has demonstrated the business venture is lucrative when the puree and bakery production are done in the same processing facility [9]. Value addition through processing of raw sweet potatoes in Rwanda has positively transformed the livelihoods of farmers through income generation [12]. Processing and commercialization of OFSP puree products such as breads, doughnuts, biscuits, and cakes in Rwanda have been well established. For instance, Golden Power Biscuits (made with 43% puree) and mandazi (fried doughnuts-made with 20-50% puree) were popular products made from OFSP puree at Urwibutso Enterprise in Rwanda [13]. The sale of these two OFSP products over a 19 months period generated $364,410 USD and the products continued to be made and sold through Urwibutso's eleven stores [14]. In Kenya, high profit margins were realized since the launch of OFSP puree bread and particularly with the use of high fiber puree [9]. According to Bocher [9], OFSP bread began being marketed in six Tuskys stores in June 2015, and it had reached twenty stores by August 2016, the OFSP bread was well received by customers and the puree production became profitable (18% profit margin) when it was shifted from using peeled to unpeeled roots--the new product being a "high fiber" puree. Incorporating 20-45% OFSP puree in place of wheat flour in bakery applications results in OFSP puree composite products of high acceptability by consumers [15]. The commercialization of

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the OFSP puree bread creates a market for the OFSP roots; this trickle down to improve the rural economies of households involved in the production of OFSP roots from small-holder farmers who have suffered for years for the lack of market for their excess crops, thus improving their incomes and livelihoods. Despite the substantial economic benefits of OFSP puree value chain, little information is available to support the nutritional importance of OFSP puree composite products. The current analysis therefore aimed at determining the beta-carotene content and proximate composition in OFSP puree composite products (OFSP bread, cake, biscuits, buns, muffins, soft cookies and flakes) and whole wheat flour (WWF) bread.

MATERIALS AND METHODS

Source of WWF product and OFSP puree composite products

Table 1 shows the source of OFSP products. All the samples were received packaged in air-tight plastic bags and stored at -20°C. Sample preparations and analysis were done in Food and Nutritional Evaluation Laboratory (FANEL) in Biosciences Eastern and Central Africa (BeCA), ILRI, Nairobi.

Processing of OFSP products

The ingredient formulations of WWF bread and OFSP puree composite baked products are shown in Table 2. For the OFSP biscuits and golden power biscuits, the proportions of OFSP puree and wheat flour were thoroughly mixed. The dough was kneaded by a rolling stick to get the desired thickness. Thereafter, the dough was cut to a round shape using a biscuit cutter having 5 cm diameter and then baked in the oven at 200°C for 15 minutes. The samples were cooled and packed in air-tight containers. The breads and buns were baked according to the proportions listed. The WWF flour and OFSP puree were mixed with the dry ingredients according to their proportions listed in Table 2, and later the wet ingredients were added. After binding, the bread dough was shaped and put in bread tin and the bun dough was subdivided into smaller portions depending on the required size and placed on a tray. The doughs were subjected to an appropriate temperature (30°C) for yeast fermentation to occur, thus making them rise. They were then heated in an oven at 180°C to enable baking. The breads and buns were cooled and packed in air-tight bags ready for analysis. Whole wheat flour bread was prepared according to the formulation in Table 2. The dough was prepared and left to undergo proofing after which it was baked in the oven at 180°C. After cooling, the bread was kept in air-tight plastic bag. The muffins were prepared by mixing the ingredients together to form a batter. The batter was poured in equal proportions onto muffin baking tins and placed in the oven at 180°C to bake for 35 minutes. They were cooled and packed in air-tight bags. The cakes were prepared by mixing the WWF flour and OFSP puree with dry ingredients and later the wet ingredients added. The batter was added to a baking tin and placed in a preheated oven to bake at 180°C for 35 minutes; storage of the cake was in air-tight bags. The soft cookies were baked according to the proportions listed. The dry and wet ingredients were added and kneaded to form dough. The cookies were shaped using a cookie cutter and placed on the baking tray inside a pre-heated oven (180°C) to bake for 25 minutes. The cookies were cooled and later packed in air-tight bags for storage. The flakes were made from 100% puree processed from OFSP roots (Variety:Yansu H25). The puree was mixed homogeneously and placed on the baking tray in a preheated oven to bake at 350°C for 15 minutes. After baking, the sample was cooled, and the batter was cracked into small flakes using hands. The flakes were stored in an air-tight container.

Analysis of Carotenoids in OFSP puree composite products

Carotenoid analysis was carried out following the methods by Muzhingi [15] and Hosotani [16] with appropriate modifications. Equipment used: water bath (SW23GB, JULABO) and Centrifuge (Eppendorf, Centrifuge 5810) speed of 1872xg. N-Evap machine (Organomation, Model OA-8125) and HPLC (Waters 2695 separation module) with a 2996 PDA detector and a C30 carotenoid column (3µm, 150X4.6 mm, YMC Wilmington, NC) utilizing a reverse phase gradient HPLC method. The procedure was done under yellow light using amber glassware and aluminum foil for proper protection [15].

Moisture content

Moisture content in the samples was determined by drying the homogenized samples to a constant weight in a dry air hot oven set at 105°C as per the method described by AOAC method [17].

Crude protein

Protein content was determined by Kjeldhal method as described by AOAC method [17]. Equipment used: Dk 18/26 digestion unit, Velp scientifica, Udk 129 kjeldahl distillation unit, Velp scientifica. The average titre was used to calculate the amount of protein in the sample by using a factor of 5.70.

Crude fiber

Crude fiber was determined according to AOAC method [17]. Equipment used: muffle furnace (Vulcan Multi-stage furnace, 3-550) at 550°C.

Crude ash

Ash content was determined by AOAC method [17] method. Equipment used: Muffle furnace (Vulcan Multi-stage furnace, 3-550) at 550˚C.

Crude fat

Crude fat was determined according to AOAC method [17]. Equipment used: Digester (Hu 6 hydrolysis unit, Velp Scientifica) for digestion, Solvent extractor (Velp Scientifica SER148).

Carbohydrates

Carbohydrate content for each sample was calculated by difference, that is, 100 - (moisture content+crude fat+crude fiber+crude protein+crude ash) [17].

Data Analysis

The values were expressed on a fresh weight basis. The data was exported to Minitab 19 [18] and the means and standard deviations were calculated. One-way ANOVA was used to check for statistical mean differences in the samples with p value set at 0.05. The mean differences were separated by post hoc Tukey test.

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RESULTS AND DISCUSSION

Beta-carotene content in WWF bread and OFSP puree composite products
Beta-carotene content and corresponding retinol activity equivalents (RAE) in WWF bread and OFSP puree composite products are shown in Table 3. The RAE were calculated on µg/100g fresh weight basis and the content varied significantly with ranges from 6.9 µg/100g in WWF bread to 1443.2 µg/100g in OFSP flakes. A study done by Afework [19] on OFSP biscuits with 70% wheat flour and 30% OFSP flour revealed vitamin A concentration of 379 µg/100g. These concentrations were higher than our findings in OFSP biscuits with 40% puree and 60% wheat flour. According to name??[19], the combined effect of OFSP blending and high baking temperature and time affect vitamin A content. Orange fleshed sweet potato puree is rich in VA content compared to WWF, which is devoid of VA, therefore, adding OFSP puree to locally available WWF for bread making improves VA content of the local breads. The high concentration of RAE in OFSP flakes is expected as its composition is 100% OFSP puree compared to the other baked products which have a mixture of different ingredients. Orange fleshed sweet potato flakes have been dried, hence the concentration of β-carotene is substantial, and this makes the flakes more nutritious. A 100g serving of orange fleshed sweet potato flakes can provide more than 100% of the RDA of VA. There were significant differences in total β-carotene concentrations (Table 3) in OFSP puree composite products with OFSP buns having the least (0.58 mg/100g) and OFSP flakes with the highest concentration (19.86 mg/100g). Proportion of OFSP puree: wheat flour determines the final β-carotene concentration of the products. WWF bread was lower in β-carotene (0.1 mg/100g) since the percentage of wheat flour was higher than OFSP puree which was not included in the blend. OFSP buns had 20% of OFSP puree compared to OFSP flakes which had 100% puree. There were no significant differences in β-carotene concentrations between OFSP cake, OFSP bread and OFSP biscuits (Table 3). Orange fleshed sweet potato biscuits, soft cookies and cake each had 40% OFSP puree and OFSP bread had 35% OFSP puree. From Table 3, the β-carotene concentrations were bread (3.02 mg/100g), OFSP biscuits (2.39 mg/100g), and OFSP cake (2.3 mg/100g). Lower concentrations in biscuits and cake as compared to bread shows that other factors such as ingredients used, quantity of ingredients, cooking method, and duration of cooking are likely to be major contributing factors to the trends observed. Afework [19] obtained a β-carotene content of 6.01 mg/100g in OFSP biscuits substituted with 30% OFSP flour, this concentration is higher than our findings and this could be attributed to lower baking temperature and time. According to Anjum [20], it is important to note that higher temperatures and longer heating time of foods could result in reduced amount of β-carotene due to degradation, while lower baking temperature and time cause less degradation hence the beta-carotene concentration could be much higher.

The major β-carotene component in all samples was all-trans BC, followed by 13-cis BC and 9-cis-BC (cis-isomers), respectively. An example of a chromatogram of OFSP bread is shown in Figure 1. Orange fleshed sweet potato buns had the lowest value of all-trans ß-carotene (0.4 µg/100g) while the highest value was obtained from OFSP

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flakes (15.2 µg/100g). Muzhingi [15] previously reported relatively high all-trans ß-carotene (3.14 mg/100g) in bread substituted with 45% OFSP puree.

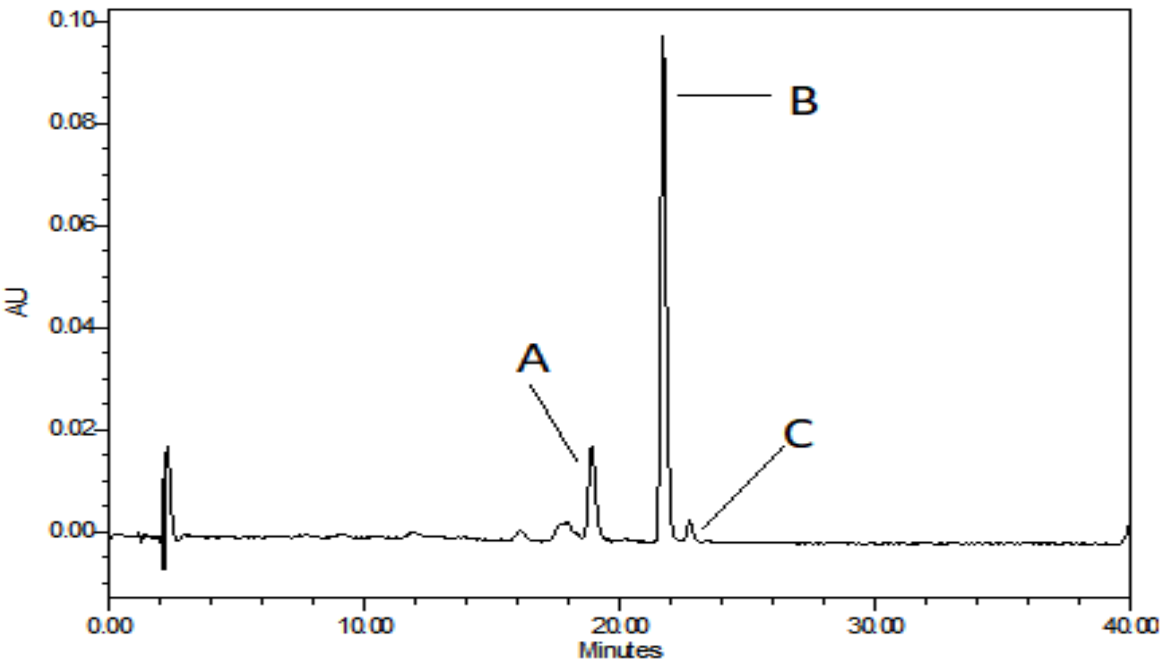

Figure 1: An image of a chromatogram of β-carotene in OFSP bread: A-13-cis β-carotene; B-all-trans β-carotene; C-9-cis β-carotene

Estimation of the contribution of WWF bread and OFSP Puree Composite products to VA requirements in different age groups

The RDA of various age groups is shown on table 4 [21]. Conversion factor used is 1 µg Vitamin A activity = 24 µg 9-cis and 13-ci-ß-carotene and 12 µg all-trans ß-carotene [22]. In this study, 100 g of all OFSP puree composite products could provide more than 50% of the recommended daily allowance for VA in children between 1 to 3 years (Table 5). Orange fleshed sweet potato flakes (100 g) provides more than the recommended daily allowance of VA for all age groups. Additionally, OFSP puree composite products (100 g) other than OFSP buns in this study can suitably cater for more than 10% VA body requirements for lactating mothers and pregnant women. Whole wheat flour products are very low in VA, hence, they cannot provide the recommended daily VA allowance. This data supports the fact that including OFSP puree composite products as part of the diet could contribute to tackling VA deficiency in SSA countries. Assuming more than 90% beta-carotene retention after boiling OFSP roots, serving 100 g of boiled OFSP roots could provide sufficient VA dietary requirements in children and pregnant women. The same amount would also provide about 70% VA requirements in lactating mothers. From this analysis, OFSP flakes are a superior source of beta-carotene as compared to the other baked products.

Proximate composition in WWF bread and OFSP puree composite products (fresh weight)

The proximate composition of WWF bread and OFSP puree composite products are shown in Table 6. The moisture content varied significantly with OFSP bread showing the highest concentration of 29.7% followed by WWF bread (28.6%). According to Kidane [23], the moisture content of the OFSP breads increases as the blending level of OFSP puree increases. Low moisture content in OFSP flakes (2.4%) is attributed to the process of oven drying at elevated temperatures that drives out moisture to attain the desirable characteristic of crunchiness [24]. Orange fleshed sweet potato golden biscuits had a moisture content of 5.57%. Low moisture content in biscuits is important for desirable sensory attributes, particularly crunchiness and enhanced keeping quality. A study by Eke [24] showed moisture content in OFSP biscuits within the range of (3.00- 6.79). Eke also reported a relatively low moisture content in cakes (22.0-22.3%) and biscuits (3.0-6.8%) made from sweet potato-wheat composite flour. Incorporating OFSP in wheat products reduces the moisture content due to the difference in the flour structure and water holding capacity [25]. The dry matter content of OFSP products ranged between 70.3% in OFSP bread to 97.6% in OFSP flakes. This is an important factor for obtaining products with desirable organoleptic properties as well as keeping quality. The findings indicate OFSP processed products could be a reliable source of energy, fat, protein, minerals, and fiber important for human health.

High fat content was obtained in both OFSP biscuits and OFSP golden biscuits at 18.1 and 16.0% respectively. The fat content in OFSP bread (3.2%) was lower compared to WWF bread (3.8%). Lyimo [26] reported that substituting higher levels of OFSP puree in the formulation reduces the fat content. OFSP biscuits had high fat content probably because of the use of high amount of fat (150 g) as an ingredient during the process of formulation. Afework [19] obtained a low-fat content of 2.8% in OFSP biscuits prepared with 30% OFSP flour, 20% sugar, 5% milk, 15% egg, 0.5% baking powder and no fat. This was attributed to different proportions of ingredients (particularly cooking fat/oil) in the two studies. Orange fleshed sweet potato buns and flakes had the least fat content at 0.8% and 0.7%, respectively.

Orange fleshed sweet potato cake had the lowest protein content at 5.1% despite being supplemented with milk and eggs. The low protein content could be due to the lower amount of proteins in OFSP puree compared to wheat flour [25, 27]. The protein content in WWF bread was significantly ($p<0.05$) higher (7.6%) than in OFSP bread (6.6%). The protein content in OFSP bread was due to supplementation of milk with the ingredients which are known to be rich in protein, however the higher concentration in WWF bread could also be due to the higher amount of wheat flour in the blend (100%) as wheat flour is high in proteins than OFSP flour [23]. Kidane [23] obtained a protein content of 4.62% in OFSP flour and 10.72% in WWF, these findings are consistent with our study. Protein is required by the human body to supply an adequate amount of required amino acids [28]. The crude protein concentration of these samples was also lower when compared to other sources of protein-rich foods such as cow peas, beans, and soybeans, which ranges between 23% and 34% [29]. This suggests that consumers should consume protein-rich foods to supplement the protein deficit in OFSP products.

Crude fiber content ranged between 2.8% in OFSP flakes to 1.0% in OFSP soft cookies. Higher amount of crude fiber in OFSP flakes may be explained by its high dry matter content. Mais [25] reported increased fiber content due to increased addition of OFSP flour in other baked products. Consumption of high fiber food products has been linked to a reduction in hemorrhoids, diabetes, high blood pressure, and obesity [28]. There were significant differences in total ash content with OFSP flakes having a higher concentration of 2.4% and OFSP bread having the least (0.7%). The ash content of food material could be used as an index of mineral constituents [30]. Significant varietal differences can be seen in carbohydrate content. It ranged between 50.7% in OFSP cake and 83.7% in OFSP flakes. According to Onabanjo [31], OFSP had higher carbohydrate content compared to wheat and using higher baking temperature and time could result in a concentrated carbohydrate. The carbohydrate values in OFSP products under this study highlighted them as a good source of energy.

CONCLUSION

The study has shown that OFSP puree can be incorporated to WWF to produce nutritious products with increased VA content. The nutritional properties of the products changed due to incorporating OFSP puree and also due to the type of ingredients used and quantity, cooking time and method used. The inclusion of OFSP products in feeding programs will help to overcome the existing nutrient deficiencies of VA in developing countries. This is an economical approach of how to utilize OFSP puree while maximizing its nutritional benefits. It is important to develop a robust market for OFSP products that will help sweet potato farmers have a stable income from the sale of large quantities of OFSP. Expansion of the market of these value-added OFSP products enables people in both rural and urban areas to have access to these nutrient rich foods.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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Table 1: Source of OFSP products

OFSP products	Puree (%)	Source of OFSP products
Flakes	100	China
Bread	35	Kenya
Cookies	40	Malawi
Muffins	30	Kenya
Biscuits	40	Rwanda
Bread	0	Rwanda
Buns	20	Mozambique
Cakes	40	Rwanda
Golden power biscuit	43	Rwanda

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Table 2: Ingredient formulation for WWF bread and OFSP puree composite products

	Ingredients								
Samples	WWF Flour (%)	OFSP Puree (%)	Milk (mls)	Salt (g)	Sugar (g)	Yeast (g)	Fat (g)	Eggs (n)	Baking Powder (g)
WWF bread	100	0	20	20	150	50	40	nil	nil
OFSP bread	65	35	20	20	150	50	40	nil	nil
OFSP cakes	60	40	20	nil	250	nil	nil	2	20
OFSP golden biscuit	57	43	35	nil	350	nil	150	4	20
OFSP biscuits	60	40	35	nil	350	nil	150	4	20
OFSP buns	80	20	20	20	150	50	40	nil	nil
OFSP flakes	nil	100	nil	nil	nil	nil	nil	nil	nil
OFSP muffins	70	30	nil	20	150	nil	nil	2	20
OFSP soft cookies	60	40	35	nil	300	nil	150	4	20

Key:

Mls-milliliter's
g-grams
n-number
%-percent

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Table 3: β-carotene content (mg/100g FWB) and RAE (µg/100g FWB) in WWF flour and OFSP puree composite products

Sample	13cis	9cis	All trans	β-carotene (mg/100g)	RAE (µg/100g)
WWF bread	0.0±0.0^{f}	0.0±0.0^{c}	0.0±0.0^{e}	0.10±0.0^{e}	6.9±0.0^{e}
OFSP bread	0.7±0.0^{b}	0.2±0.0^{b}	2.2±0.0^{b}	3.02±0.0^{b}	216.67±1.4^{b}
OFSP biscuit	0.6±0.0^{bc}	0.1±0.0^{bc}	1.7±0.0^{c}	2.39±0.0^{bc}	170.47±2.5^{b}
OFSP cake	0.5±0.0^{c}	0.1±0.0^{bc}	1.8±0.0^{bc}	2.30±0.0^{bc}	169.15±3.3^{b}
OFSP buns	0.1±0.0^{e}	0.1±0.0^{bc}	0.4±0.1^{e}	0.58±0.1^{e}	41.19±9.0^{d}
OFSP flakes	3.6±0.1^{a}	0.7±0.1^{a}	15.2±0.4^{a}	19.86±0.6^{a}	1443.2±43.0^{a}
OFSP soft cookies	0.3±0.0^{d}	0.0±0.0^{c}	1.5±0.1^{cd}	1.83±0.1^{c}	137.60±5.9^{bc}
OFSP muffins	0.23±0.0^{de}	0.1±0.0^{bc}	1.0±0.0^{d}	1.21±0.0^{d}	88.47±3.4^{c}

Values represent mean and standard deviation. Values bearing different superscript letters in a column are significantly different at $p<0.05$ (Conversion factor: 1 µg, VA activity = 24 µg 9-cis, and 13-cis-ß-carotene; 1 µg VA activity = 12 µg all-trans ß-carotene) (WWF-whole wheat flour, OFSP-orange fleshed sweet potato) NB: Data on OFSP golden biscuits is unavailable

Table 4: Recommended Dietary Allowances (RDA) for Vitamin A in different age groups

Age group	RAE (µg/100g)
Infants (0-6 months)	400
Infants (6-12 months)	500
Children (1-3 years)	300
Children (4-8 years)	400
Children (9-13 years)	600
Above 14 years	900
Pregnant women	770
Lactating mothers	1200

RAE: Retinol Activity equivalents. Conversion factor 1 µg Vitamin A activity = 24 µg 9-cis and 13-ci-ß-carotene; Conversion factor 1 µg Vitamin A activity = 12 µg all-trans ß-carotene [24]

Table 5: Contribution of OFSP composite products to VA requirements in different age groups

Sample	RAE	1-3y (%)	9-13y (%)	Pregnant women (%)	Lactating mothers (%)
WWF bread	6.9	2.3	1.2	0.9	0.6
OFSP bread	216.67	72.2	36.1	28.1	18.1
OFSP cakes	169.15	56.4	28.2	21.9	13.0
OFSP biscuits	170.47	56.8	28.4	22.1	13.1
OFSP buns	41.19	13.7	6.9	5.3	3.4
OFSP flakes	1443.2	>100	>100	>100	>100
OFSP soft cookies	137.60	45.9	22.9	17.9	11.5
OFSP muffins	88.47	29.5	14.7	11.5	7.4

Y: years; RAE: Retinol Activity equivalents (µg/100g)

Table 6: Proximate composition of WWF product and OFSP puree composite products (g/100g fresh weight)

Sample	Moisture (%)	Protein (%)	Ash (%)	Fiber (%)	Fat (%)	Carbohydrate (%)
WWF bread	28.6±0.9^{b}	7.6±0.0^{a}	1.7±0.1^{b}	1.4±0.0^{c}	3.8±0.1^{e}	56.9±0.9^{e}
OFSP bread	29.7±0.3^{a}	6.6±0.1^{bc}	0.7±0.1^{e}	1.3±0.1^{c}	3.2±0.0^{f}	58.4±0.4^{e}
OFSP biscuit	9.90±0.1^{d}	6.2±0.1^{c}	1.1±0.0^{d}	1.9±0.1^{bc}	18.1±0.2^{a}	62.9±0.3^{d}
OFSP cake	28.8±0.2^{ab}	5.1±0.0^{d}	1.4±0.1^{c}	1.4±0.0^{c}	12.7±0.1^{c}	50.7±0.3^{f}
OFSP buns	26.0±0.2^{c}	7.3±0.1^{ab}	1.4±0.1^{c}	1.1±0.1^{d}	0.8±0.0^{g}	63.4±0.3^{d}
OFSP flakes	2.40±0.1^{g}	7.9±0.7^{a}	2.4±0.1^{a}	2.8±0.8^{b}	0.7±0.0^{g}	83.7±1.1^{a}
OFSP cookies	7.60±0.1^{e}	7.9±0.2^{a}	2.0±0.0^{a}	1.0±0.1^{d}	6.3±0.1^{d}	75.3±0.1^{b}
OFSP golden biscuits	5.57±0.2^{f}	7.63±0.5^{a}	1.93±0.0^{ab}	4.5±0.8^{a}	16.0±0.0^{b}	69.94±0.4^{c}

Values represent mean and standard deviation in triplicate analysis. Values bearing different superscript letters in a column are significantly different at $p<0.05$ (WWF-whole wheat flour, OFSP-orange fleshed sweet potato) NB: Data on OFSP muffins is unavailable

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