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SENSORY CHARACTERIZATION, CONSUMER ACCEPTABILITY AND PHYSICAL PROPERTIES OF COMPOSITE WHEAT BREAD SUBSTITUTED WITH ORANGE-FLESHED SWEET POTATO FLOUR AND PUREE

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Abstract
Orange-fleshed sweet potato (OFSP), a pro-vitamin A-rich crop, has become an important ingredient in baked products. Incorporation of OFSP, either as flour or puree, has implications for sensory characteristics, and quality control of wheat flour-based bread. This study described the sensory characteristics and magnitude of difference among bread made with 100% wheat flour, incorporated with OFSP flour, and puree. OFSP flour and puree were substituted in wheat flour-based bread at 0-30% levels. Bread samples were characterized using descriptive sensory attributes, physical properties and consumer acceptability. Bread from 100% wheat flour had lower scores for crumb yellowness, crumb cell largeness, sweet aftertaste, grittiness and denseness. Bread with OFSP flour had higher crumb yellowness, crumb cell largeness, sweet aftertaste, grittiness, denseness, loaf weight (193.74-198.50 g) and crumb moisture (27.81-27.91%). Bread with OFSP puree were characterized by higher crust brownness, crumb cell uniformity, freshly baked bread aroma, crumb softness, higher loaf volume (872-885 cm^3), specific volume (4.59-4.76 g/cm^3), oven spring (0.50-1.00 cm), softness (18.35-20.20 mm), crust moisture (18.05-18.17%) and consumer acceptability (7.14-7.50). Overall consumer acceptability scores were higher for bread substituted with OFSP puree than bread substituted with OFSP flour. Bread substituted with 10% OFSP puree had the highest acceptability (7.50). Some descriptive terms generated in this study may be employed as sensory quality control indices for OFSP-substituted bread due to the significant correlations that exist amongst these parameters and consumer acceptability.

Keywords: *Orange-fleshed sweet potato, bread, quantitative descriptive analysis, consumer acceptability, sensory quality*

Introduction

Sensory analysis in product development and quality control have continued to attract attention over the years (Carpenter et al., 2000; Etaio et al, 2010; Ojeda et al., 2015; Gonzalez-Casado et al., 2019). Sensory analysis is used to characterize and measure sensory attributes of products, establish difference among similar products, or to establish whether product differences are noticeable and are acceptable or unacceptable to the consumer. The applications of sensory analysis in product development and quality control include product matching, product mapping, product reformulation, and product acceptability, among others (Carpenter et al., 2000). Descriptive sensory analysis is a powerful tool that has been used to predict product quality and consumer acceptance of newly developed food products or those containing new ingredients (Dansby and Bovell-Benjamin 2003; Greene and Bovell-Benjamin 2004; Varela and Ares 2012;Olatunde et al. 2016a; Lynch *et al*. 2017; Yang and Lee, 2019).

Orange-fleshed sweet potato (OFSP), a bio-fortified crop, rich in beta-carotene, is being promoted in Africa, for consumption as a food-based intervention to tackle the problem of vitamin A deficiency (van Jaarsveld *et al*., 2005; Burri, 2011; Berni et al., 2015; Islam et al., 2016; Laurie and Classen, 2017; Neela& Fanta, 2019). In addition to its nutritional value, OFSP has the potential to add colour and flavour to food products and hence improve the sensory appeal (van Hal, 2000; Truong *et al*., 2018). Flour and puree are intermediate products from the processing of OFSP and each of these forms has its advantages. For example, OFSP flour, a dry powdery product has a long shelf life due to its relatively low moisture content, and so may be available all year round (Olatunde et al., 2016b). OFSP puree is a mashed product from boiled or steamed OFSP roots and although it has a relatively higher moisture content than flour, there are indications that OFSP puree retains higher β-carotene than the flour (Chilungo *et al.*, 2019), and add an appealing colour and flavour to food products. The potentials of OFSP flour and puree could lead to increased consumption of OFSP and thus β-carotene, thereby improving the vitamin A status of consumers.

Within the last decade, there has been efforts at partial substitution of wheat flour with orange-fleshed sweetpotato (OFSP), either as flour or puree, in baked products (Selvakumaran et al., 2017, Mu et al., 2019), particularly bread (Trejo-Gonzalez et al., 2014;Awuni et al., 2017; Edun et al., 2019; Wanjuu *et al.*, 2018); therefore, OFSP flour and puree has become important ingredients. Bread is one of the most widely acceptable food products in the world, hence bread incorporated with OFSP is being considered as a vehicle for increased intake of vitamin A (Low and van Jaarsveld, 2008; Awuni et al., 2017; Nzamwita *et al.*, 2017).

Several reports are available on physicochemical properties and carotenoid content of wheat flour-OFSP composite bread. Edun *at al.* (2019) investigated some quality attributes of flour, dough and bread from wheat flour substituted with OFSP (cv Mothers' Delight, Nigeria) flour at 0-30% levels; however, neither the sensory properties and consumer acceptability of the bread, nor the use of puree were reported. Trejo-Gonzalez et al. (2014) evaluated bread from composite wheat flour and 0-20% OFSP (cv Nylon, Mexico) flour; the number of panelists used by the authors for consumer acceptability test was lower than the standard minimum of 100 participants or at least 50 participants for in-house consumer studies (Watts et al., 1989). In addition, the 5-point hedonic scale used was a less sensitive compared to the 9-point scale (Lim, 2011). Furthermore, the authors did not report on the use of OFSP puree.Wanjuu et al. (2018) studied the physicochemical properties and shelf-life of OFSP puree composite bread (30-45% of wheat flour); however, sensory properties and consumer acceptability were not reported in this study. Awuni et al. (2017) studied wheat flour-OFSP puree composite bread as a significant source of dietary vitamin A and consumer-oriented preference and hedonic tests were conducted; however, product-oriented sensory characterization of the bread was not reported. Nzamwita et al. (2017) evaluated the stability of β-carotene during baking of OFSP flour (0-30%)-wheat composite bread and estimated the contribution to vitamin A requirement; however, the authors did not use OFSP puree and sensory properties of the bread were not reported.

As highlighted earlier, several reports are available on physicochemical properties of OFSP bread and its potential to contribute to vitamin A intake of consumers. However, information about the sensory attributes of this bread is limited. No report is available, that compared the descriptive sensory characteristics of bread made with OFSP puree to that made with OFSP flour, as well as the consumer acceptability of the two types of bread. Such information from a single study is particularly not available. For quality control purposes, it is important to describe the sensory characteristics and magnitude of difference among OFSP flour-, OFSP puree-, and 100% wheat bread. It is also important to document whether the differences are noticeable and acceptable to consumers. Hence, the objectives of this study were to describe and determine differences and magnitude of differences in sensory attributes of wheat bread substituted with or without OFSP flour or puree, as well as to compare some physical properties and consumer acceptability of the bread.

Materials and Methods

OFSP Roots

The Mother's Delight variety of OFSP roots (UMUSP03) were obtained from a farmer in Ijebu-jesha, Osun State associated with the Sweet potato for Health and Wealth in Nigeria Project. Wheat flour (Honeywell), fat (Topper), sugar (Dangote), dry yeast (STK Royal) and table salt (Dangote) were obtained from Kuto market in Abeokuta, Ogun State, Nigeria.

OFSP Flour

OFSP flour was produced according to the method described by Olatunde *et al.* (2016b).OFSP roots were sorted, graded and washed with water to remove dirt and soil. The roots were peeled, sliced(2-3 mm) and dried in a cabinet dryer (Genlab™DC500, Mainz, Germany) at 50 °C for 5 h. The dried chips were milled into flour, sieved (250 μm), packed in Ziploc ® bags and stored in the refrigerator (4 °C) tillfurther use.

OFSP puree

OFSP puree was produced as described by Low and van Jaarsveld (2008) with minor modifications (roots were peeled before boiling to reduce time required to soften and reduce loss of carotenoids). OFSP roots were sorted, graded, washed, peeled and boiled for 10 min to soften. Boiled roots were homogenized in a blender (BL335-Kenwood, Harvant, Hamphire, UK) for 5 min to form a puree and then cooled to 28±2 °C.

Baking Process

Wheat flour was substituted with OFSP flour and puree at graded levels of 0%, 10%, 20% and 30%.The straight dough process as described by Kamal et al. (2013) was used to prepare the bread. Wheat flour or wheat-OFSP flour/puree composites (100%), sugar (5%), shortening (6.5%), compressed yeast (3.5%), salt (1%)and water (60-65%) were used. The wheat flour and composite sampleswere mixed separately with other ingredients in a mixer (KMIX-Kenwood, Harvant, Hampshire, UK) for 3 min, water was added and mixed for 5-8 min until a soft dough was produced. The whole mass was kneaded mechanically and divided Into equal portions of 200 g. Each portion was kneaded, moulded into cylindrical shape and placed in the baking pan (14.5 x 9 x 7.5 cm). The dough was subjected to proofing at 40 °C/85% RH for 45-70 min. The proved dough was baked at 160 °C for 25-28 min using a gas oven (Dako NOVITA 5B-Korea). The baked bread samples were de-panned, cooled at ambient temperature (28±2 °C), packed in re-sealable Ziploc® bags and stored in the refrigerator (4 °C) for further analysis.

Descriptive Analysis

The procedure described by Stone (1992) reported in Greene and Bovell-Benjamin (2004) was followed for descriptive analysis.

Panel selection- Undergraduate students from the Department of Food Science & Technology, Federal University of Agriculture, Abeokuta, Nigeria served as sensory panelists. The ten-member panel consisted of 5 females and 5 males between the ages of 17 and 25 years. Panelists were selected based on good health, non-smoker, availability, non-allergic to wheat and/or sweet potato, bread consumer and willingness to participate.

Panel training- Judges were led by a panel leader and trained for three days during 2 h sessions. Panelists already possessed a general knowledge about sensory analysis. On the first day, panelists were taken through detailed theory and principles of descriptive analysis. This was followed by practice using bread from 100% wheat flour as samples. On the second day of training, seven bread samples (study samples) were presented in order to have an experience of all the possible attributes to be encountered. Descriptive terms were generated and defined through group discussions. Consensus terms were selected from the preliminary terms while redundant terms were discarded. The descriptive terms covered attributes of appearance, taste, aroma, colour and texture. On the third day, the study samples were presented again, along with the terms and definitions. The judges practised rating the intensity of the attributes as a group followed by independent practice in individual booths.

Sample evaluation- The seven study samples were presented at four and three samples per session. The samples were bread from (1) 100% wheat flour (WF) (2) 10% OFSP flour:90% WF (3) 20% OFSP flour:80% WF (4) 30% OFSP flour:70% WF (5) 10% OFSP puree:90% WF (6) 20% OFSP puree:80% WF (7) 30% OFSP puree:70% WF. Each sample was coded with 3-digit random numbers and served under controlled temperature (28±2 °C) and white fluorescent light. Testing was performed in a sensory laboratory with individual booths. The judges rated the intensity of samples for each attribute on a 15 cm line scale anchored with the terms 'not/none' at the low end and 'very' at the high end. Water was used for palate cleansing in between evaluations.

Consumer Acceptability

Consumer acceptance test was conducted using fifty in-house untrained panelists comprising undergraduate students of Federal University of Agriculture, Abeokuta, Nigeria. Panelists scored their degree of likeness on a 9-point Hedonic scale with 9 corresponding to “extremely like” and 1 corresponding to "extremely dislike". Bread samples were scored on attributes of crust and crumb colour, crumb texture, aroma, taste and overall acceptance.

Physical Properties of Bread

Oven spring was determined from the differences in the height of dough just before and after baking (Shittuet al. 2007). Loaf volume was measured after baking by the rapeseed displacement method as described by Shittuet al. (2007). Sorghum grains were used in place of rapeseeds. Sorghum was poured into a container of known volume until the bottom of the bowl was covered with the sorghum. The test bread was then placed inside the container, followed by more sorghum which was levelled across the top with a spatula. The displacement of the sorghum seeds that were not required to fill the container was measured in a graduated cylinder and used to express volume of the loaf.Bread weight was determined after sufficient cooling using a digital balance (KERN ABS 220-4N, Germany).

Specific volume of each loaf was calculated as:

$$\text{Specific volume (cm)}^3 = \frac{\text{Loaf volume}}{\text{loaf weight}}$$

Samples were measured in triplicate, and the average was recorded.Bread softness was determined by the method of Kotancilar *et al*. (2009) using a penetrometer. Two slices of 27 mm were taken from both sides of centre slice of the loaf and each sample was compressed at 6 points by 54.6 g conical probe for 5 sec. The measurement data for the 6 points from each slice were averaged and the compressibility value expressed as penetrometer unit (PU) (1 PU = 0.1 mm).

Statistical Data Analysis

Sensory data and physical properties were subjected to analysis of variance (ANOVA). Significant difference among samples was established at $p<0.05$. Duncan's Multiple Range test was performed to separate the means where significant difference exists. Pearson's correlation coefficient between consumer acceptability and sensory attributes were computed, significance was established at $p<0.05$. Statistical package, SPSS version 21.0 (SPSS Inc., Chicago, IL, USA) was employed.

Results and Discussion

Descriptive Sensory Profile of Bread from Wheat Flour Substituted with OFSP Flour or Puree

Nine descriptive terms were generated to describe the attributes of the bread samples (Table 1). Some of these terms were similar to those generated by Greene and Bovell-Benjamin (2004) for 'sweetpotato breads'. Spider plots of bread from wheat flour and wheat-OFSP composites (Figures 1a-1c) depict the sensory descriptive profile. The plots were created from mean values of intensity rating for each sensory attribute. According to Stone (1992), each spoke represents one attribute and the relative intensity of each attribute is indicated by its position relative to the centre of the spider web, with the lesser intensity towards the centre and the greatest intensity farther away from the centre. Crust brownness and crumb yellowness were the terms identified for colour attributes of the bread samples. Bread from 100% wheat flour(WF) (Figure 1a) had the highest score for crust brownness (12.50) while bread

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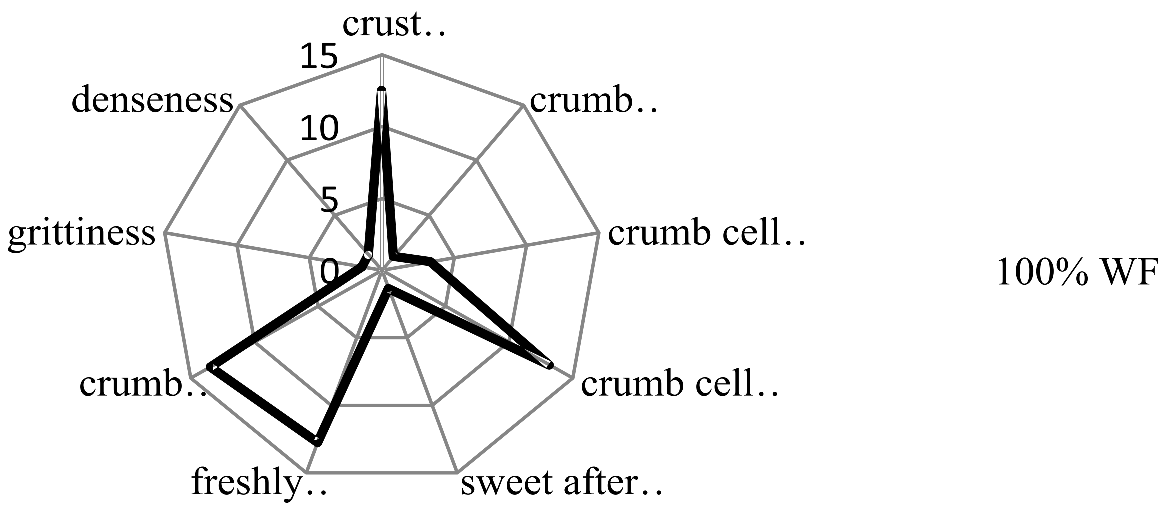
Table 1: Attributes and Definitions used in Sensory Descriptive Analysis of Bread from Wheat Flour Substituted with OFSP Flour and Puree

Terms	Definitions
Colour	
Crust brownness	Hue of brown colour from light to dark brown
Crumb yellowness	Typical white colour of bread through yellow to deep orange colour of OFSP root
Appearance	
Crumb cell largeness	Cell size of crumb resembling mesh of tiny diameter size
Crumb cell uniformity	Similar appearance and even distribution of crumb cells
Flavour	
Sweet aftertaste	Characteristic of baked sweetpotato aftertaste
Freshly baked aroma	Characteristic aroma of freshly baked bread
Texture	
Crumb softness	Ability of bread to separate slowly when pulled apart
Grittiness -	Presence of small coarse particles in the mouth after chewing
Denseness	Bread loaf has heavy, compact, thick inner structure

OFSP: Orange fleshed sweetpotato



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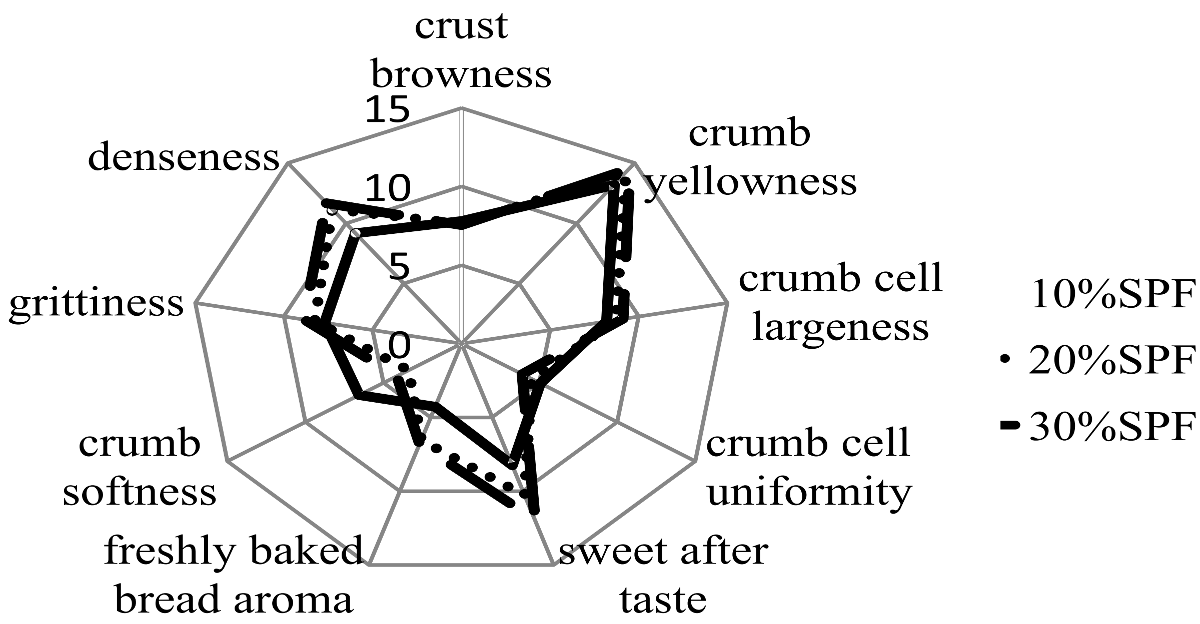

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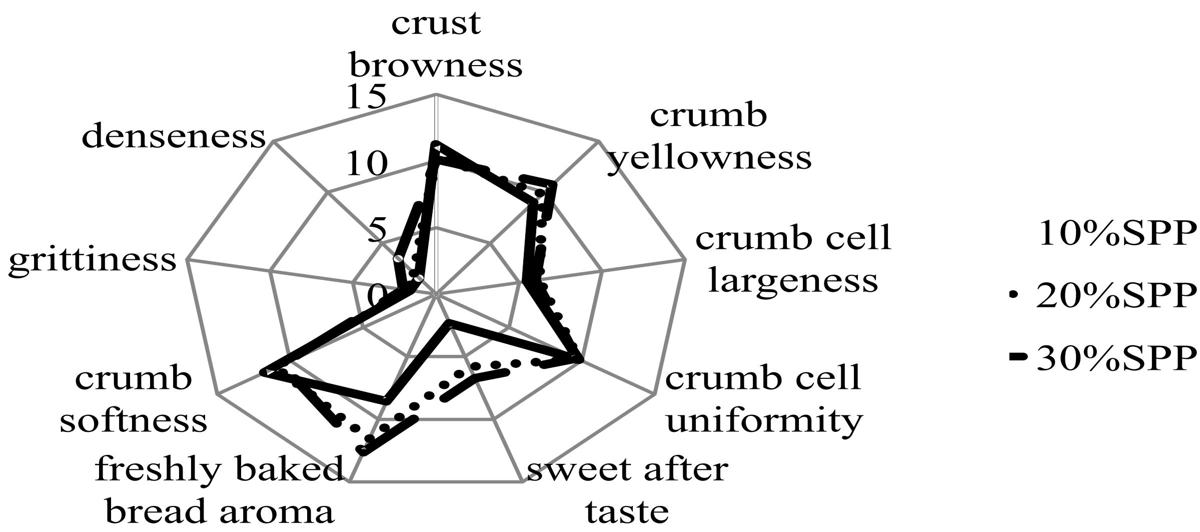

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Figure 1: Spider plots for descriptive sensory profile of bread from wheat flour substituted with OFSP flour or puree

1a- Bread from 100% wheat flour; 1b-Bread from wheat-OFSP flour composites; 1c-Bread from wheat-OFSP puree composites
OFSP: Orange-fleshed sweetpotato, SPF: OFSP flour, SPP: OFSP puree, WF: Wheat flour

The reduction in bread crust brownness as OFSP flour or puree is increased in the wheat flour may be due to the decrease in protein content as the wheat flour reduced, since sweet potato flour is low in protein content (1.44-7.78%) as compared to wheat flour (7.40-16.8%) (van Hal, 2000; Kuktaiteet al., 2004; Oluwalanaet al., 2012).

The inner portion of bread is the crumb and it has indirect and lower exposure to heat; hence it is usually white in colour for bread from 100% WF. Introduction of orange colour of OFSP into wheat flour imparted a range of hue (yellow to orange) into the bread samples. Crumb yellowness was significantly ($p<0.05$) different among bread samples. Crumb yellowness increased as the proportion of OFSPincreased in the bread; from

13.20 to 14.55 for flour and from 8.98 to 10.72 for puree. Bread from 100% WF had the lowest crumb yellowness (1.24) while 30% OFSP flour bread had the highest value (14.55). This agrees with Green and Bovell-Benjamin (2004) where yellow-orange intensity increased with increase in sweet potato flour in the composite bread. The crumb yellowness of bread substituted with OFSP may be an attraction to consumers thereby driving likeness and acceptance. Yellowness of bread crumb made from OFSP puree or flour is an indication of the presence of trans-β-carotene and a source of vitamin A for consumers (Nwamwita et al., 2017; Awuni et al., 2017).

Besides colour, crumb appearance was described by cell largeness and cell uniformity. Bread substituted with OFSP flour and puree had cell largeness ranging from 8.20 to 9.10 and 5.49 and 6.00 respectively. Cell uniformity in wheat-OFSP flour and wheat-OFSP puree composite bread ranged from 3.90 to 5.04 and 2.34 to 6.73 respectively. Bread from100% WF had the lowest cell largeness (1.35) and highest uniformity (13.17) while bread substituted with 30% OFSP flour had the highest crumb cell largeness (9.10) and lowest uniformity (2.34).Crumb cell largeness and uniformity may be a function of the nature of the starch source and visco-elastic properties of the dough. Size and shape are major morphological characteristics that differentiates starch from different sources and which influences their functionality and behaviour in foods (deMan, 1999). According to Martinez & Gomez (2017), small wheat starch granules formed uniform starch-hydrocolloid matrix which remained uniform throughout fermentation and influenced the bread crumb properties. The authors added that large potato starch granules did not form a continuous starch-hydrocolloid matrix resulting in bread with the lowest cohesiveness among other crumb properties. The highest cell uniformity score for 100% WF bread may be due to the fact that the starch granules are from the same source (wheat only, with small sizes) while the decrease in cell uniformity for bread containing OFSP may be due to the different properties of starch granules as a function of the mixed starch sources (wheat, a cereal, and sweet potato, a root). Green and Bovell-Benjamin (2004) reported lower scores for cell size and cell uniformity for bread samples containing sweet potato compared to bread from 100% WF. These authors speculated that the low scores were possibly due to unevenly dispersed starch granules, and lack of a uniform network structure.

Flavour attributes of bread were described by sweet aftertaste and freshly baked aroma. As the percentage of OFSP flour increased, sweet aftertaste increased (8.24 to 11.92) while freshly baked bread aroma decreased (6.79 to 4.26) but bread from OFSP puree had lower sweet after-taste (2.34-6.73) and higher freshly baked aroma (8.55-12.64). Bread from 100% WF had the lowest sweet aftertaste (1.37) and highest freshly baked bread aroma (12.75). Flavour attributes combine the sensations of taste and smell and they are important indicators of bread freshness particularly across storage period. Green and Bovell-Benjamin (2004) described the flavour attributes of bread by terms such as fresh bread smell, strong wheaty smell, strong sweetpotato smell, wheaty taste and aftertaste.

Texture attributes of bread were described by crumb softness, grittiness and denseness. There existed significant ($p < 0.05$) differences in texture attributes among bread samples. Bread from 100% wheat flour had the highest softness (13.45) followed by bread containing OFSP puree (10.58-11.77) and OFSP flour (4.14-6.55). Grittiness and denseness increased (7.71 – 8.90) with increase in OFSP flour in bread but decreased and was lower in OFSP puree breads (1.55-3.49).

Consumer Acceptability of Bread from Wheat Flour Substituted with OFSP Flour or Puree

There were significant ($p<0.05$) differences in consumer acceptability scores for each of the sensory attributes among the bread samples (Figure 2). Bread substituted with 30% OFSP flour had the highest acceptability score (7.4) for crust colour while bread from 100% WF had the lowest (5.5), followed by bread with 10% OFSP puree (5.7). Generally, the range of acceptability score for crust colour of bread substituted with OFSP flour and puree were (6.6-7.4) and (5.7-7.2) respectively. Consumer acceptability scores for crumb colour ranged from 7.0 to 7.5 for bread substituted with OFSP flour and from 6.8 to 7.1 for bread substituted with OFSP puree. Acceptability scores for bread crumb colour increased for flour but decreased for puree with increase in OFSP substitution. Bread substituted with 30% OFSP flour had the highest acceptability score (7.5) for crumb colour while bread from 100% WF had the lowest (5.7). Crumb texture acceptability scores were lower(5.6-6.3) than (6.7-7.0)for bread substituted with flour and puree respectively. Bread from 100% WF and from 10% OFSP puree both had the highest score (7.0) while bread with 30% OFSP flour had the lowest (5.6). Bread containing OFSP flour had lower aroma scores (5.9-6.4) than bread containing puree (6.7-6.8). The lowest aroma score (5.9) was for bread containing 10% flour while bread containing !0% and 30% puree had highest score of 6.8 each. Acceptability scores for taste were lower (6.2-6.4) for bread substituted with OFSP flour than (6.3-6.8) for bread substituted with OFSP flour. Bread containing 10% and 30% flour had similar taste scores (6.2). The lowest taste score (5.7) and highest (6.8) were for bread from 100% WF and bread containing 10% puree respectively.

There were significant ($p<0.05$) differences in overall consumer acceptability scores for the bread samples.

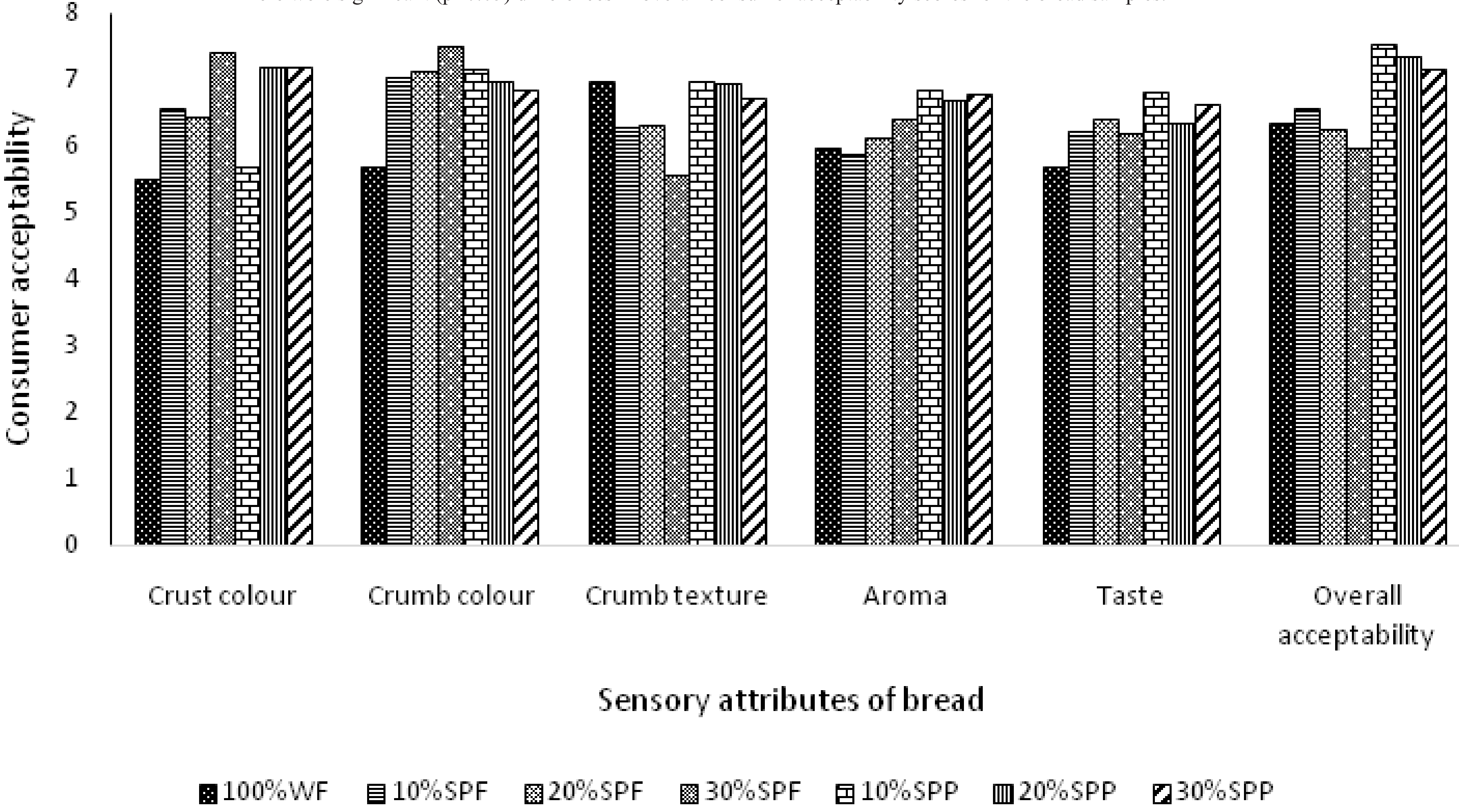

Figure 2: Consumer acceptability scores for bread from wheat flour substituted with OFSP flour or puree

OFSP: Orange-fleshed sweetpotato, WF: Wheat flour, SPF: OFSP flour, SPP: OFSP puree

Acceptability scores were lower (5.9-6.6) for bread substituted with OFSP flour than for bread substituted with OFSP puree (7.1-7.5). Bread containing 10% puree had the highest (7.5) acceptability score while bread with 30% flour had the lowest (5.9%). Generally, for each of flour and puree forms, overall acceptability scores of breads decreased with increase in OFSP substitution. All the composite bread samples, except those containing 20-30% OFSP flour (5.9-6.2), had higher acceptability scores that 100% wheat bread (6.3).

Correlations between Sensory Descriptive Scores and Consumer Acceptability of Bread From Wheat Flour Substituted with OFSP Flour or Puree

There were some significant correlations between consumer acceptability of OFSP substituted bread and some descriptive sensory properties. For bread substituted with OFSP flour, only aroma showed a significant ($p<0.05$) negative correlation ($r = -0.96$) with acceptability. This may suggest that the lower the freshly baked bread aroma, the higher the acceptability. However, it may imply that the most acceptable bread in this category had a very low freshly-baked bread aroma. On the other hand, for bread substituted with OFSP puree, there were strong positive correlations between acceptance and crumb colour (0.99), freshly baked bread aroma (0.94) and taste (0.91) but only that of crumb colour was significant ($p<0.01$). This indicates that these attributes appealed more to the senses of the consumers and therefore influenced acceptance. Some other attributes showed various degrees of high correlations with overall acceptance; they are crust brownness (-0.72), crumb yellowness (0.89), crumb cell largeness (0.87), crumb cell uniformity (-0.94), freshly baked aroma (-0.71) and softness (-0.76).

Physical Properties of Bread from Wheat Flour Substituted with OFSP Flour or Puree

Substitution of WF with OFSP flour or puree significantly ($p<0.05$) reduced the volume, specific volume, oven spring, softness and crumb moisture of the bread while the weight and crumb moisture increased (Table 2). Bread from 100% WF had the highest volume (906 cm^3), specific volume (5.01 cm^3/g), oven spring (1.30 cm), softness (21.35 mm), crust moisture (18.83%) and but the lowest weight (180.70 g) and crumb moisture (26.00%). Bread samples substituted with OFSP puree were characterized by higher range of volume (872-885 cm^3), specific volume (4.59-4.76 g/cm^3), oven spring (0.50-1.00 cm), softness (18.35-20.20 mm) and crust moisture (18.05-18.17%) and lower range of loaf weight (185.79-189.77 g) and crumb moisture (27.15-27.79%) compared to bread samples substituted with OFSP flour which were characterized by higher range of loaf weight (193.74-198.50 g) and crumb moisture (27.81-27.91%) but lower range of loaf volume (771-869 cm^3), specific volume (3.88-4.49 g/cm^3),

Table 2: Physical properties of bread from wheat flour substituted with OFSP flour or puree

Bread Sample	Volume (cm^3)	Weight (g)	Specific volume (cm^3/g)	Oven spring (cm)	Softness (mm)	Crust moisture (%)	Crumb moisture (%)
100%WF:0%SPF	906^{g}	180.70^{a}	5.01^{d}	1.30^{d}	21.35^{d}	18.83^{c}	26.00^{a}
90%WF:10%SPF	869^{c}	193.74^{d}	4.49^{b}	0.45^{b}	18.25^{c}	17.81^{ab}	27.81^{b}
80%WF:20%SPF	857^{b}	194.90^{e}	4.40^{b}	0.45^{b}	12.40^{ab}	17.42^{a}	27.90^{b}
70%WF:30%SPF	771^{a}	198.50^{d}	3.88^{a}	0.15^{a}	11.60^{a}	17.40^{a}	27.91^{b}
90%WF:10%SPP	885^{f}	185.79^{b}	4.76^{c}	1.00^{d}	20.20^{c}	18.05^{b}	27.15^{ab}
80%WF:20%SPP	882^{e}	188.96^{c}	4.67^{c}	0.67^{c}	18.80^{cd}	18.14^{b}	27.73^{b}
70%WF:30%SPP	872^{d}	189.77^{cd}	4.59^{bc}	0.50^{bc}	18.35^{c}	18.17^{b}	27.79^{b}

Mean values in the same column with different alphabets are significantly different ($p<0.05$)

OFSP: Orange-fleshed sweet potato, WF: Wheat flour, SPF: OFSP flour, SPP: OFSP puree oven spring (0.15-0.45 cm), softness (11.60-18.25 mm), and crust moisture (17.40-17.81%). Generally, substitution of wheat flour with OFSP flour or puree increased the loaf weight (2.82-9.85%) and crumb moisture (4.42-7.35%) but reduced the loaf volume (2.20-14.90%), specific volume (4.99-22.55%), oven spring (23.08-88.46%), softness (5.39-45.67%) and crust moisture (3.51-7.59%).

Conclusion

Nine descriptive terms were generated to describe the sensory attributes of bread samples from 100% wheat flour and those substituted with orange-fleshed sweet potato (OFSP) flour or puree. Bread substituted with OFSP were generally characterized by high scores for crumb yellowness, crumb cell largeness and sweet aftertaste. Bread containing OFSP flour were particularly characterized by denseness and grittiness. Bread containing OFSP puree had crumb softness, freshly baked aroma and crust brownness that were comparable with bread from 100% wheat flour. Bread samples substituted with OFSP flour were characterized by higher range of loaf weight and crumb moisture while bread from OFSP puree had higher range of loaf volume, specific volume, oven spring, softness, and crust moisture. Overall consumer acceptability scores were higher for bread substituted with OFSP puree than bread substituted with OFSP flour. Some sensory

OFSP: Orange-fleshed sweet potato, WF: Wheat flour, SPF: OFSP flour, SPP: OFSP puree oven spring (0.15-0.45 cm), softness (11.60-18.25 mm), and crust moisture (17.40-17.81%). Generally, substitution of wheat flour with OFSP flour or puree increased the loaf weight (2.82-9.85%) and crumb moisture (4.42-7.35%) but reduced the loaf volume (2.20-14.90%), specific volume (4.99-22.55%), oven spring (23.08-88.46%), softness (5.39-45.67%) and crust moisture (3.51-7.59%).

Conclusion

Nine descriptive terms were generated to describe the sensory attributes of bread samples from 100% wheat flour and those substituted with orange-fleshed sweet potato (OFSP) flour or puree. Bread substituted with OFSP were generally characterized by high scores for crumb yellowness, crumb cell largeness and sweet aftertaste. Bread containing OFSP flour were particularly characterized by denseness and grittiness. Bread containing OFSP puree had crumb softness, freshly baked aroma and crust brownness that were comparable with bread from 100% wheat flour. Bread samples substituted with OFSP flour were characterized by higher range of loaf weight and crumb moisture while bread from OFSP puree had higher range of loaf volume, specific volume, oven spring, softness, and crust moisture. Overall consumer acceptability scores were higher for bread substituted with OFSP puree than bread substituted with OFSP flour. Some sensory descriptive terms generated in this study may be employed as quality control indices for OFSP-substituted bread due to the significant correlations that exist amongst these parameters.

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