Research Article

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Sensory Attributes of Composite Breads from Shelf Storable Orange-Fleshed Sweetpotato Puree

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Abstract: Technological advances in baking have enabled the use of bread as a food vehicle for various nutrients through use of composite flours. Orange-fleshed sweetpotato (OFSP) puree subjected to cold chain storage has been used to enrich bread with beta-carotene. However, this has proven expensive and inconsistent in supply of puree. This study sought to develop shelf-storable OFSP puree bread with similar sensory qualities to fresh OFSP puree bread. Bread in which two treatments of shelf-storable OFSP puree (treatments 1 and 2 with 0.5% potassium sorbate+0.5% sodium benzoate+1% citric acid and 0.2% potassium sorbate+0.2% sodium benzoate+1%citric acid respectively) were incorporated at 30% and 40% and were subjected to descriptive sensory analysis with white and fresh puree breads as controls. The results indicate that both the 40% and 30% wheat substitution with either treatment 1 or 2 OFSP puree bread are acceptable to the consumers, $p<0.05$. The saltiness, smoothness and crumb color scores for shelf-storable OFSP puree bread were similar to those of fresh puree bread but were significantly ($p<0.05$) higher than that of white bread. Shelf-storable OFSP puree bread had similar sensory profile to fresh OFSP puree bread thus can be exploited as an alternative to fresh puree bread.

Keywords: Sensory attributes, OFSP puree, Shelf-Storable, Bread

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1 Introduction

Sensory evaluation is the scientific discipline that is employed to measure and interpret consumer responses to the qualities of products based on their perception by their five senses, namely taste, sight, touch, smell and hearing (Sindi et al. 2013). The sensory appeal acts as the first determinant for majority of the consumers' purchase of a food product, thus affects the marketability of a food product (Swahn et al. 2012). Descriptive analysis is used to establish differences in various sensory parameters as influenced by adjustments and changes in the ingredients (Vindras-Fouillet et al. 2014). Descriptive sensory analysis gives the sensory profile of a product; this influences its acceptability by consumers.

The incorporation of orange-fleshed sweetpotato (OFSP) puree in bread is aimed at improving the vitamin A status of the consumers as OFSP is known to be rich in beta-carotene, a pro-vitamin A compound (Bonsi et al. 2014; Low et al. 2007). The use of the OFSP puree over OFSP flour has been shown to be advantageous in terms of economic returns such as reduction in energy consumption and conversion rate; nutritional content such as beta-carotene content; sensory attributes such as color and taste; and quality parameters such as loaf volume and texture (Muzhingi et al. 2016; Sindi et al. 2013). Incorporation of any ingredient to improve the nutritional quality of bread must not adversely affect sensory attributes as consumers' perception would define the acceptability of such bread and therefore its marketability. There are indications that OFSP puree bread has a higher acceptability and consumers are willing to pay more for it than the white wheat bread (Wambui 2017).

Currently OFSP fresh puree is used for bakery application in Kenya, and it is delivered to end users in a frozen state. In order to reduce the cost of cold chain transportation, manage seasonality of OFSP fresh root supply for puree production and expand on the user base of OFSP puree, International Potato Center Sub-Saharan Africa (CIP-SSA) embarked on a project to develop a shelf-storable OFSP puree which will make bakery products

similar to those from frozen OFSP puree (Bocher et al. 2017). Shelf-storable OFSP puree can be made using aseptic processing and packaging technologies. Also, in Kenya, it is most cost effective and easier to use chemical preservatives such as benzoate, sorbate and citric acid with Modified Atmosphere Packaging to make OFSP puree shelf-stable. However, it is currently not known whether products made from shelf-storable OFSP puree are similar to those made from fresh OFSP puree in taste, color and flavor. This study sought to establish the sensory profile and consumer liking of bread developed from shelf-storable OFSP puree.

2 Materials and Methods

2.1 Sample preparation

Tubers of OFSP variety Kabode were pureed using a pureeing machine. Wheat flour, Exe (Unga Limited, Kenya) was purchased from a retail outlet. Salt (Kensalt Limited, Kenya), Sugar (South Nyanza *Sugar Company* Limited, Kenya), baking powder (Kapa Oil Refineries, Kenya), baking soda (R H Devani Limited, Kenya) and yeast (Foodplus, Kenya) were purchased from the local shops in Homa Bay County. Two treatments of shelf storable OFSP puree were prepared. Treatment 1 (T1) had 0.5% potassium sorbate + 0.5% sodium benzoate + 1% Citric acid while treatment 2 (T2) had 0.2% potassium sorbate + 0.2% sodium benzoate + 1% Citric acid. A control fresh puree was stored frozen at -20°C for a period of four months. Treatment 1 and 2 OFSP purees were stored away from light in ambient temperatures (15-23°C) where sampling of the puree for bread baking was done monthly for a period of four months. Shelf-storable OFSP puree were incorporated into bread at 30%, which was the minimum level that provided optimal beta-carotene for fortification (Muzhingi et al. 2016; Sindi et al. 2013), and 40% which is the substitution level in practice in the Kenyan market. The acidity due to citric acid in shelf-storable OFSP puree was neutralized using sodium bicarbonate (baking soda) with the quantities determined as per the method used by Groves and Bill (2015). Fresh OFSP puree bread at similar levels of substitution and white bread acted as controls in the study.

The neutralization value for citric acid was 159 as stated by the manufacturer (Univar Food Ingredients, United Kingdom).

The ingredient mixes were done as per the recipes used by local bakeries for the breads, Table 1. The preparation of the breads was done as shown in Figure 1. The baked breads were cooled overnight, packaged into polythene bags and stored at 23°C for sensory evaluation.

2.2 Analytical methods

2.2.1 Determination of pH

The pH of the puree and dough was determined using a pH meter (Mettler Toledo, USA). A sample of 10 g was homogenized in 20 ml of deionized water and the pH determined using a calibrated pH meter.

2.2.2 Sensory analysis

The sensory analysis of the breads was done in Homabay County using a semi-trained panel. A panel of thirty people with an attrition of 10% (16 males and 14 females aged between 20 and 55 years) was randomly selected among locals who were regular consumers of bread in Homa Bay

Table 1: Formulation for White, Fresh OFSP and Shelf-Storable OFSP Puree Breads

Ingredient (g)	White bread	30% Fresh puree bread	40% Fresh puree bread	30% T1 SS bread	40% T1 SS bread	30% T2 SS bread	40% T2 SS bread
Flour	2500	1750	1500	1750	1500	1750	1500
Puree	0	750	1000	750	1000	750	1000
Sugar **	125	75	75	75	75	75	75
Salt**	25	25	25	25	25	25	25
Fat**	100	75	75	75	75	75	75
Yeast**	37.5	50	50	50	50	50	50
Bread Improver**	0	7.5	7.5	7.5	7.5	7.5	7.5
Baking powder**	0	0	0	12.5	12.5	12.5	12.5
Baking soda	0	0	0	11.9	15.9	11.9	15.9

*SS-shelf-storable, T1 had 0.5% potassium sorbate+0.5% sodium benzoate+1% citric acid and T2 had 0.2% potassium sorbate+0.2% sodium benzoate+1% citric acid. **Ingredients added as proportion of the total quantity of wheat flour + OFSP puree composite.

County. Verbal consent of the panelist was sought with the study being explained to the panelists. A 30 minute training session was held for the panelists on predetermined descriptors of the bread samples as established by Al-Saleh and Brennan (2012) and Vindras-Fouillet (2014), namely appearance (crumb and crust color), odor (yeasty and grainy), taste (saltiness, sweetness and sourness), texture (crispiness and smoothness), long lasting taste and overall acceptability. The panel was used for the entire period of study of four months. All aspects of the study were approved by The Graduate School, University of Nairobi.

The bread samples were marked using randomly chosen three digit numbers in duplicates and presented to the panel to assess. The intensity of each attribute was scored using a 9-point verbally anchored scale according to procedures established by Nordic Committee on Food Analysis (2015). The samples were scored from 1-extremely low to 9-extremely high. The panelists were provided with water to refresh their palate before evaluating successive samples.

2.3 Statistical Analysis

The data were analyzed in Genstat version 15. Descriptive statistics such as the mean of replicates and standard deviation of the means of sensory scores were obtained. ANOVA test was used to test the significant differences of pH in randomized block design while the sensory scores were in split-plot design. Fischer's LSD test was used to separate means that were significantly different.

Ethical approval: The conducted research was not related to either human or animal use.

3 Results

3.1 pH of Dough

Significant differences ($p<0.05$) existed in the crust color, crumb color, saltiness, smoothness and overall acceptability as shown in Table 2. Only the sensory perception of crust color and smoothness significantly ($p<0.05$) varied among breads developed from shelf-storable OFSP puree sampled at different storage periods as shown in Tables 3 and 4. The interaction of the storage period and the sample also resulted into significant ($p<0.05$) differences in the perception of smoothness and color.

Both the fresh and shelf-storable OFSP puree breads of both treatments had golden yellow crumb color

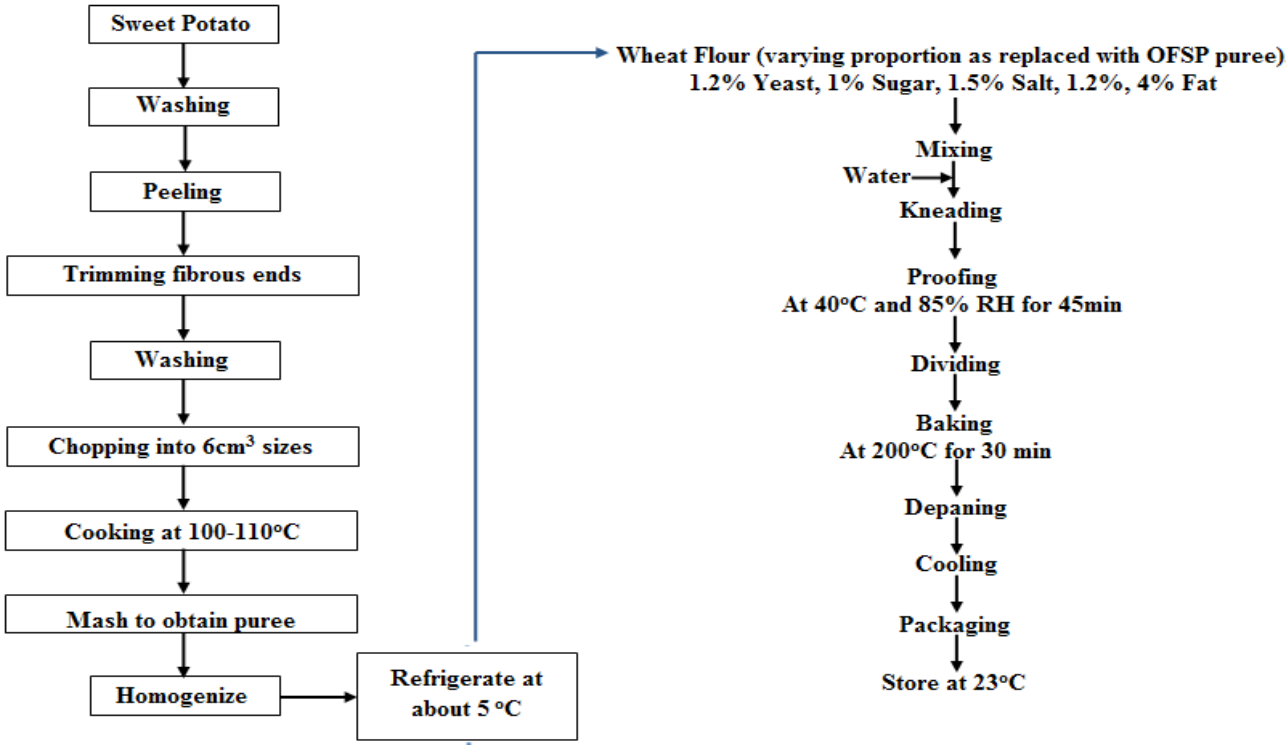

Figure 1: Flow diagram for baking of OFSP bread

(sensory score >5) as shown in Table 2. The intensity of the golden yellow color in fresh puree bread crumbs (6.20-6.79) was higher than that of shelf-storable OFSP puree breads ($p<0.05$). There was no variation in the crumb color across the months ($p<0.05$). Both treatments of OFSP purees at either level of substitution, 30% or 40%, had an intensively browner color as compared to the white bread. There were no significant differences ($p<0.05$) between the crust color of 30% OFSP puree bread and 40% OFSP puree bread for the respective purees. The crust color was significantly different for breads sampled at different months but with a maintained trend of lower scores for the control white breads, 3.63±0.45 to 3.70±0.09 ($p<0.05$), as shown in Table 3. Samples with higher sensory scores (>5) at the first month of storage of the shelf-storable OFSP puree did not have any significant change ($p<0.05$) in the scores even with storage.

Table 2: Results for descriptive sensory scores of bread samples

Parameters	Samples						
	White bread	30% Fresh puree bread	40% Fresh puree bread	30% T1 SS bread	40% T1 SS bread	30% T2 SS bread	40% T2 SS bread
Crispiness	3.76±1.90^{a}	4.29±2.10^{a}	4.44±2.03^{a}	4.28±1.94^{a}	4.36±1.86^{a}	4.22±2.06^{a}	4.21±2.10^{a}
Crust color	3.19±1.36^{a}	5.83±1.34^{cd}	6.16±1.83^{d}	5.74±1.63^{bc}	5.92±1.53^{cd}	5.45±1.49^{b}	5.78±1.55^{bc}
Crumb color	2.74±0.95^{a}	6.20±1.02^{d}	6.79±1.22^{e}	5.83±1.43^{c}	6.05±1.43^{c}	5.29±1.33^{b}	6.03±1.50^{c}
Grainy odor	4.82±1.78^{a}	4.64±1.85^{a}	4.47±1.91^{a}	4.72±1.92^{a}	4.36±1.92^{a}	4.28±1.89^{a}	4.33±1.85^{a}
Yeasty odor	3.79±0.78^{a}	4.77±0.97^{a}	4.83±0.06^{a}	4.73±0.16^{a}	4.28±0.20^{a}	4.38±1.04^{a}	4.21±1.02^{a}
Saltiness	3.99±0.04^{a}	4.61±0.85^{b}	4.67±0.86^{b}	4.63±0.04^{b}	4.57±1.97^{b}	4.62±1.00^{b}	4.72±0.13^{b}
Smoothness	3.16±0.27^{a}	5.36±0.11^{c}	5.11±0.94^{bc}	5.44±0.27^{c}	6.53±0.26^{d}	4.82±0.97^{b}	5.13±0.96^{bc}
Sourness	4.19±1.06^{a}	3.98±1.91^{a}	4.21±1.98^{a}	4.11±1.88^{a}	3.97±1.99^{a}	4.07±1.98^{a}	4.29±1.21^{a}
Sweetness	4.55±1.98^{a}	5.01±1.92^{a}	4.80±1.93^{a}	4.31±1.85^{a}	4.13±1.94^{a}	4.17±1.05^{a}	4.44±1.85^{a}
Long lasting taste	4.90±1.96^{a}	4.70±2.04^{a}	4.23±1.92^{a}	4.35±2.12^{a}	4.42±2.07^{a}	5.16±2.31^{a}	4.83±2.21^{a}
Overall Acceptability	6.01±2.06^{b}	6.23±1.94^{b}	6.70±1.91^{c}	5.14±1.46^{a}	5.78±1.73^{b}	5.29±2.37^{a}	5.74±1.93^{ab}

*T (treatment), SS (Shelf Storable) Means with the same superscript across a row are not significantly different ($p>0.05$)

Table 3: Sensory Scores for Crust Color

Months	Sample							Average
	White bread	30% Fresh puree bread	40% Fresh puree bread	30% T1 SS bread	40% T1 SS bread	30% T2 SS bread	40% T2 SS bread	
1	3.63±0.45^{b}	5.90±0.06^{a}	5.70±0.96^{a}	4.97±0.24^{a}	5.50±0.33^{a}	4.97±0.47^{a}	5.46±0.55^{a}	5.16±1.61^{a}
2	2.73±0.25^{a}	5.93±0.46^{a}	6.17±0.93^{ab}	6.40±0.89^{b}	6.17±0.84^{a}	5.50±0.59^{b}	6.10±0.42^{a}	5.57±2.01^{ab}
3	2.70±0.34^{a}	5.53±0.22^{a}	6.00±0.83^{a}	5.77±0.43^{b}	5.97±0.65^{a}	5.60±0.20^{b}	5.57±0.62^{a}	5.31±1.83^{a}
4	3.70±0.09^{b}	5.93±0.57^{a}	6.77±0.46^{b}	5.83±0.62^{b}	6.03±0.22^{a}	5.73±0.57^{b}	5.97±0.61^{a}	5.71±1.69^{b}
Averages	3.19±1.36^{A}	5.83±1.34^{C}	6.16±1.83^{D}	5.74±1.63^{BC}	5.92±1.53^{CD}	5.45±1.49^{B}	5.78±1.55^{BC}	

Values with different lowercase letters along a column and uppercase across a row a significantly different at $p<0.05$.

Table 4: Sensory Scores for Smoothness

Months	Sample							Average
	White bread	30% Fresh puree bread	40% Fresh puree bread	30% T1 SS bread	40% T1 SS bread	30% T2 SS bread	40% T2 SS bread	
1	3.47±0.01^{a}	4.83±1.01^{a}	4.83±0.70^{a}	4.90±0.88^{a}	6.30±0.02^{a}	3.70±0.47^{a}	5.46±0.76^{a}	4.60±1.69^{a}
2	3.83±0.09^{a}	5.90±1.26^{b}	5.07±0.98^{a}	5.67±0.27^{ab}	6.50±0.31^{a}	5.03±0.11^{b}	6.10±0.90^{a}	5.23±2.04^{b}
3	3.13±0.72^{a}	5.37±0.85^{ab}	5.00±1.21^{a}	5.93±0.48^{b}	6.73±0.51^{a}	3.13±1.20^{a}	5.57±1.10^{a}	5.22±2.12^{b}
4	3.20±0.16^{a}	5.33±1.26^{ab}	5.53±0.83^{a}	5.27±0.17^{ab}	6.60±0.16^{a}	3.20±0.66^{a}	5.97±0.63^{a}	5.26±1.84^{b}
Average	3.16±1.28^{A}	5.36±2.11^{C}	5.11±1.94^{BC}	5.44±1.27^{C}	6.53±1.26^{D}	4.82±1.97^{B}	5.13±1.93^{BC}	

Values with different lowercase letters along a column and uppercase cross a row a significantly different at $p<0.05$.

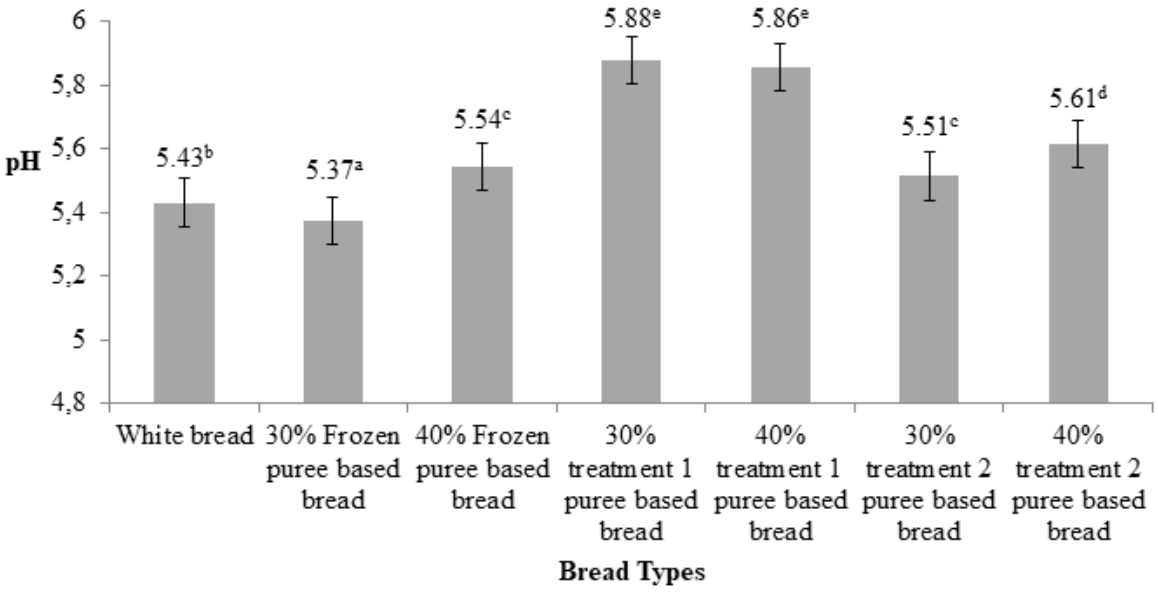

Figure 2: pH of dough used in bread baking (Means with different letters in the superscript are significantly different at P<0.05, LSD 0.030)

All the breads had an overall acceptability score greater than 5. The OFSP bread with 40% fresh puree incorporated was the most acceptable (p<0.05) while the 30% fresh OFSP puree bread had similar acceptability scores to both treatments 1 and 2 shelf-storable OFSP puree bread at 40% level of substitution and white bread (p<0.05) as shown in **Table 2**. Increasing the proportion of shelf-storable OFSP puree from 30% to 40% increased the overall acceptability of the bread (p<0.05).

There were significantly higher saltiness scores (p<0.05) in all shelf-storable OFSP puree breads (4.57-5.72) as compared to normal white bread (3.99). Both treatments of shelf-storable OFSP puree breads achieved similar saltiness scores to fresh puree breads (p<0.05). The saltiness scores of the breads did not significantly differ for breads made from OFSP puree sampled at different months (p<0.05).

Incorporation of either shelf-storable or fresh OFSP puree into bread increased the smoothness of the bread crumb as perceived by the panelists and shown in **Table 2** (a score greater than 5), p<0.05**.** Both treatments of shelf-storable OFSP puree achieved breads with greater smoothness (ranging from 4.82±0.97 to 6.53±0.26) than the control white bread (3.16±0.0), p<0.05. Bread with 40% treatment 1 shelf-storable OFSP puree incorporated was perceived to be the smoothest (6.53±0.26), p<0.05. White bread had the least average sensory scores for the smoothness of the crumb, 3.99±0.04 (p<0.05). Bread with 40% OFSP puree incorporated had smoother crumbs than those with 30% of OFSP puree incorporated as shown in **Table 4,** p<0.05**.** Significant differences existed in breads sampled at different months with samples made OFSP puree that had been stored for one month averaging the lowest scores (p<0.05).

4 Discussion

4.1 Adjustment of the pH of dough using chemical leaveners

All the dough had a slightly acidic pH which is attributed to the leavening activity by the yeast in the dough; this is necessary for the flavor of the breads (Struyf et al. 2017). Dough in which either fresh or shelf-storable OFSP puree was incorporated had a higher pH as compared to dough made from wholly wheat. Both the doughs in which fresh and shelf-storable puree OFSP were incorporated had chemical leavening agents, baking soda and/or baking powder, among the ingredients to aid the leavening activity. The basic nature of the dough is therefore due to the basic nature of the leavening agents which is known to raise the pH of products (Tejinder et al. 2015). The pH of dough in which shelf-storable OFSP puree sampled at different months was found to be the same. This can be explained by the fact that similar amounts of the baking soda were used for breads made from the same OFSP puree at similar levels of substitution over the period.

4.2 Crumb and crust colors of shelf-storable OFSP puree bread

Breads developed from OFSP puree had golden yellow colored bread crumbs (sensory score greater than 5). The consumer rating of the crumb color is in agreement with the studies of Bonsi et. al. (2014), where the distinctive color of bread developed from OFSP puree was noted across varied study populations in Ghana. The OFSP puree imparts golden yellow color to bread that is highly likable to consumers, thus presents an economic advantage (Low and Jaarsveld 2008). The OFSP puree bread is known for its distinctive golden yellow color in the Kenyan markets (Wambui 2017). The golden yellow color is attributed to beta-carotene which on top of the nutritional advantages it presents, can also serve as a natural food colorant. With most consumers not liking artificial colorants, the food coloring property of beta-carotene is commendable in bread. The higher intensity of the golden yellow color in fresh puree breads than the shelf-storable OFSP puree breads is attributed to the higher retention of much of the beta-carotene in fresh puree (Musyoka et al. 2018).

Incorporating either shelf-storable or fresh OFSP puree into breads increased the intensity of the crust color of the breads. The browning on the crust of bread is usually due to non-enzymatic chemical reactions involving sugars (caramelization) and sugars and amino acids (Maillard reaction) (Purlis 2010). The intensity of the crust color and the thickness of the crust in bread have been associated with moisture content and water activity when temperature as a factor has been standardized. Intense browning and size of the crust increases as more water vapor is lost through vapor pressure gradient (Chhanwal and Anandharamakrishnan 2014); higher moisture content as in the case of OFSP puree based bread would result into a thicker and more browner crust.

4.3 Acceptability of shelf-storable OFSP puree bread

Bread in which 40% fresh OFSP puree was incorporated was found to be the most acceptable while the one with 30% fresh puree had similar acceptability to the shelf-storable OFSP puree and white breads. This finding was different from the results of Sindi et al. (2013), where bread with 30% incorporation of fresh OFSP puree was more acceptable than white bread. Another study by Awuni et al. (2017) which focused on bread with 46% fresh puree incorporated, attributed the higher acceptability scores of fresh OFSP bread over white bread to its golden yellow color. All the shelf-storable OFSP puree breads were found to be acceptable to the consumers. An overall acceptability score (≥5) for OFSP bread on a 9-point hedonic rating is indicative of consumer liking of the product (Bonsi et al. 2014). With evidence of a higher willingness to pay by consumers as shown by consumer profile studies in Kenya (Wambui 2017), shelf-storable OFSP puree bread can serve to expand the accessibility of this bread.

4.4 Taste of shelf-storable OFSP puree bread

Shelf-storable OFSP puree breads were more salty than the white breads, but similar to fresh puree breads. Consumers rated saltiness of bread developed from both treatments of shelf-storable purees as neither too high nor too low. Saltiness can greatly impact on the acceptability of these breads as taste has been established as an influencing factor on consumer preference of bread (López et al. 2013). The firmness and porosity of the bread crumbs is known to influence the release of sodium ions during mastication; softer breads such as the OFSP puree bread will have a higher saltiness (Pflaum et al. 2013). The role of the porosity and firmness of the OFSP puree bread crumbs should be evaluated to provide further evidence of the influence of the porosity and distribution of gas cells on saltiness in OFSP puree bread with prospects of reducing salt levels used. The levels of sodium ions in the bread were not checked but this would need to be probed further as higher sodium levels would also prove unhealthy.

4.5 Texture of shelf-storable OFSP puree breads

Incorporating either fresh or shelf-storable OFSP puree into bread was noted to increase the smoothness of the bread crumbs. A study done among the Kenyan consumers evaluating the acceptability of OFSP puree bread showed similar results, its approved characteristics of a smooth crumb resulting in higher likability by consumers (Wambui 2017). Smoothness is an important attribute in bread as it has also been established that consumers believe smooth breads are fresh (Heenan et al. 2009). Consumers would therefore prefer breads with either shelf-storable or fresh OFSP puree incorporated due to their soft crumb texture.

5 Conclusion

Substitution of wheat flour with 30% and 40% of different treatments of shelf-storable OFSP puree achieves similar sensory parameters to fresh puree based bread. Bread in which 40% fresh OFSP puree is incorporated has a higher acceptability than shelf-storable OFSP puree based bread. The study established that shelf-storable OFSP puree can be used as an alternative to fresh OFSP puree in bread baking with minimal alterations to the sensory quality.

Conflict of interest: The authors declare no conflict of interest.

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