

Development and Assessment of Frying Characteristics, Chemical Composition, Descriptive Sensory Properties and Preference Mapping of Wheat-Orange Fleshed Sweet Potato Composite Swahili Buns (*Maandazi*)

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Abstract

This study was carried out to investigate frying characteristics, chemical composition and sensory evaluation of whole-wheat buns (WWB) and Wheat-Orange fleshed sweet potatoes - composite buns (WPCB) at different levels of wheat flour substitutions. A whole-wheat buns (WWB) and OFSP-composite buns (WPCB 1, WPCB 2 and WPCB 3) were prepared in triplicate at 0, 10, 20 and 30% levels of wheat flour substitution respectively, and evaluated for weight, volume, specific volume, proximate composition, vitamin A, descriptive sensory profile, consumer liking and preference mapping. Completely randomized design was used to assess and compare frying characteristics, proximate and vitamin A contents between samples with bread types being the principal factor while Randomised complete Block design was used to assess sensory properties and consumer acceptability of the bread samples with panelists and bread types being the principal factors. The results showed that moisture content, crude fibre, and ash contents of the composite buns increased significantly ($p < 0.05$) while the carbohydrate, crude fat and protein contents decreased significantly ($p < 0.05$) with progressive increase in the OFSP flour. The WPCB3 had significantly ($p < 0.05$) highest moisture, ash and fibre values of 17.13, 2.97 and 1.31 g/100g DM, respectively, compared to lowest values of 14.05, 2.17 and 0.48 g/100 g DM, respectively in WWB. However, significantly ($p < 0.05$) higher fat, carbohydrate and protein values of 1.95, 70.68 and 8.06 g/100g DM compared to lowest values of 0.89, 54.13 and 6.56 g/100 g DM, respectively was observed in WPCB 3. Vitamin A content increased significantly ($p < 0.05$) as OFSP flour increased with the highest value of 700 $\mu\text{g}/100\text{ g RE DM}$ in WPCB3 and smallest value of 170 $\mu\text{g}/100\text{g RE DM}$ in WWB. The mean intensity values of all sensory attributes between samples differed significantly as a wheat flour substitution increased except for taste and aroma between WWB and WPCB 1 which had statistically ($p > 0.05$) similar mean intensity scores in taste, aroma, and texture acceptability as WWB. Similarly, consumers showed statistically similar scores in acceptability between WWB and WPCB 1. The Preference mapping results showed colour and taste were the main drivers for consumer preference. In conclusion, the study shows that the use of OFSP flour up to 10% of the flour into wheat flour produced nutrient enhance buns with similar and acceptable taste, texture, mouth feel and aroma comparable to 100% wheat buns.

Keywords: Chemical composition, sensory evaluation, preference mapping, Orange fleshed sweet potatoes, wheat

Introduction

Sweet potatoes (*Ipomoea batatas*) are the fifth most important food crop on fresh weight basis in developing countries, after rice, family Convolvulaceae is They rank as the wheat, maize and sorghum (Nungo *et al.*, 2007;

worlds' seventh most important food crop and the fifth most important food crop on fresh weight basis in developing countries, after rice, wheat, maize and sorghum (Nungo *et al.*, 2007;

FAO, 2004). In Tanzania, sweet potato is the third most important root and tuber crop after cassava and Irish potatoes (Alliance for a Green Revolution in Africa (AGRA, 2014). It is a food and nutritional security crop, grown almost in all agro-ecological zones because of its hardy nature and broad adaptability, hence providing a sustainable food supply when other crops fail (Ndunguru and Rajabu, 2000). Other positive attributes include high yield with limited inputs, short duration, high nutritional value and tolerance to various production stresses (Mitra, 2012). However, the predominant sweet potato cultivars are white-fleshed varieties that contain negligible amounts of beta-carotene, a vitamin A precursor (Kapinga *et al.*, 2010). In recent years, an orange-fleshed sweet potato (OFSP) naturally rich in vitamin A in the form of β -carotene, starch, sugars and minerals has emerged as an important strategy to improve vitamin A status in many parts of the world especially in developing countries (Mitra, 2012). Use of orange-flesh sweet potato (OFSP) to prevent vitamin A malnutrition has been used in a few feeding trials in some countries in Africa and Asia. A study conducted to serve 125 g per day for 53 school days to 5–10 years old children in Durban, South Africa showed significant improvement of vitamin (van Jaarsveld *et al.*, 2005).

Vitamin A is an essential for immune system functions and the survival, growth and development of children. Its deficiency remains a public health concern affecting about one-third of children aged 6 to 59 months (in 2013), with the highest rates in sub-Saharan Africa (48 per cent) and South Asia and South East Asia (44 per cent) (WHO, 2013). It was further reported that, 190 million pre-school children are vitamin A deficient, and an estimated 250, 000 to 500, 000 vitamin A-deficient children become blind every year, half of them dying within 12 months of losing their sight. In Tanzania, the prevalence of VAD is estimated to be 33 % for children of age 5-59 months and 36 % for women (Tanzania demographic and Health Survey (TDHS), 2010). These proportions are higher than the WHO cut-off levels for public health significance (> 20 %). Therefore, increased consumption of vitamin

A rich OFSP by low-income households with limited access to expensive animal and plant vitamin A rich foods such as oil, fish, eggs and milk would be one of affordable approaches to meet their daily requirements of vitamin A and some other essential nutrients. Incorporation of OFSP flour to other foods appears to be the most effective way for increasing the VA content of OFSP enriched products (Kidane *et al.*, 2013).

Wheat is rich in gluten protein and is an essential ingredient in confectionery and baked products (Scherf, 2016; Kumar, 2011). It is the fourth most important staple in the diet of Tanzanians (Maro, and Barreiro-Hurlé, 2012). However, wheat is poor in vitamin A and its production is limited in tropical countries, thus it needs to be imported in order to meet the local demands. According to Bekele (2012), wheat production in East African countries is about 25 per cent of the regional potential, leading to imports of 1.6 million tons of grain every year costing 1.4 billion USD. In Tanzania, wheat production is not a priority crop for the agriculture sector development, however it accounts for close to 30 percent of total agricultural imports with an average import bill of over 150 million USD per year (Maro, and Barreiro-Hurlé, 2012). Hence, considerable efforts to promote the use of composite flours seem to be some of the ways to reduce the burden of wheat importation (Bekele, 2012; Mepba, 2007). Composite flour technology allows flour from locally grown crops such as cassava, yams and sweet potatoes replaces a portion of wheat flour for use in baked products. Therefore, incorporation of OFSP flour into wheat flour for confectionery and baked products could serve dual purposes of reducing wheat importation costs as well as producing nutrient dense baked products especially vitamin A content. Various researchers have worked on wheat-non wheat composite flours in baked and confectionery products. Ade-Omowaye *et al.* (2008), evaluated tigernut/wheat composite flour and bread, Ammar *et al.* (2009) studied taro/wheat composite bread, Mepba *et al.* (2007) studied wheat/plantain breads, Kidane *et al.* (2013) studied wheat/OFSP bread and Bibiana *et al.* (2014) studied wheat/maize/OFSP bread. However, information on

physical characteristics, chemical composition, descriptive sensory properties and preference mapping of wheat-OFSP composite Swahili buns (*Mandazi*) mostly consumed in coastal Swahili areas of Kenya and Tanzania is limited. This study therefore aimed at develops and determine quality parameters in orange-fleshed sweet potato-wheat composite buns (*Mandazi*) at different levels of wheat flour substitutions.

Materials and methods

Study location

The study was carried out at the Department of Food Technology, Nutrition and Consumer Sciences laboratory, Sokoine University of Agriculture (SUA), Morogoro. OFSP drying and flour production were conducted at the Danida project plant while chemical composition and sensory analyses were done at the Food Science laboratory, SUA.

Materials

OFSP samples were collected randomly from the farms at the Danida site and stored in a cool place in the plant prior to drying and flour preparation. A 100% hard winter wheat flour, yeast (instant dry yeast), fat, baking powder, sugar were purchased from local shops in Morogoro. Analytical grade reagents and chemicals were obtained from Food Science and Technology laboratory.

Research design

Completely randomized design (CRD) was used in the study. The principal factor was the buns type at different substitution levels of OFSP-Wheat flour (0, 10, 20, and 30%). The model is presented in equation 1.

$$Y_{ij} = \mu + t_i + e_{ij} \dots\dots\dots(1)$$

Whereby, Y_{ij} is observation for the i th treatment appearing in j th row and k th column, μ is an overall mean effect, t_j is a the effect of i th treatment appearing in j th row and k th column and e_{ij} is the error term.

Preparation of orange-fleshed sweet potato flour

OFSP flour was prepared according to a method

by Hagenimana and Owori (2000) with slight modification (Figure 1). Sound OFSP tubers were selected, washed thoroughly with tap water to remove physical dirty and soils, peeled using a stainless steel knife, re-washed and cut into four quarters. The quarters were grated using electrical grater and small pieces were subjected to solar tunnel dryer (Hoenheim, Innotech, Germany) until they attain constant weight and predetermined moisture content was obtained. The dried pieces were milled into flour using a milling machine and the flour was packed into a polyethylene bags and stored at 50C prior to composite flour preparation.

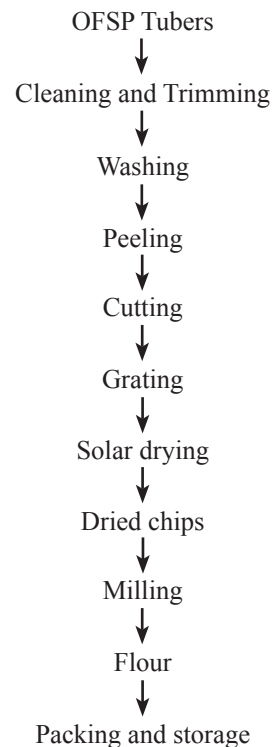


Figure 1: OFSP flour processing flow chart as modified from Hagenimana and Owori (2000)

Preparation of wheat-OFSP composite flour

The wheat-OFSP composite flour was processed by blending wheat and orange sweet potato flour at predetermined proportions. The 10, 20 and 30 parts by weight of OFSP flours mixed with 90, 80 and 70 part by weight of wheat flour to obtain 10, 20 and 30% of OFSP/wheat composite flours

respectively. Whole wheat containing 100% wheat flour was used as a control. The processed flour was packed in a polythene bag and stored at 50C prior to buns preparation.

Buns (*maandazi*) making

The whole-wheat (WWB) and Wheat potato composite buns (WPCBs) were made by mixing the flours with weighed ingredients as indicated in Table 1 followed by stirring using Henglan mixers for 5-0 minutes to obtain dough. The dough was allowed to ferment in a bowl for 60 minutes at room temperature, punched and cut into equal pieces using a glass top round. The dough pieces were fried in oil for 3-5 minutes until colour change from white to brown. The fried buns were removed from the frying pan, cooled at room temperature and packed in a plastic bag prior to analyses.

Determination of buns characteristics

repeated three times and the average value of seed weight was recorded (C g). Weighed buns were placed in the box and weighed seeds (1200 g) were used to fill the box and leveled off as before. The overspill was weighed and from the weight obtained, used to calculate the weight of seeds around the loaf and volume of seed displaced by the loaf were using the Equations 1 and 2 as described by AACC method 10-05.01 (2000). The overspill was weighed, and from the weight used to calculate the weight of seeds around the buns and the volume of seeds displaced by the buns using the following equations by AACC method 10-05.01 (2000).

Seeds displaced by buns (L) = C g + overspill weight – 1200g.....(Eq 2)

$$\text{Volume of bun}(V) = \frac{L \times 1383.31 \text{ cm}^3}{c} \dots(\text{Eq 3})$$

Table 1. Composition of wheat-orange sweet potato products

Ingredients	Product			
	WWB	WPCB 1	WPCB 2	WPCB 3
Wheat Flour % (g)	100 (91.5)	10 (9.15)	20 (18.3)	30 (27.45)
OFSP Flour % (g)	0 (0)	90 (82.35)	80 (73.2)	70 (64.5)
Baking Powder (g)	2	20	20	20
Fat (g)	2.5	2	2	2
Sugar (g)	2.5	2.5	2.5	2.5
Salt (g)	2.5	2.5	2.5	2.5
Total	100	100	100	100

Buns physical characteristics were determined by measuring weight, volume and specific volume. Weight was measured 30 minutes after frying using a digital weighing balance whereas volume was measured using the rapeseed displacement method as modified by Giami and Ekiyor (2004). A box of fixed dimensions (12.00 x 12.530 x 9.2 cm) of internal volume 1383.31 cm³ was put in a tray half filled with pearled rice and shaken vigorously 5 times, then filled till slightly overfilled so that overspill fell into the tray. The box was agitated twice again, and then a straight edge was used to press across the top of the box once to give a level surface. The seeds were emptied out from the box into a receptacle and weighed. The procedure was

The specific bun volume was determined by dividing the loaf volume by its corresponding loaf weight as described by Araki *et al.* (2009).

Chemical analysis

Proximate analysis

Proximate composition of the whole wheat and composite buns samples were determined using AOAC (1995) methods. Moisture content (MC) was determined by oven drying method at 105°C for 24 hours. Crude protein (CP) was determined by Kjeldahl method and the percentage nitrogen obtained was used to calculate the CP using the relationship: CP = % N X 6.25. Ether extract (EE) was determined using Soxhlet system HT-extraction technique while ash content was

determined by incinerating the samples in a muffle furnace at 550°C for four hours. The ash was cooled in a desiccator and weighed. Crude fibre was determined by dilute acid and alkali hydrolysis and carbohydrate was calculated by difference.

Vitamin A determination

Vitamin A determination was performed using the method described by Rodriguez-Amaya and Kimura, (2004). One gram of a ground dried sample was homogenized before extracted 4 times using 50 ml proportions of cold acetone. The prepared four portions of extracts were transferred to separating funnel containing petroleum ether at 40-600C Bp, followed by a thorough washing with about 300 ml of distilled water until the extracts were acetone free. During the washing process, distilled water was added by the wall of the glass-separating funnel to avoid formation of emulsions (water stones) in the carotenoid extracts. The washed samples were then passed through an anhydrous sodium sulphate to make it free from any trace of water. The dried carotene extracts were collected into a clean and dry volumetric flask. The extract was read under UV-Visible Spectrophotometer at 450 nm to obtain its optical density (OD) which enabled to estimate the vitamin A in the sample using the following formula;

$$VitaminA(\mu g) = \frac{(A - blank\ absorbance \times Vol.\ of\ extract\ (mls) \times 10000)}{E \times sample\ weight(g)}$$

Whereby A is sample absorbance at 450 nm and E is the absorbance coefficient of vitamin A in petroleum spirit (2592).

Sensory evaluation

Descriptive analysis

A descriptive sensory profiling was conducted by a trained sensory panel of 10 assessors, comprising of four males and six females with age ranging from 22 to 26 years according to the method described by Lawless and Heyman (2010). The assessors were selected and trained according to ISO Standard (1993). In a pre-testing session, the assessors were trained in developing sensory descriptors and the definition of the sensory attributes.

They developed a test vocabulary describing differences between samples and agreed upon to six descriptors for Brown crust colour, white crumb colour, bun aroma, sweetness, softness, and mouth feel (Table 2). An unstructured 9 point line scale was used for rating the intensity of an attribute with the left side corresponded to the lowest intensity of each attribute (value 1) and the right side corresponded to the highest intensity (value 9). The actual analyses of the four samples were carried out in two sessions and each assessor was evaluating two samples per session. Samples coded with 3-digit random numbers served to each panelist in a randomized order with water alongside for rinsing mouth before evaluating other samples during the test. The average responses were used for statistical analyses.

Table 2: Definitions of sensory attributes used in descriptive sensory analysis.

Attribute	Definition
Crust hue	Dark brown-Yellowish brown
Crumb hue	Dark brown-Yellowish brown
Colour intensity	Clear, strong colour
Wheat bun aroma	Aromatics associated with wheat buns
Bun taste	The taste associated with buns
Oiliness	Perception of oil measured by tactile means
Crumb Softness	The quality of being easy to mold, cut, compress, or fold.
Chewiness	Length of time (in sec) required to masticate the sample, at a constant rate of force application, to reduce it to a consistency suitable for swallowing

Source: Trained panelists in the study

Consumer test

The test was carried out in the Department of Food Technology, Nutrition and Consumer Sciences Laboratory by 68 untrained consumers aged 21 and above years using a 9 point hedonic

scale (where 1 = dislike extremely and 9 =like extremely) as described by Lawless and Heyman (2010). Samples were sliced into pieces of uniform thickness (2 cm), coded with 3-digit random number and served to the panelists in a randomized order at around 10.30 a.m. with distilled water for rinsing mouth between tests. Consumers were instructed to assess the samples and indicate their degree of liking or disliking by putting a number as provided in the hedonic scale. Each consumer evaluated four samples in a single session under the same conditions as for the sensory descriptive test.

Statistical data analysis

The data were analysed by using the R statistical package (R Development Core Team, Version 3.0.0, Vienna, Austria) for one-way and two way analysis of variances to determine the significant differences between factors. Means were separated by Turkey's Honest Significant Difference at $p < 0.05$. Principal component analysis (PCA) (Wold, 1987) and partial least squares regression (PLSR) (Martens and Naes, 1989). were performed for multivariate data analysis using the Panel Check and Consumer Check statistical packages (Tomic *et al.*, 2010). The main sources of systematic variation in the average sensory descriptive results were determined by using Principal Component Analysis (PCA) while the external preference mapping showing relationship between descriptive data and hedonic liking from the consumers were determined by PLSR. The variables were standardized and full cross-validation was applied. Correlation loading plots were applied with circles indicating 50 and 100% explained variance, respectively. In the correlation loadings plots products were included as dummy variables to improve the visual interpretation as described by Martens and Martens (2001).

Results and discussion

Products physical characteristics

The physical characteristics of the buns samples are presented in Figure 2 (a-c). The volume (cm^3), and specific volume (cm^3/g) of the buns decreased significantly ($p < 0.05$) while weight increased significantly ($p < 0.05$) with increasing

wheat flour substitution. WPCB 3 had the highest weight of 115 g compared to lowest value of 105, in WWB (Figure 2a). Both the

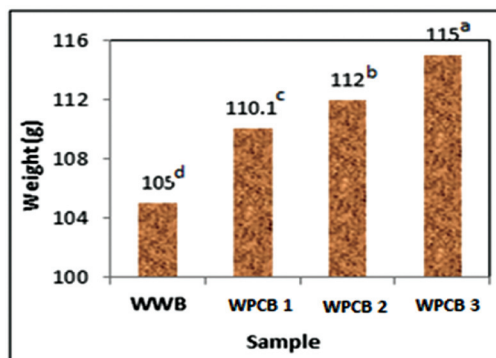


Figure 2a

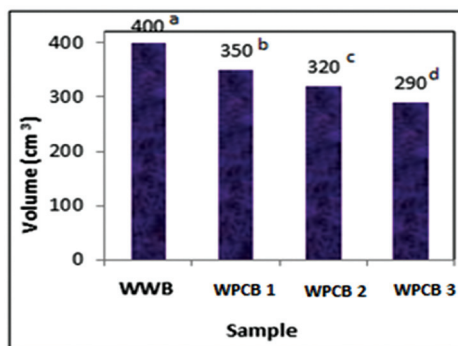


Figure 2b

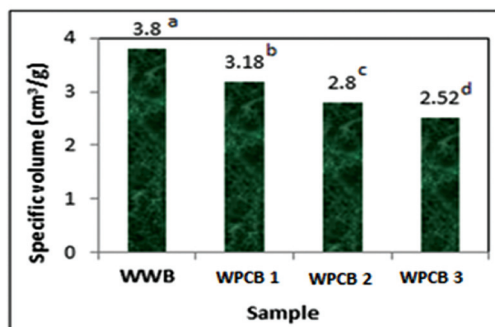


Figure 2c

Figure 2a-c: Physical characteristics of Whole wheat bun and wheat potatoes composite bun (WPCBs) samples. Values in the bars with different letters are significantly different at $p < 0.05$. WWB, WPCB 1, WPCB 2 and WPCB 3 are whole wheat buns, wheat-orange flashed sweet potato buns with 0%, 10%, 20% and 30% OFSP flour, respectively.

highest loaf volume and specific loaf volume of 400 and 3.8 cm³ were respectively observed in WWB (Figure 2 b and c).

The findings of this study have shown that, substituting wheat with OFSP from 10-30 % have significant effect on the physical characteristics of the baked products. The decrease in bun volume at increased wheat flour substitution could be attributed to the dilution of gluten, which is responsible for the elasticity of the dough and trapping of carbon dioxide generated by yeast during fermentation (Rossell *et al.*, 2001). Mixing of non-wheat and wheat flours reduced the extensibility of the dough and carbon dioxide gas retention during dough proofing and thus rendering gas cells in the dough not able to expand resulting in lower bun volume (Ngozi, 2014). Volume is an important

bakery industries. Similar findings were also reported in other wheat-non-wheat flour baked products (Mongi *et al.*, 2011; Mepba *et al.*, 2007).

Proximate composition

There were progressive significant (p<0.05) increments in moisture, ash, and fibre contents with progressive increase in wheat flour substitution levels (Table 3). Respective higher values of 21.25±0.07, 3.0±0.03 and 1.34±0.01 g/100g DM were observed in WPCB 3 compared to other samples. Conversely, fat, protein and carbohydrate contents decreased significantly (p<0.05) with progressive increase in wheat flour substitutions where higher values of 2.12±0.01, 9.48±0.08, and 71.58±0.04 g/100 g respectively were obtained in WWB.

Table 3: Proximate composition of whole wheat and wheat-OFSP composite buns (g/ 100 g DM)

Sample	Moisture	Ash	Crude fat	Crude fibre	Crude protein	CHO
WWB	14.07±0.01a	2.30±0.01a	2.12±0.01a	0.49±0.01a	9.48±0.08a	71.58±0.04a
WOCB 1	17.25±0.07b	2.37±0.02a	1.79±0.01b	0.81±0.1b	9.45±0.23a	68.33±0.25b
WPCB 2	19.30±0.14c	2.69±0.01b	1.42±0.02c	1.00±0.01c	8.75±0.0b	66.83±0.12c
WPCB 3	21.25±0.07d	3.00±0.03c	0.95±0.02d	1.34±0.01d	8.36±0.03b	65.07±1.11d

Values are expressed as mean±SD (n=3). Mean values with different superscript letters along the column are significantly different at p<0.05. WWB, WPCB 1, WPCB 2 and WPCB 3 are whole wheat buns, wheat orange flashed sweet potato composite buns with 0%, 10%, 20% and 30% OFSP flour, respectively.

indicator for identifying bun characteristics because it provided quantitative measurement of frying performance (Tronsmo *et al.*, 2003). The significant reduction in specific bun volume with increased wheat flour substitution could be directly associated with the lower volume of the bun samples. On the other hand, the observed increase in buns weight with increasing amount of OFSP flour could be associated to less retention of carbon dioxide gas in the mixed flour, hence yielding products with higher water absorption and compact texture (Gomez *et al.*, 2003). This shows that a certain required level of gluten in wheat flour is required for the production of yeast-leavened bread and due to the fact that non-wheat flours have little gluten contents, they could not be used exclusively for

The higher moisture content in composite buns than in whole-wheat buns could be linked to the high interaction between their fibre contents and water as described by Gomez *et al.* (2003). The high total fibre content in the non-wheat flour interact relatively well with a large amount of water through the hydroxyl group existing in the fibre structure. Similarly, Mansour *et al.* (1999) found that, addition of pumpkin and canola proteins to wheat flour resulted in an increase in water absorption. Nevertheless, the trend is different from findings reported by Eddy *et al.* (2007). The low protein content of the composite buns might be due to the low protein content in OFSP flour compared to wheat flour. A similar decrease in protein with an increase in wheat flour substitution was also reported by

Okorie *et al.* (2002) who found protein values ranging from 11.6 to 7.6 g/100 g for wheat, potato and cocoyam composite breads. The protein level of the WWB in the present study is higher than wheat buns (6.80%) reported in the Ethiopian food composition (1997). The differences in wheat varieties and methods of preparation could be ascribed to the observed variation. Moreover, the significant reduction in fat content with an increase in levels of OFSP flour may be associated with lower protein content and oil holding capacity of non-wheat flour. Shad *et al.* (2013) reported that, the proteins in the flour, which physically bind to fat by capillary attraction, exhibit high oil holding capacity. They expose more non-polar amino acids to the fat and enhance hydrophobicity as results a flours absorb oil (Shad *et al.*, 2013). This finding is in agreement with other reported findings (See *et al.*, 2008; Lyimo, 2007).

The significant increase in crude fibre with increased levels of OFSP could be due to more

OFSP flour in the buns making could enhance the mineral intake. Ash is an indicative of the amount of minerals contained in any food sample (Olaoye *et al.*, 2007). This finding is in agreement with study by Okorie *et al.* (2002) who observed similar higher ash contents ranging from 1.2 to 2.9% for composite breads made from wheat, potato and cocoyam. The reduction in carbohydrate content might be due to increase in moisture, ash, crude fibre contents in the formulation. Similarly, Greene and Howell-Benjamin (2004), observed mean carbohydrate values reduced from 70.08 to 54.13 g/100 g with an increase in the proportion of OFSP flour.

Vitamin A

The total vitamin A results are presented in Figure 3. There was significant ($p < 0.05$) increase in vitamin A with an increase in OFSP flour. The lowest value of 170 $\mu\text{g}/100\text{ g RE}$ was observed in WWB while the highest value of 700 $\mu\text{g}/100\text{ g RE}$ was obtained in WPCB 3.

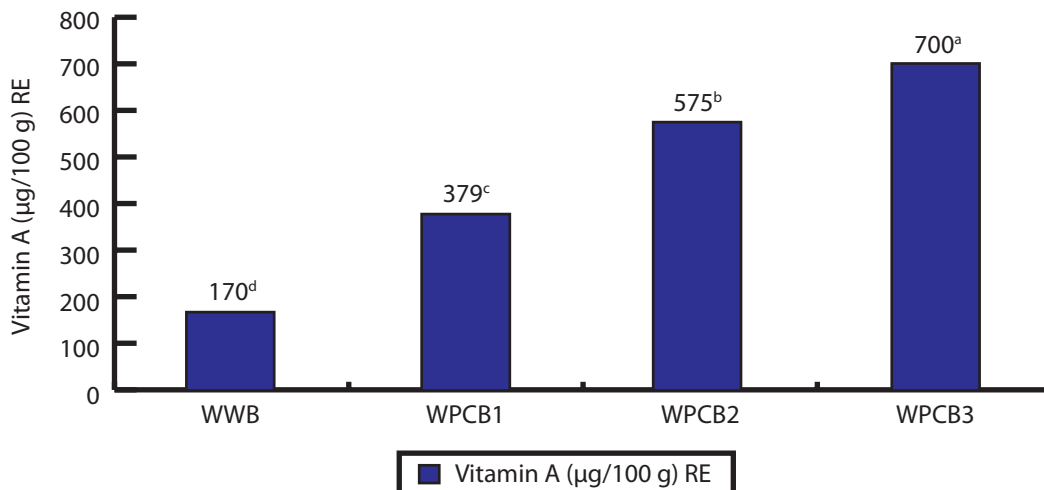


Figure 3: Vitamin A content of WWB and PCBs ($\mu\text{g}/100\text{ g RE}$)

Values are expressed as mean \pm SD ($n=3$). Mean values with different superscript letters are significantly different at $p < 0.05$. WWB, WPCB 1, WPCB 2 and WPCB 3 are whole-wheat buns, orange flashed sweet potato-wheat composite buns with 0%, 10%, 20% and 30% OFSP flour, respectively.

fibre content in OFSP flour than in wheat as reported by Assefa *et al.* (2007) and Singh *et al.* (2008). This was also found to be true for the ash content, implying that incorporation of

The higher vitamin A content in composite samples compared to whole wheat bread indicated that OFSP is rich in beta carotenoids while wheat is poor source. (Kidane, 2013;

Pareyt and Delcour, 2008). This suggests that, wheat and OFSP may be blended for production of vitamin A enriched confectionery and baked products (Burri, 2011). A similar increase in vitamin A content of wheat-OFSP composite products was also reported by Van-Hal (2000). The findings showed that, consumption of 100 g of WPCB 1 (vitamin A of 355 µg/100 g RE)

among the composite samples. With exception of chewiness, the intensity of all descriptive sensory attributes decreased significantly with progressive increase in OFSP flour where the WWB samples had significantly ($p < 0.05$) higher values while WPCB 3 samples had lowest values.

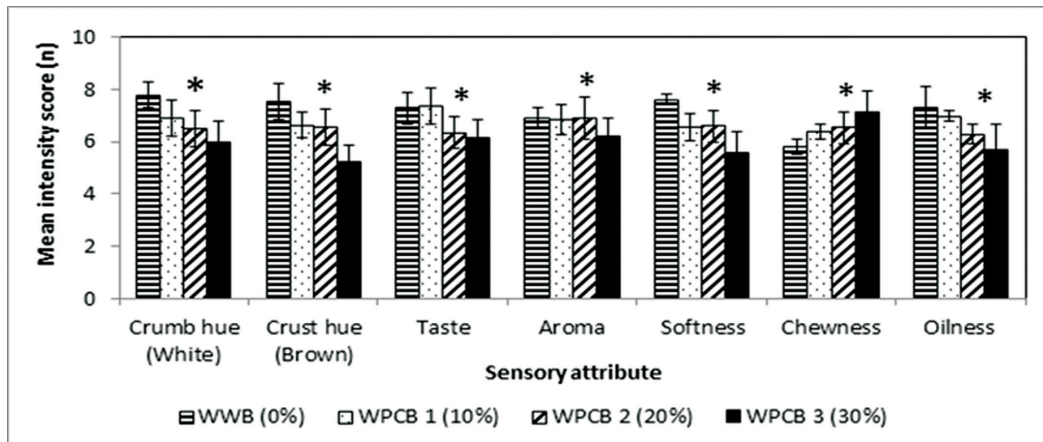


Figure 4: Mean intensity scores of buns samples

Values are expressed as mean±SD (n=3). Asterisk within bars of each sensory attributes indicates significant at $p < 0.05$. WWB, WPCB 1, WPCB 2 and WPCB 3 are whole wheat buns, wheat-orange flashed sweet potato buns with 0%, 10%, 20% and 30% OFSP flour, respectively.

would meet 71 % of the Recommended Dietary Allowance for children aged 4 to 8 years (500 µg/day), 39% for males aged 14 years and above (900 µg/day) and 50.7% for female aged 14 years and above (700 µg/day). Moreover, it could meet 46.1 and 27.3% of RDA in pregnant women and lactating mother of 770 and 1300 µg/day respectively (USDA, 2009). However, Kosambo (2004) found that, 30% of the recommended intake of provitamin A for children from 100 g of Jonathan sweet potato variety flour enriched porridge. The observed variation might be due to difference in type of product, variety and processing methods used in the formulation.

Sensory quality

Descriptive analysis

The results for mean intensity ratings of descriptive attributes of samples are presented in Figure 4. The results showed significant ($p < 0.05$) differences in intensity scores between WWB and composite samples and

Consumer test

The mean hedonic scores of consumers for WWB and WFSPs samples are presented in Figure 5. There was significant ($p < 0.05$) difference in consumer liking between the samples with WWB and WPCB 1 having higher scores of 7.6 and 7.3 respectively than the other WPCB samples. This finding suggests that, consumer liking decreased with increase in wheat flour substitution levels.

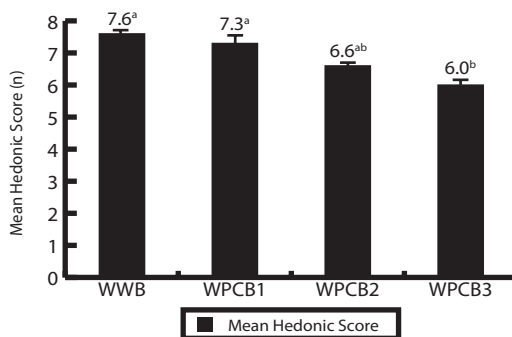


Figure 5: Mean hedonic scores for buns by consumers

Values are expressed as mean \pm SD ($n=68$). Values in bars with different superscript letters are significantly different at $p<0.05$. WWB, WPCB 1, WPCB 2 and WPCB 3 are orange flashed sweet potato-wheat composite bread with 0%, 10%, 20% and 30% OFSP flour, respectively.

The significant variations in sensory attributes between WWB and WPCBs show that incorporation of OFSP in wheat flour has an effect on the bun products. Colour change may primarily be contributed by the orange colour of the potatoes, which differed in intensity according to the amount used. In addition, the dark brown colour of the crust may be associated with the extent of the maillard reaction between reducing sugars and amino acids protein (Phisut and Jiraporn, 2013). Nevertheless, mild surface browning in the baking industry is desirable to give the products an appealing taste and moisture content retention in baked products to prolong their freshness (Briscoe and Gaine, 2014). The observed significant lower softness and higher chewiness intensities in composite buns may be connected to the addition of fibrous non-wheat flour to the wheat that resulted in their less retention of carbon dioxide gas, increased water absorption and harder texture (Gomez *et al.*, 2003) than whole-wheat buns. This contributed to low score in composite products by both descriptive panel members and consumers. Increase oiliness intensity in WWB

may be ascribed to its high oil holding capacity due high protein contents which expose more non-polar amino acids to the fat and enhance hydrophobicity as results a flour absorb oil (Shad *et al.*, 2013). However, nevertheless, the observed less and insignificant variations between WWB and WPCB 1 suggest that, incorporation of OFSP to wheat up to 10 % may produce more nutrient dense buns, with similar sensory properties that will be acceptable by consumers as whole wheat buns.

Relationship between descriptive data and hedonic liking by PLSR

Principal component of descriptive sensory data Figure 6 shows a bi-plot with the first two significant principal components of principal component analysis (PCA) on average sensory attributes. The results show a principal component (PC) 1 accounted for 92.8% of the systematic variation in the data while principal component (PC) 2 accounted for 5.0%. WWB and composite buns were well separated. WWB and WPCB 1 samples correlated positively with each other and with all descriptive attributes in PC1. However, they were negatively correlated in PC 2. The results indicated the variation between samples in PC 1 was between chewiness and all remaining attributes while in PC 2 variations were between taste, oiliness and chewiness on one side and aroma, crust hue and softness on the other side. Moreover,

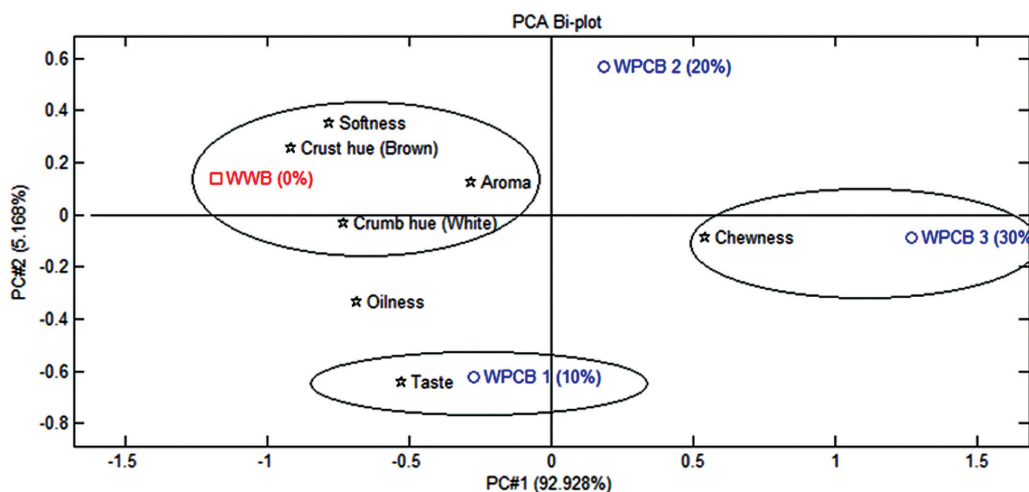


Figure 6: Bi-plot from PCA of significant descriptive sensory data for WWB and Composite bun samples. WWB, WPCB 1, WPCB 2 and WPCB 3 are whole wheat orange flashed sweet potato composite buns with 0%, 10%, 20% and 30% OFSP flour, respectively.

between WWB and composite samples and among the composite samples. WWB samples had higher values in all attributes except for chewiness, which observed to be highest in WPCB 3. Consumers showed highest liking for WWB followed by WPCB1 while WPCB 3 and WPCB4 scored lowest consumer liking. The observed less and insignificant variations between WWB and WPCB 1 suggest that, incorporation of OFSP to wheat up to 10 % may produce more nutrient dense buns, with similar sensory properties as whole-wheat buns and acceptable to the consumers. The colour, softness and taste attributes were the major drivers for consumers liking for WWB samples while taste and aroma attributes were the major drivers for consumers liking for WPCB 1 sample. Observed low liking of WPCB 2 and WPCB 3 by consumers could probably be due to their unappealing sensory properties they possess probably due to increased levels of Wheat flour substitution in the flour. It is, therefore, recommended that, development and consumption of wheat-OFSP buns be advocated as one of the ways to find vitamin A deficiency through food based approach.

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