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Soymilk Dreg (Okara) from a Food Waste to Valuable Ingredient for Shortbread with Improved Sensory Quality

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Abstract: *Despite its nutritional value, food utilisation of okara (a by-product from soymilk processing) is low. There are renewed interests nowadays to harness the inherent potentials of okara for value-addition in foods. The development of a pleasant shortbread from wheat flour enriched with okara powder was evaluated. Wheat flour was substituted with okara powder (10%-40%). Wheat flour (100%) was used as the control. Bread samples were produced using straight dough technique. Physical characteristics (dough expansion, bread weight, loaf volume, and specific loaf volume), crust colour, firmness, proximate composition, and sensory quality of samples were analysed. The results showed that dough expansion was not significantly different at ≤20% but differed between 30%-40% okara substitution. Bread firmness and crust colour values increased significantly, more at higher levels of okara powder addition to the wheat flour. Breads' weight, specific volume and density differed significantly. Breads' protein and fibre contents increased with increasing substitution of wheat flour with okara powder. Conversely, carbohydrate contents decreased with increasing okara substitution into wheat flour. Significant differences exist among samples in term of crumb colour, taste, and flavour. Breads with okara powder were more acceptable to the panellists and were scored higher than the control. Bread with 40% okara powder had the highest overall acceptability score of 8.2 on a 9-point hedonic scale. Thus, by-product from soymilk processing can be added into wheat flour for bread production. This suggests that, more sustainable food systems capable of enhancing higher consumer patronage with pleasant sensory properties can be achieved*.

Keywords: Bread, composite, okara powder, physico-sensory, wheat flour.

1. Introduction

There is growing interest for soybean milk as a substitute for the convectional milk in sub-Saharan Africa. Despite the embedded nutritive value and health-promoting potentials, okara has not been fully utilised in food products development (Ichikawa *et al.,* 2022). For instance, okara, a by-product from soymilk processing industry is a food waste that is generated after production. High-level of its perishability, low digestibility and impaired sensory properties may have limited incorporation of okara in food systems (Feng *et al.,* 2022). Okara is usually disposed by landfilled due to its high-perishable nature (Privatti, & Rodrigues, 2021). The composition of okara may depend on soybeans type as well as method of soymilk extraction (Pešic et al., 2023). Nearly 40% of okara generated from soymilk production is used as feed and about 10% as food for human consumption while the remaining ends up as waste. Okara essentially contains dietary fibre (50%), protein (15-40%), lipids by composition (10%–20%) and soy-related isoflavones (Lee, Gan, & Kim, 2020). Okara's nutritional content makes it a desirable material for upcycling and valorisation into products with additional value (Feng *et al.,* 2022). Efficient use of okara could lead to a reduction in environmental pollution and possibly enhance the nutritive value and product's sensory quality (Agu, Ihionu, & Mba, 2023). Food by-products contribute to environmental pollution and waste of resources, consequently resulting into serious economic losses (Ichikawa *et al.,* 2022). Urbanization in the recent times has created more challenges to foods and nutritional security, especially in sub-Saharan Africa. To address the UN projected rise in world population by 2030, food waste has to be minimised, and perhaps considered as a viable strategy to achieve the UN Sustainable Development Goal (SDG 2)-zero hunger (Nyhan, Sahin, Schmitz, Siegel, & Arendt, 2023). Food by-products such as okara with the inherent nutritional profile, could be ideal ingredient that can be incorporated into wheat flour for food product development. Okara is capable of addressing hunger,

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nutrient deficiency and promote human health when incorporated into most of the staple diets (Feng *et al.,* 2022), such as bread or other formulated food products. To increase the nutritive value and improve the sensory quality of shortbread prepared from wheat flour, okara powder could be a probable gluten-free substitute ingredient needed.

There are several reports on okara food-potentials, as a substitute ingredient into food materials (Atlaw *et al.*, 2020; Mustapha *et al.* 2021; Feng *et al.*, 2022; Pešic *et al.*, 2023). The nutritional and organoleptic properties of an Ethiopian flat-bread combined with okara and soybeans were investigated by Atlaw *et al.* (2020). The author found that, protein and fat content of the resulting product (bread) increased, while its sensory quality remained satisfactory.

The authors proposed that the bread may serve as a remedy for the growing population where protein-energy malnutrition is prevalent. Mustapha *et al.* (2021) evaluated the influence of fermentation periods on dough and bread properties, and found that addition of unfermented-okara in dough negatively affected bread properties. On the other hand, as okara ferments, its fibre components – possibly through an increase in soluble fibre content- change, leading to enhanced dough and bread properties (Mustapha *et al.*, 2021). The authors concluded that, soft bread with higher loaf volume is produced after a prolong fermentation period. Okara has been reviewed by *Feng et al.* (2022) from waste to value-added food materials to highlight its potential to increase food products' functional and nutritional value.

Furthermore, it is essential for developing nations, Africa in particular, to tap into other sources of flour that may be used in the manufacturing of bread, given the high cost of wheat importation, which has driven up the price of bread and continuously drains our foreign exchange earnings. Recently, Pešic *et al.* (2023) investigated the physico-sensory properties of okara-enriched bread, and found that panellists showed more preference to the composited bread in terms of symmetry, and chewiness. Furthermore, okara-based bread reportedly to be high in dietary fibre, protein, iron and zinc but low in sugar, saturated fatty acids and caloric contents. The authors thus hypothesized that addition of okara in bread production could be a technology to formulate a more-nutritive, health-promoting, less energy-dense bread, and for better soymilk waste utilization.

Within our literature search, there is a paucity of information on the quality of shortbread made from wheat flour and okara-powder composite. Therefore, this study attempts to strengthen the potential of wheat flour and okara powder blends for the production of shortbread. The study evaluated the effect of substituting okara powder into wheat flour, on the physical properties (dough expansion, bread firmness, crust colour, loaf weight, specific volume and density) with the aim of using okara as a valuable ingredient for shortbread having improved sensory quality.

2. Materials and Methods

2.1 Sample collection

Wheat flour (20 kg) was purchased from a retail market in Ilaro. Baker's yeast, baking fat, powdered milk, sugar and salt were purchased from a retail store in Lagos. All the ingredients were kept at 4 °C until required.

2.2Processing of soybean into okara powder

Processing of soybean grains into soymilk and retrieval of okara were done at Food Processing Workshop, The Federal Polytechnic, Ilaro. Okara powder was produced as described by Swallah, Fan, Wang, Yu and Piao (2021). Cleaned soybeans were soaked in boiled-water (100 ºC, 25 min) and dehulled to reduce the levels of anti-nutrients and beans flavour. A kilogram of dehulled soybeans was wet-milled. Water-soluble filtrate (soymilk) was collected separately with a muslin cloth. Wet okara was then dried (50 ºC, 4 h) in a cabinet dryer, ground into powder (500 µm sieve size) and kept in an air-tight plastic container at 4 ºC for further use.

2.3 Sample formulation

Wheat flour was replaced with okara powder at 10, 20, 30 and 40% respective. 100% wheat flour was used as the control for the experiment. Other ingredients including sugar, salt, bakers' yeast, baking fat and water were used at 6, 2, 1, 1% (flour weight) respectively.

2.4 Processing of flour to bread

Wheat flour and okara powder were mixed thoroughly to achieve a uniform blend. Straight dough technique was used to prepare the dough for bread baking. Flour sample was mixed together with the other ingredients in stainless bowl and the heterogeneous mixture was homogenized in an electric mixer fitted with a whisk device, for 5 min to make a smooth dough. The dough was bulk fermented for 1 h, knocked back and subjected to intermediate proof (30 °C, 80%-85% RH) for 30 min. Dough was cut into the baking pan and covered with the lid, and proofed at 30±2 °C. To obtain the bread, dough was baked at 220 °C for 30 min. Bread samples were removed from the baking pans, cooled for 20 min to 27 ± 2 °C before analysis

2.5 Analyses of dough and bread samples

All the analyses were conducted in triplicates

2.5.1 Dough Expansion

Exactly 50 g dough prepared from wheat flour and okara powder composite was fitted into a-250 ml glass cylinder. The content proofed at 40 °C for a time of 20 min. For a period of 110 min, the volume of dough was recorded. Dough expansion was estimated as the ratio of bread volume to that of the dough.

2.5.2 Specific loaf volume and loaf density determination

Specific volume and loaf density were estimated by the official standard methods (AACC, 2003). The determination was conducted after baking. Specific loaf volume (cm^3/g) and the loaf density (g/cm^3) were calculated as shown below:

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

Loaf density (g/cm^3) = $\frac{Loaf\ weight}{Loaf\ volume}$

2.5.3 Crust colour instrumental measurement

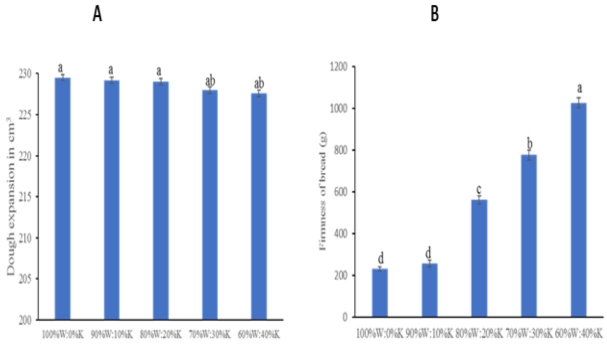
Colour of bread crust was measured using a colorimeter (CR-400 Chroma Meter, Konica Minolta Sensing, Osaka, Japan) at three different positions of the crust. The lightness (L^*) and red ($+a^*$) and yellow ($+b^*$) characteristics were measured according to the CIE *Lab* colour system.

2. 5.4 Firmness determination

Bread firmness was determined by cutting the loaf into 2.5 cm by 2.5 cm by 2.5 cm respectively as length, width and thickness. Firmness was measured using a texture analyser (AMETEK Brookfield CTX Texture Analyzer, United States) automatically with cylinder probe (Mustapha et al., 2021).

2.5.5 Proximate composition determination

The proximate composition (moisture, crude fat, crude protein, ash and crude fibre contents) of bread samples was



determined using the official methods (AOAC, 2016). Carbohydrate content of samples was calculated by difference and the Atwater factor described by FAO (2003) was used to calculate the energy value content.

2.5.6 Sensory evaluation

Sensory evaluation of bread samples was conducted after 1 h of baking. A-65 panel members (55.4% females and 44.6% males) volunteered to partake in the evaluation. The panellists are regular consumers of bread and are aged between 20 and 35 years (63.1%), 40–50 years old (36.9%) were selected. The evaluation was conducted in the sensory laboratory with individual assessors in a separate booth. The samples were evaluated at room temperature. Panellists were instructed to clean their palates with filter water in between sample evaluation. A piece of bread (15 cm × 5 cm) was presented in a disposable dish and blind-coded using 3-digit codes. A 9-point hedonic scale (from minimum of 1=dislike extremely to maximum of 9=like extremely) was employed to evaluate the sensory attributes (appearance, taste, texture, aroma, crumb and overall actability) of bread samples.

2.6 Statistical analysis

Data was collected in triplicate (sensory test was done once). The results were expressed as means ± SD replicated data. The significant difference was calculated using One-way analysis of variance and Tukey's test was used to separate the means ($p < 0.05$). Principal component analysis was conducted to identify sensory attributes that were significant among the samples. XLSTAT® software package (Addinsoft™, New York) was used for the analysis.

3. Results

3.1 Dough expansion and bread firmness

The final dough expansion volume measured at 110 min of proofing is shown in Figure 1 (A). The control (100% wheat flour) dough showed the highest expansion compared to those composited with okara. A final volume

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of 229.5 cm^3 was recorded for the control. The addition of okara powder significantly decreased the dough expansion from 229.2 cm^3 to 227.2 cm^3 compared with the control sample. However, the dough expansion was not significantly ($p>0.05$) different among the samples. Figure 1 (B) shows the firmness of bread with and without okara powder. Firmness are significantly ($p<0.05$) different among the tested samples. The values of firmness recorded for breads from composited flour were significantly higher than that of control. The highest firmness value was recorded in the sample with formulation 60%W: 40%K (60-part of wheat flour and 40-part okara powder).

Fig. 1 (A) Effect of substituting wheat flour with okara powder on flour dough expansion. (B) Firmness of bread with and without okara powder. Key: 100%W: 0%K = 100-part wheat flour only (Control); 90%W: 10 K = 90-part wheat flour+10-part okara powder; 80%W: 20%K = 80-part wheat flour+20-part okara powder; 70%W: 30%K = 70-part wheat flour + 30-part okara powder; 60%W: 40%K = 60-part wheat flour + 30-part okara powder

3.2 Crust colour parameters

Table 1 shows the effect of okara powder substitution in wheat flour on the colour parameters of the bread crusts. Colour parameters ($L*$, $a*$, $b*$) of the samples were significantly different ($p<0.05$). The colour parameters increased with increasing level of substituting refined wheat flour with okara powder. The values were specifically higher in okara-enriched samples than in the control. The highest $L*$ (63.48) value was recorded at 60%W: 40%K while the lowest was in the control (57.14).

Table 1**.** Effects of okara powder addition to wheat flour on breads' crust colour parameters.

Bread sample	Crust colour parameters		
	$L*$	$a*$	$b*$
100%W:0%K	57.14±1.23^{d}	15.51±0.23^{a}	25.30±2.07^{ab}
90%W:10%K	60.21±1.14^{c}	15.10±0.54^{a}	28.27±2.18^{a}
80%W:20%K	62.20±1.26^{b}	13.41±0.21^{b}	20.38±2.19^{c}
70%W:30%K	63.22±1.21^{a}	13.40±0.16^{b}	21.03±2.05^{c}
60%W:40%K	63.48±0.56^{a}	13.42±0.47^{b}	23..65±2.61^{bc}

Values are mean scores ± standard deviation of replicate determinations (n=3). $^{a–d}$ Different superscript(s) mean significantly different among groups at p = 0.05 level by Tukey's test.
Key: 100%W: 0%K = 100-part wheat flour only (Control); 90%W: 10 K = 90-part wheat flour+10-part okara powder; 80%W: 20%K = 80-part wheat flour+20-part okara powder; 70%W: 30%K = 70-part wheat flour + 30-part okara powder; 60%W: 40%K = 60-part wheat flour + 30-part okara powder

3.3 Physical characteristics of breads

Table 2 illustrates the physical characteristics of the composite bread samples substituted with okara-powder at different levels. The bread weight ranged between 137.4 g and 140.5 g. The weight of the bread varied from 137.4 to 140.5 grams. According to Table 2, the specific volume ranged between 2.933 cm^3/g and 3.410 cm^3/g. Among the bread samples, there were significant differences in the specific volume ($p\leq0.05$) of most of the samples. The bread density varied from 0.395 gcm^{-3} to 0.542 gcm^3. The density of the control and composite breads did not varied significantly ($p<0.05$) compared to the control, the composite bread samples have a lower density.

Table 2. Effect of okara substitution into wheat flour on physical characteristics of bread

Bread sample	Physical characteristics of breads		
	Weight (g)	S.V (cm^3/g)	Density (g/cm^3)
100%W:0%K	145.5^{a}±2.3	3.410^{a}±0.001	0.542^{a}±0.002
90%W:10%K	137.2^{b}±2.1	3.335^{a}±0.002	0.510^{a}±0.001
80%W:20%K	135.6^{b}±1.6	3.310^{ab}±0.001	0.480^{a}±0.003
70%W:30%K	134.8^{b}±1.3	3.300^{b}±0.003	0.410^{ab}±0.002
60%W:40%K	134.6^{bc}±2.4	2.933^{c}±0.002	0.395^{ab}±0.001

Values are mean scores ± standard deviation of replicate determinations (n=3). S.V= Specific volume.
$^{a–d}$ Different superscript(s) mean significantly different among groups at p<0.05 level by Tukey's test.

Proximate composition of the bread samples

Significantly ($p\leq 0.05$) moisture content in bread samples that was higher than that of the control bread sample (25.1%-40.7%) as indicated in Table 3. The protein, ash and dietary fibre contents of bread samples increased significantly with increasing substitution of okara powder into wheat flour, while the carbohydrate content decreased abnormally. The energy value of bread samples containing composite blends (331.8 kcal/100 g–345.3kcal/100 g) was lower than that of the control (373.2 kcal/100 g).

Table 4 displays sensory qualities that show a statistically significant ($p<0.05$) difference in ratings between bread samples substituted with okara powder and those without (no okara powder). The sensory quality assessments of the bread samples varied in terms of crumb, colour, taste, flavour and overall acceptability. A comparison of the bread substituted with okara powder revealed that there were statistically significant differences in the sensory quality scores for symmetry or shape or aroma. Bread prepared by substituting 40% okara powder received the highest scores by the panellists for most individual sensory attributes; notably are crumb colour (7.88), crust colour (7.52), taste (7.84), flavour (7.44), aroma (7.36), symmetry or shape (7.60) and overall acceptability (8.16). Following consumer sensory evaluation, the bread enriched with 40% okara was the sample that scored highest overall across all quality characteristics (Table 4).

The first two principal components explained nearly 97% of the total variation (Fig. 3), shows the first two principal component scores of the refined wheat flour with okara powder. PC1 explained nearly 95% of the total variation

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and separated and bread on their ingredient components the 100%W: 0%K bread to the left and the refined wheat enriched with okara bread to the right. PC2 accounted for only 2% of the total variation and separated samples with high-okara content bread at the top and lower okara content breads at the bottom.

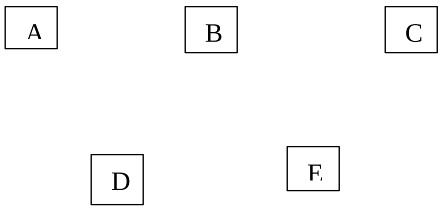

Fig. 2. Bread samples from wheat flour substituted with okara powder at different levels.
Key: A=100%W:0%, B=90%W:10%K, C=80%W:20%, D=70%W:30%K, E=60%W: 40%K.

Table 3. Effect of okara substitution into wheat flour on proximate composition and energy value content of bread

Sample	Energy (kcal/100 g)	Proximate composition (%)					
		Carbohydrate	Crude protein	Crude fibre	Total ash	Crude fat	Moisture
100%W:0%K	373.2^a±1.3	45.5^c±1.4	6.2^e±0.2	10.2^c±0.08	0.6^d±0.03	8.5^a±0.1	26.1^c±0.5
90%W:10%K	341.4^b±1.6	41.6^d±1.1	6.8^d±0.4	10.4^b±0.03	0.7^c±0.02	6.4^b±0.1	40.7^a±0.2
80%W:20%K	345.3^b±2.7	47.4^b±1.9	7.1^c±0.3	10.5^c±0.02	0.8^c±0.02	4.2^c±0.1	31.0^b±0.3
70% W:30%K	331.8^c±1.8	42.6^d±2.0	9.5^b±0.3	10.6^b±0.02	1.9^b±0.01	3.7^d±0.1	25.1^c±0.1
60% W:40%K	342.4^b±2.9	51.0^a±5.7	11.0^a±0.3	10.8^a±0.02	2.1^a±0.01	0.5^e±0.1	26.4^c±0.6
*p*0.05	< 0.0001	< 0.0001	< 0.0001	<0.0005	< 0.0001	< 0.0001	< 0.0001

Mean values (g/100 g, dry basis except moisture) are mean scores ± standard deviation of replicate determinations (n=3). [a–d] Different superscript(s) mean significantly different among groups at p = 0.05 level by Tukey's test.
Key: 100%W: 0%K = 100-part wheat flour only (Control); 90%W: 10 K = 90-part wheat flour+10-part okara powder; 80%W: 20%K = 80-part wheat flour+20-part okara powder; 70%W: 30%K = 70-part wheat flour + 30-part okara powder; 60%W

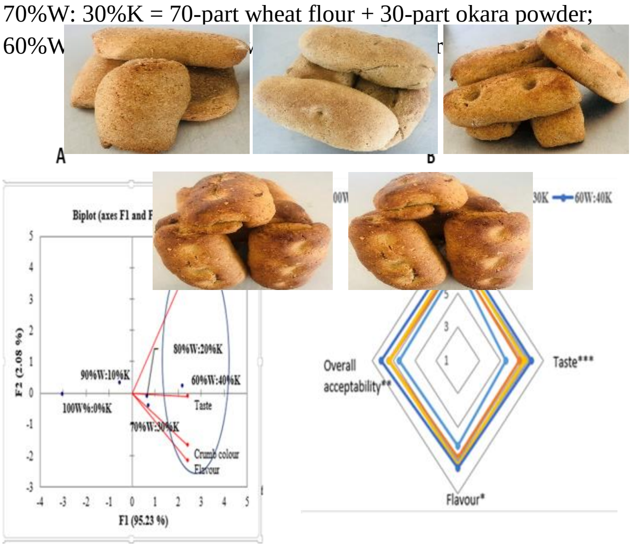

Fig. 3. (A) Principal component analysis score plots of the sensory attributes (that are significant) breads prepared from the flours of wheat flour and okara powder. Blue ring indicates acceptable bread samples by the panellist. (B) Spider chat showing breads' sensory attributes that are significant. Different colour lines indicate the different breads' sensory attributes.

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4. Discussion

A major requirement for wheat-composite dough to produce leavened bread with a desirable porous crumb structure is that the dough expansion and gas retention characteristics should be similar to wheat flour dough (Mustapha et al., 2021). Dough expansion depends on the strength of the gluten network (Mustapha et al., 2021). The addition of okara-powder to wheat flour enhances the dietary fibre of the dough (Table 2), which may explain the steady decrease in dough expansion (Fig. 1A). During dough proving, a high dietary fibre content found in bread formulations incorporating grape peel pomace (Mironeasa, Iuga, Zaharia, & Mironeasa, 2019) and refined wheat flour (Lin *et al.,* 2020) reduced gas retention and leavening ability (Mustapha *et al*., 2021). High dietary fibre perhaps is responsible for possible collapse of the viscoelastic matrix because the dietary fibre could have weakened the little gluten available in the composite dough, thereby reducing the ability of the dough to retain expanding gas structures (Wang, Tua, Shia, & Yang, 2023). An increase in the *L** value of crusts with increasing level of okara substitution could indicate a lighter crust colour than the control. Sample 60%W: 40%K with the highest *L** value), could implies the lightest crust colour among the bread samples. Higher *L** values for bread with okara-powder agree with the consumer response (Table 3) with increased score values for crust colour. This assumption is further strengthened as shown in Fig. 2, which indicates darker colour of crusts. The darker colour of crusts is synonymous with a reduction in *L** values in the composite bread samples. The hydrolysis of these biopolymers increases the reactant potentials for the Maillard reaction; hence, resulting to a pronounced rate of the non-enzymatic browning and consequently a darker bread crust colour formation.

Table 4. Effect of okara substitution into wheat flour on breads' sensory attributes and consumer willingness-to-buy the bread

		Bread sensory attributes							
Bread samples	Willingness to buy	Overall acceptability	Shape	Aroma	Flavour	Crumb texture	Taste	Crust colour	Crumb colour
100%W:0%K	6.00^b	6.44^b	6.68^b	6.52^b	6.12^b	6.20^b	5.48^c	7.00^ab	6.72^c
90%W:10%K	7.24^a	7.36^a	6.84^ab	6.56^b	6.84^ab	6.60^ab	6.76^b	6.96^b	7.04^bc
80%W:20%K	6.88^ab	7.44^a	6.96^ab	7.00^ab	7.08^a	6.72^ab	7.60^ab	7.32^a	7.44^abc
70%W:30%K	7.56^a	7.40^a	7.40^ab	7.60^a	7.32^a	6.96^ab	7.20^ab	7.24^a	7.52^ab
60%W:40%K	7.76^a	8.16^a	7.60^a	7.36^ab	7.44^a	7.32^a	7.84^a	7.52^a	7.88^a

Bread volume is an important quality attribute of bread. A higher specific volume of bread indicates good quality bread and could attract wide rated consumer preference, whereas the reduction in the bread specific volume is considered an undesirable feature. Low loaf volume obtained in this study could be due to the increasing addition of okara to wheat flour. This finding agrees with previous studies on breads that showed a reduction in bread volume after adding oat fibre and pineapple peel fibre (Mironeasa *et al.,* 2019). The decrease in loaf volume and specific volume of bread samples could be attributed to increasing substitution of wheat flour with okara powder. This could because okara is gluten-free and might have led to decrease the viscoelastic power of wheat flour by diluting the gluten-potential of the wheat flour during dough formation. Furthermore, the addition of fibre-rich dietary ingredients despite diluting wheat protein, it also disrupts and weakens the gluten-viscoelastic network, thereby limiting gas retention and bubble development during the baking process (Mustapha et al., 2021). Furthermore, because of this occurrence, the bread structure becomes more compact, lowering the porous structure of the bread volume. The addition of okara powder to the control bread enhanced the dietary fibre content, lowering its density.

Essentially, the hydrogen bonds between the hydroxyl groups of the fibre structure and the free water molecules, are reportedly to contribute to the product's improved water retention, might be responsible for increase in the observed moisture content. As a result, the more fibre there is, the more moisture content. The increase in the fibre and ash content of composite flours can be attributed to the incorporation of okara powder rich in fibre and ash (Mustapha *et al.,* 2021) compared with the composite breads. The increase in fibre content in the composited bread samples could be due to the presence of dietary fibre in okara. Okara-based breads could be considered functional bread as they contained higher fibre content. An increase in fibre content could promote the health of consumers by facilitating the digestion of food in the colon, due the presence of roughage in fibre (Mironeasa *et al.,* 2019).

High-total ash content due to increasing addition of okara could be an indication that okara is rich in mineral elements. An increase in the protein content can be ascribed to an increase in the level of okara in wheat flour. This is quite expected because okara is reportedly by many researchers, a good source of protein (Mustapha *et al.*, 2021; Pešic *et al.,* 2023). Okara contains nearly 15% to 40% proteins, with essential amino acids as the pre-dominants. The significantly higher protein content in okara-based bread than the control may be attributed to the substantial amount of protein in okara powder compared to wheat flour. Also, the observed decrease in the crude fat content of okara-based bread samples implies that okara is low in crude fat and increasing the addition of okara powder further reduced the fat content in the composite bread. Bread samples displayed an increase in carbohydrate content with okara powder addition. This increase could be that okara powder has more starch content and so adds to the total carbohydrate content of the composite breads. The energy value of the composite bread increases. This could be attributed to the increase in carbohydrate and decrease in fat contents recorded for the bread samples, as shown in Table 3.

The bread containing 40% okara powder had almost the same sensory quality as the control. The darker crust colour (Fig. 2) could be that okara powder, which is dark has contributed to the colour (brown or dark) of bread. The crumb texture, which was observed by panellists as rough, could be attributed to the presence of more fibre, which was contributed by okara used for the study. The addition of okara powder to wheat flour could be responsible for the intense flavour perceived in the composite breads. Intense flavour that, the protein-rich okra powder's may have produced more flavour compounds arising from the browning reaction between the amino groups and the reducing groups of the carbohydrates, thus contributing to perceived intense flavour in bread. The control was least preferred probably due of the crust colour, which was less brown than those of okara-based samples. Though, the taste and flavour of okara breads were the more preferred, probably due to the aromatic compounds from okara powder. The latter may have stimulated the interest of consumers to show 'willingness-to-buy' the okara based bread.

Conclusion and Future works

This study shows that an acceptable bread with good sensory quality can be produced from wheat flour and okara powder blends. The bread with 40% okara powder has physical quality similar to that of the control in terms of loaf volume and specific volume. Breads' firmness and crust colour did not show much difference with the control. Bread formulated with 40% okara powder has the highest preference by the panellists. The application of okara powder in bread making could further strengthen the opportunity for consumers of bread to buy the product at a low cost. Therefore, this approach could be a promising strategy to reduce the accumulation of okara, a food by-product, prevents environmental pollution, and improves economic benefits of okara through value addition and enhancing higher consumer patronage with pleasant sensory properties.

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