



## **Comparative Study on Consumer Acceptability of Bread Produced with Composite Flour Fermented by Yeast Isolated from Palm Wine and Stale Bread**

**T. Bolaniran<sup>1</sup>, D. J. Arotupin<sup>1</sup>, O. I. Afolami<sup>1\*</sup> and O. F. Fasoranti<sup>1</sup>**

<sup>1</sup>Department of Microbiology, Federal University of Technology, P.M.B. 704, Akure, Ondo State, Nigeria.

### **Authors' contributions**

*This work was carried out in collaboration between all authors. Author DJA supervised the study. Authors TB and DJA designed the study and managed the analyses of the study. Authors TB and OIA performed the statistical analysis, wrote the protocols and the first draft of the manuscript. Author OFF managed the literature searches. All authors read and approved the final manuscript.*

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### **ABSTRACT**

This study investigated the sensory acceptability of bread produced from composite flour (wheat, air potato and cassava) fermented using yeasts from palm wine and stale bread among prospective consumers at the Federal University of Technology (F.U.T), Akure, Nigeria. Different blend ratios (A-F) of composite flour containing wheat, cassava and air potato flours were formulated; proximate and mineral analysis of representative flours were carried out according to standard procedures set by A.O.A.C., 2012. A descriptive sensory evaluation was carried out to assess bread products (A-F) produced from the different composite flour blends as sensory evaluators were selected by cross sectional simple random sampling techniques. The organoleptic parameters accessed for the bread products include taste, aroma/texture, appeal/appearance and overall consumer acceptability index respectively. Bread products A<sub>1</sub>-F<sub>1</sub> were fermented by yeast isolated from palm wine while products A<sub>2</sub>-F<sub>2</sub> were fermented by yeast from stale bread. Products A<sub>1</sub>-C<sub>2</sub> were adjudged standard controls for

\*Corresponding author: E-mail: [afolamiolufemiifeoluwa@gmail.com](mailto:afolamiolufemiifeoluwa@gmail.com);

Air potato flour (A), Wheat flour (B) and Cassava flour (C) while products D<sub>1</sub>-F<sub>2</sub> were the test bread products of varying formulation blends of the composite flour. All the bread products (A<sub>1</sub>-F<sub>2</sub>) were evaluated and compared statistically at p ≤ 0.05 level of significance. The Bread products D<sub>2</sub> and F<sub>1</sub> had the highest overall acceptability (99.90±0.10%) followed by E<sub>1</sub> (88.89±1.11%) while D<sub>1</sub>, E<sub>2</sub>, and F<sub>2</sub> stood (66.67±1.33%) acceptance respectively. The findings of this research revealed realistic potentials of air potato flour supplemented with wheat and cassava flours respectively and the alternative sources of yeasts isolate clones that can be specifically used in fermenting different flour blends for production of widely accepted bread products in Nigeria.

**Keywords:** Air potato; composite flour; yeast; sensory evaluation; overall acceptability.

## 1. INTRODUCTION

Bread is an important staple food in Nigeria and all over the world, with an exponential increase in consumption over recent years [1-3]. The rising cost of bread production in Nigeria is due to a variety of factors, chief amongst them been the importation of wheat flour, one of the major ingredients in bread production [2-5]. Wheat flour is suitable for bread production because of its gluten content; a protein which aids excellent formation of bread dough during fermentation, however, many locally made Nigerian flour products lacks adequate levels of gluten protein to enable them compete effectively as suitable alternatives to wheat flour [2-4]. There have been therefore lots of researches carried out to discover suitable alternatives to wheat flour that can be used to bake bread thereby reducing the demand for wheat and also improve the economic value of locally made flour products in Nigeria [3-5]. While research efforts were originally geared towards blending several locally made flours from starch derived Nigerian crops with wheat flour to obtain appropriate blends suitable for bread production, efforts are now channeled towards supplementing wheat flour with locally made flours to improve the nutritive value and market acceptability of bread products in Nigeria [1,3,5]. There have been reports of bread made from flour of cereal grains such as rye, maize, barley, oats, and flours from root tubers like cassava and cocoyam have also been supplemented in blends with wheat flour for bread production [4,5].

Cassava (*Manihot esculenta Crantz*) a common root tuber is consumed extensively in Nigeria as a major staple food [2,6]. Nutritionally, cassava is a major source of dietary energy for low income consumers in many parts of Nigeria [1-3,7]. Despite being a cheap source of food calories, cassava is nutritionally deficient in essential amino acids but rich in arginine [8]. Its use in the

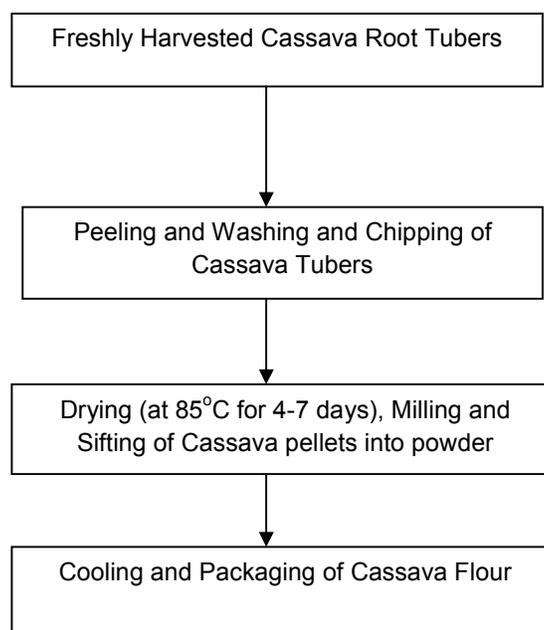
production of bread as composite flour has been reported in [1,3,4]. Air potato (*Dioscorea bulbivora*) is a true yam species in the family Dioscoreaceae and it has attracted scientific interests owing to its numerous therapeutic applications which have been attributed to its unique phytochemistry [6,8]. The yam species is highly underutilized in Nigeria and only consumed in some rural areas despite its immense health benefits [8]. *Dioscorea bulbifera* has been reported to be a good source of protein, lipids and crude fibers; making it an alternative suitable flour source for bread production [1-4,8].

In Nigeria, baked products are fermented by Baker's yeast (*Saccharomyces* spp), however, findings have shown that yeasts from other natural sources can also effect qualitative fermentation processes of baked products for consumption [9,10]. The use of composite flour and yeasts from different sources has the potential to conserve the foreign exchange spent on wheat importation and also add value to indigenous crops like air potato and cassava locally grown in Nigeria [1,3,10]. Hence, this study investigated the sensory acceptability of bread produced from composite flour (wheat, air potato and cassava) fermented using yeasts isolated from palm wine and stale bread among prospective consumers at the Federal University of Technology (F.U.T), Akure, Nigeria.

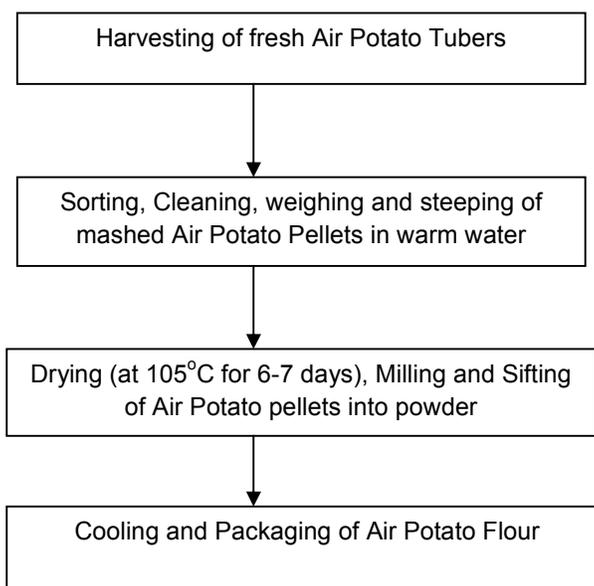
## 2. MATERIALS AND METHODS

### 2.1 Production of Composite Flour

The dried unfermented cassava and air potato flour was prepared by adopting the method of [11-13] as indicated in Figs. 1 and 2. Already prepared wheat flour was sourced from commercial vendors at the main market of the Akure metropolis.



**Fig. 1. Flowchart for production of cassava flour [14]**



**Fig. 2. Flowchart for production of Air Potato Flour [13]**

## 2.2 Proximate Analysis of Composite Flour

The Association of Official Analytical Chemist (A.O.A.C, 2012) protocols were adopted to determine the proximate and mineral compositions of the wheat flour, cassava flour and air potato flour respectively [14-16]. The moisture content, ash content, crude fiber

content, crude protein content, fat content, carbohydrate content, water and oil absorption capacity and swelling index were all determined using the A.O.A.C, 2012 protocols as described in [13,15,17]. Moreover, mineral elements compositions of the composite flour were analyzed for calcium, iron, potassium, manganese, sodium and zinc contents respectively [16,17].

### 2.3 Isolation of Yeasts from Palm Wine

Freshly trapped palm wine samples were obtained from local farmers at the F.U.T. Junction area of the Akure Metropolis into sterile labeled universal bottles and analyzed in the laboratory for mycological investigations within 6hr of collection. The methods described in [5,7] were adopted for water sample preparation and inoculum standardization in which sterile distilled water was used as diluents and a 1ml of the palm wine stock was taken aseptically into 9ml of sterile distilled water for serial dilution procedure in sterile test tubes under aseptic conditions. The third and fourth dilutions were estimated for yeast colony forming units on Potato Dextrose Agar (P.D.A) fortified with 0.1% lactic acid [5,7]. The plates were incubated at 30°C for 3-5 days for optimal growth and the fourth dilution plates were established as inoculum standards for the isolation of yeasts due to easy numerical estimation of the colony forming units. Distinct colonies were identified by macro and microscopic morphology using cotton-blue-in-lacto phenol dye and viewed under high power oil immersion lens of the microscope, after which the identified yeast colonies were confirmed as *Saccharomyces* spp by sub-culturing on freshly prepared Yeast extract Agar and incubated at 30°C for 3-5 days [5,7]. The obtained pure isolates of the yeast were preserved on P.D.A slants and stored at 4°C [5,7].

### 2.4 Isolation of Yeasts from Stale Bread

Stale bread samples of about 5-10 days after baking were obtained from local food vendors at the Akure South Local Government Area of the Akure Metropolis into sterile containment packs and analyzed in the laboratory for investigations within 6hr of collection [5,7]. Inoculum standardization, sample preparation, identification and confirmation of the distinct colonies of *Saccharomyces* spp were done in similar manner as described above for isolation of yeasts from palm wine samples [5,7]. The obtained pure isolates of the yeast were also preserved on P.D.A slants and stored at 4°C [5,7].

### 2.5 Formulation of Composite Flour Blends

Different composite flour blends were obtained using different ratios of Air Potato flour, Cassava flour and Wheat flour respectively by modifying the blend ratios of composite flour described in

[1-3,12-14,18]. The six flour ratios obtained were 100% Air Potato Flour (A), 100% Cassava flour (B), 100% Wheat flour (C), Air Potato flour/Wheat flour (50%/50%) (D), Air Potato flour/Cassava flour (50%/50%) (E) and Air Potato flour/Wheat flour/Cassava flour (40%/40%/20%) (F) respectively. The blend ratios are 200 g of Air potato flour for blend A, 200 g of Cassava flour for blend B, 200 g of Wheat flour for blend C, 100 g each of Air potato flour and Wheat flour for blend D, 100 g each of Air potato flour and Cassava flour for blend E and 80 g of Air potato flour, 80 g of Wheat flour and 40 g of Cassava flour for blend F respectively.

### 2.6 Production of Bread from Different Composite Flour Combinations

The different composite flour combinations A, B, C, D, E and F were all baked into bread products by yeasts isolated from both palm wine and stale bread following standard procedures of dough mixing, fermentation, punching, scaling, moulding, proofing, baking, cooling and de-panning respectively as described separately in the findings of [11-14,17,18]. The products were labeled (A<sub>1</sub>-F<sub>1</sub>) for bread products fermented by yeasts isolated from palm wine while bread products fermented by yeasts isolated from stale bread were denoted (A<sub>2</sub>-F<sub>2</sub>) respectively.

### 2.7 Description of Study Area used for Sensory Evaluation

The Federal University of Technology, Akure is found in Ondo State, Nigeria with coordinates 7°16' N 7°18' N/ 5°9' E 5°11' E [17,19]. It is located at the extreme southern region of the Akure South Local Government Area of Ondo state, Nigeria [17,19].

### 2.8 Sensory Evaluation of Bread samples

A simple random sampling method was adopted to obtain 18 students as evaluators in the study area (Federal University of Technology, Akure Campus) to assess the organoleptic properties and the overall consumer acceptability of the different bread samples produced (A-F). The organoleptic properties assessed include the taste, the aroma/texture, appeal/appearance of the products and overall acceptability by the consumers [1-7]. The authors made the evaluators assess the bread products separately at different interval of time to avoid bias, a method adopted and described in the findings of

[10-14]. Each evaluator rated the bread products independently of the authors on a hedonic scale ranging from 7 (moderately liked) to 9 (extremely liked) [2-5,18]. The bread samples A ( $A_1$ ,  $A_2$ ), B ( $B_1$ ,  $B_2$ ), and C ( $C_1$ ,  $C_2$ ) served as controls while bread products  $D_1, D_2$ ,  $E_1$ ,  $E_2$ ,  $F_1$  and  $F_2$  were the test products of interest. All bread products were nevertheless rated by the evaluators. The raw scores were expressed in percentages and analyzed statistically using the method described in [17,18].

## 2.9 Data Analysis

Analyzed bread products were in triplicates; data means obtained for evaluation ratings of the organoleptic properties of the bread products were subjected to a 2-way analysis of variance and the means were separated using Duncan's New Multiple Range test at  $P \leq 0.05$  level of significance [10-14].

## 3. RESULTS

The comparative proximate compositions (Carbohydrate, Ash, Fat, Fiber, Moisture and Protein contents) and mineral compositions (Calcium, Iron, Potassium, Manganese, Sodium and Zinc contents) of the different flours (Air potato flour, Wheat flour and Cassava flour) used in composite flour formulations were analyzed separately and reported at  $P \leq 0.05$  levels of significance as represented in Figs. 3 and 4. Air potato flour has the highest carbohydrate content ( $90.35 \pm 1.58\%$ ) while Cassava flour has the lowest content ( $37.58 \pm 1.64\%$ ); The Ash contents of Air potato flour was also the highest with ( $2.51 \pm 0.28\%$ ) while the ash contents of wheat and cassava flours respectively are not significantly different at the specified level of confidence. The fat contents of the three flours are however not significantly different at  $P \leq 0.05$  level of significance, although wheat flour has the highest fiber content ( $2.50 \pm 0.25\%$ ) while the fat contents of air potato and cassava flours are not significantly different at the specified level of significance. Cassava flour has the highest moisture content ( $61.40 \pm 2.20\%$ ) while wheat flour has the lowest moisture content ( $3.67 \pm 1.10\%$ ); alternatively, wheat flour has the highest protein content of  $11.37 \pm 1.21\%$ , while cassava flour is very low in protein content with just  $1.97 \pm 0.28\%$  concentration.

Moreover, the comparative mineral compositions of the flour samples also gave an insight into

their nutritive suitability for bread production. Air potato was discovered to have the highest calcium content at  $52.30 \pm 2.20\%$  while Cassava has the least concentration at  $20.00 \pm 1.50\%$ . The iron, zinc and manganese concentrations of all the three flours were not significantly different at the specified level of significance while wheat flour has the highest potassium concentration at  $87.50 \pm 2.50\%$  and cassava has the lowest at  $30.2 \pm 1.80\%$  concentration. On the other hand however, the sodium concentration of air potato flour was the highest ( $89.40 \pm 1.69\%$ ) while wheat has a comparatively low concentration at  $1.73 \pm 0.24\%$ . The results above signified an important edge that air potato flour possess as a suitable alternative for bread production compared to wheat flour while cassava flour is comparatively a poor alternative to wheat flour.

Furthermore, the sensory evaluation results gave useful information on the preferences of consumers to both the control bread products (A-C) and the test bread products (D-F). The evaluation indexes of the bread products ( $A_1 - F_1$ ) fermented by yeasts isolated from palm wine are represented in Table 1 with respect to the organoleptic properties (taste, appeal/appearance, texture/aroma) and overall acceptability of the bread products. Alternatively, the evaluation indexes of the bread products ( $A_2 - F_2$ ) fermented by yeasts isolated from stale bread are represented in Table 2 with respect to the organoleptic properties (taste, color/appearance, texture/ smell) and overall acceptability of the bread products.

The evaluation scores of the test bread products are represented in Tables 1 and 2; they are expressed in percentages of the 18 evaluators at  $p \leq 0.05$  level of significance and the evaluation scores of the hedonic scale 7-9 represents the acceptability of the bread products by the evaluators; a standard described in [1-7,10-14, 17,18]. Products  $F_1$  and  $D_2$  have the highest evaluation score  $99.90 \pm 0.10\%$  for taste of the test bread products followed by  $E_2$  and  $F_2$  at  $77.87 \pm 1.23\%$ ,  $E_1$  with a score of  $66.67 \pm 1.33\%$  and  $D_1$  with  $55.57 \pm 1.47\%$  respectively (Tables 1 and 2). The evaluation score for the appeal/appearance of the bread products were also similar to that of the taste as products  $F_1$  and  $D_2$  have an evaluation score of  $77.87 \pm 1.23\%$  followed by  $F_2$  at  $44.44 \pm 1.56\%$ ,  $E_2$  and  $E_1$  at a score of  $33.33 \pm 1.67\%$  while  $D_1$  had a very low evaluation score of  $11.11 \pm 1.89\%$  (Tables 1 and 2).

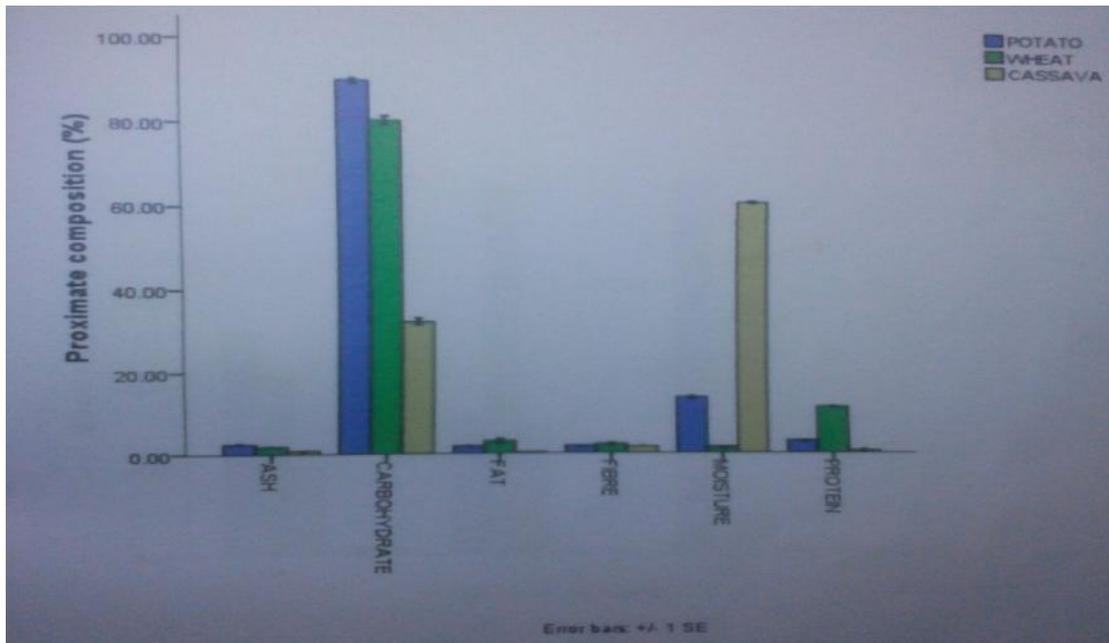


Fig. 3. Comparative proximate components of air potato flour, wheat flour and cassava flour used in composite bread production

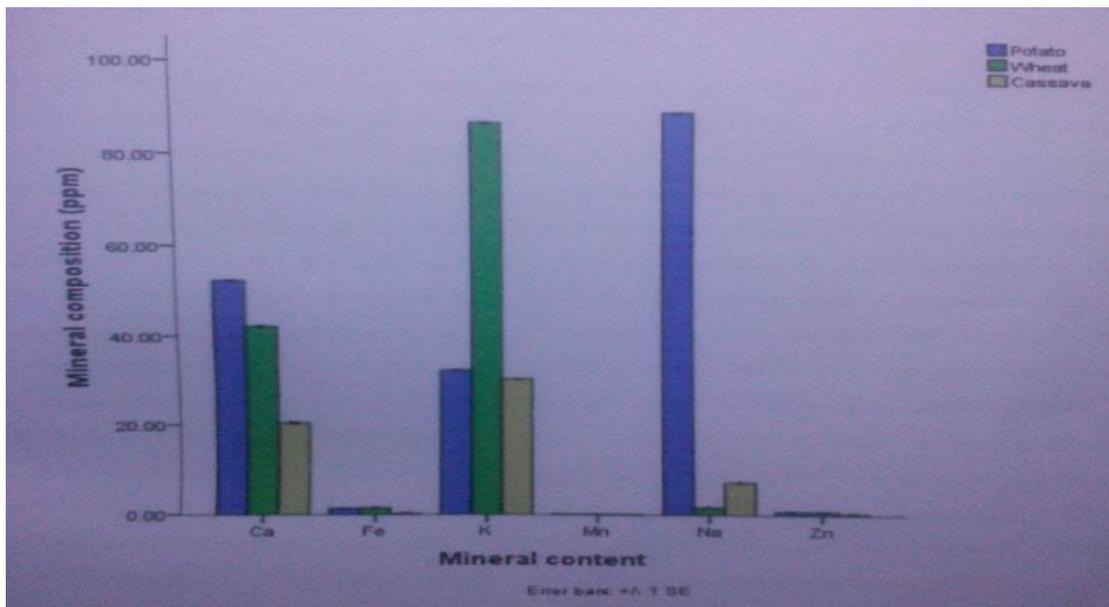


Fig. 4. Comparative minerals of air potato flour, wheat flour and cassava flour used in composite bread production

Conversely, the evaluation score of the texture/aroma of the test bread products also followed the same pattern as bread products F<sub>1</sub> and D<sub>2</sub> had the highest evaluation score in this category too at 99.90±0.10% while E<sub>2</sub> had a score of 77.87±1.23%, F<sub>2</sub> and E<sub>1</sub> had the same

score at 66.67±1.33% while product D<sub>1</sub> had its score at 55.57±1.47% respectively (Table 1 and 2). The overall acceptability of the test bread products were also estimated by the evaluators and analyzed at p≤0.05 levels of significance as bread products F<sub>1</sub> and D<sub>2</sub> had excellent

acceptability at an overall score of  $99.90 \pm 0.10\%$  while the test product  $E_1$  had an overall acceptability at  $88.78 \pm 1.12\%$  and products  $D_1$ ,  $F_2$  and  $E_2$  had the same overall acceptability index at  $66.67 \pm 1.33\%$  respectively as represented in Table 3.

#### 4. DISCUSSION

Recent efforts described in many findings are geared towards supplementing wheat flour with other flours from different crops locally produced in Nigeria for cost effective production of bread

**Table 1. Sensory evaluation scores of the bread products  $A_1$ -  $F_1$  fermented by yeast from palm wine**

H. Scale	Sensory Evaluation Scores of Bread Products for Taste (%)					
	$A_1$	$B_1$	$C_1$	$D_1$	$E_1$	$F_1$
7	$22.22 \pm 1.78^c$	$22.22 \pm 1.78^c$	$33.33 \pm 1.69^d$	$33.33 \pm 1.69^d$	$33.33 \pm 1.69^d$	$11.11 \pm 1.89^b$
8	$11.11 \pm 1.89^b$	$00 \pm 00^a$	$22.22 \pm 1.78^c$	$22.22 \pm 1.78^c$	$00 \pm 00^a$	$44.44 \pm 1.56^e$
9	$22.22 \pm 1.78^c$	$00 \pm 00^a$	$00 \pm 00^a$	$00 \pm 00^a$	$33.33 \pm 1.69^d$	$44.44 \pm 1.56^e$
H. Scale	Sensory Evaluation Scores of Bread Products for Appeal/Appearance (%)					
	$A_1$	$B_1$	$C_1$	$D_1$	$E_1$	$F_1$
7	$11.11 \pm 1.89^b$	$22.22 \pm 1.78^c$	$33.33 \pm 1.69^d$	$00 \pm 00^a$	$11.11 \pm 1.89^b$	$33.33 \pm 1.69^d$
8	$11.11 \pm 1.89^b$	$00 \pm 00^a$	$11.11 \pm 1.89^b$	$00 \pm 00^a$	$22.22 \pm 1.78^c$	$33.33 \pm 1.69^d$
9	$11.11 \pm 1.89^b$	$00 \pm 00^a$	$00 \pm 00^a$	$11.11 \pm 1.89^b$	$00 \pm 00^a$	$22.22 \pm 1.78^c$
H. Scale	Sensory Evaluation Scores of Bread Products for Texture/Aroma (%)					
	$A_1$	$B_1$	$C_1$	$D_1$	$E_1$	$F_1$
7	$11.11 \pm 1.89^b$	$22.22 \pm 1.78^c$	$22.22 \pm 1.78^c$	$11.11 \pm 1.89^b$	$33.33 \pm 1.69^d$	$11.11 \pm 1.89^b$
8	$33.33 \pm 1.69^d$	$22.22 \pm 1.78^c$	$22.22 \pm 1.78^c$	$44.44 \pm 1.56^e$	$33.33 \pm 1.69^d$	$55.57 \pm 1.43^f$
9	$00 \pm 00^a$	$00 \pm 00^a$	$00 \pm 00^a$	$00 \pm 00^a$	$00 \pm 00^a$	$33.33 \pm 1.69^d$

Keys: H. Scale- Hedonic scale, 7- moderately liked, 8- like very much, 9- liked extremely,  $A_1$ - 100% air potato flour fermented by yeasts from palm wine,  $B_1$ - 100% wheat flour fermented by yeasts from palm wine,  $C_1$ - 100% cassava flour fermented by yeasts from palm wine,  $D_1$ - 50% air potato flour + 50% wheat flour fermented by yeasts from palm wine,  $E_1$ - 50% air potato and 50% cassava flour fermented by yeasts from palm wine,  $F_1$ - 40% air potato flour + 40% wheat flour + 20% cassava flour fermented by yeasts from palm wine. Values with the same superscript have no difference at  $p \leq 0.05$  level of significance. Bread products  $A_1$ -  $C_1$  are control bread products while  $D_1$ -  $F_1$  are test bread products

**Table 2. Sensory evaluation scores of the bread products  $A_2$ -  $F_2$  fermented by yeast from stale bread**

H. Scale	Sensory Evaluation Scores of Bread Products for Taste (%)					
	$A_2$	$B_2$	$C_2$	$D_2$	$E_2$	$F_2$
7	$11.11 \pm 1.89^b$	$22.22 \pm 1.78^c$	$55.57 \pm 1.43^f$	$44.44 \pm 1.56^e$	$22.22 \pm 1.78^c$	$22.22 \pm 1.78^c$
8	$11.11 \pm 1.89^b$	$33.33 \pm 1.69^d$	$00 \pm 00^a$	$55.57 \pm 1.43^f$	$55.57 \pm 1.43^f$	$55.57 \pm 1.43^f$
9	$33.33 \pm 1.69^d$	$00 \pm 00^a$				
H. Scale	Sensory Evaluation Scores of Bread Products for Appeal/Appearance (%)					
	$A_2$	$B_2$	$C_2$	$D_2$	$E_2$	$F_2$
7	$22.22 \pm 1.78^c$	$22.22 \pm 1.78^c$	$00 \pm 00^a$	$22.22 \pm 1.78^c$	$11.11 \pm 1.89^b$	$00 \pm 00^a$
8	$66.67 \pm 1.33^g$	$00 \pm 00^a$	$55.57 \pm 1.43^f$	$55.57 \pm 1.43^f$	$22.22 \pm 1.78^c$	$44.44 \pm 1.56^e$
9	$00 \pm 00^a$	$33.33 \pm 1.69^d$	$00 \pm 00^a$	$00 \pm 00^a$	$00 \pm 00^a$	$00 \pm 00^a$
H. Scale	Sensory Evaluation Scores of Bread Products for Texture/Aroma (%)					
	$A_2$	$B_2$	$C_2$	$D_2$	$E_2$	$F_2$
7	$44.44 \pm 1.56^e$	$11.11 \pm 1.89^b$	$11.11 \pm 1.89^b$	$11.11 \pm 1.89^b$	$55.57 \pm 1.43^f$	$11.11 \pm 1.89^b$
8	$55.57 \pm 1.43^f$	$22.22 \pm 1.78^c$	$33.33 \pm 1.69^d$	$77.78 \pm 1.22^g$	$22.22 \pm 1.78^c$	$55.57 \pm 1.43^f$
9	$00 \pm 00^a$	$00 \pm 00^a$	$00 \pm 00^a$	$11.11 \pm 1.89^b$	$00 \pm 00^a$	$00 \pm 00^a$

Keys: H. Scale- Hedonic scale, 7- moderately liked, 8- like very much, 9- liked extremely,  $A_2$ - 100% air potato flour fermented by yeasts from stale bread,  $B_2$ - 100% wheat flour fermented by yeasts from stale bread,  $C_2$ - 100% cassava flour fermented by yeasts from stale bread,  $D_2$ - 50% air potato flour + 50% wheat flour fermented by yeasts from stale bread,  $E_2$ - 50% air potato and 50% cassava flour fermented by yeasts from stale bread,  $F_2$ - 40% air potato flour + 40% wheat flour + 20% cassava flour fermented by yeasts from stale bread. Values with the same superscript have no difference at  $p \leq 0.05$  level of significance. Bread products  $A_2$ -  $C_2$  are control bread products while  $D_2$ -  $F_2$  are test bread products.

**Table 3. Overall acceptability of bread products A<sub>1</sub> to F<sub>2</sub>**

Overall acceptability Bread Products fermented by yeasts from palm wine (%)					
A <sub>1</sub>	B <sub>1</sub>	C <sub>1</sub>	D <sub>1</sub>	E <sub>1</sub>	F <sub>1</sub>
66.67±1.33 <sup>b</sup>	33.33±1.69 <sup>a</sup>	66.67±1.33 <sup>b</sup>	66.67±1.33 <sup>b</sup>	88.89±1.11 <sup>c</sup>	99.90±0.10 <sup>d</sup>
Overall acceptability Bread Products fermented by yeasts from stale bread (%)					
A <sub>2</sub>	B <sub>2</sub>	C <sub>2</sub>	D <sub>2</sub>	E <sub>2</sub>	F <sub>2</sub>
77.78±1.22 <sup>c</sup>	66.67±1.33 <sup>b</sup>	55.57±1.43 <sup>a</sup>	99.90±0.10 <sup>d</sup>	66.67±1.33 <sup>b</sup>	66.67±1.33 <sup>b</sup>

Keys: A<sub>1</sub>- 100% air potato flour fermented by yeasts from palm wine, B<sub>1</sub>- 100% wheat flour fermented by yeasts from palm wine, C<sub>1</sub>- 100% cassava flour fermented by yeasts from palm wine, D<sub>1</sub>- 50% air potato flour + 50% wheat flour fermented by yeasts from palm wine, E<sub>1</sub>- 50% air potato and 50% cassava flour fermented by yeasts from palm wine, F<sub>1</sub>- 40% air potato flour + 40% wheat flour + 20% cassava flour fermented by yeasts from palm wine, A<sub>2</sub>- 100% air potato flour fermented by yeasts from stale bread, B<sub>2</sub>- 100% wheat flour fermented by yeasts from stale bread, C<sub>2</sub>- 100% cassava flour fermented by yeasts from stale bread, D<sub>2</sub>- 50% air potato flour + 50% wheat flour fermented by yeasts from stale bread, E<sub>2</sub>- 50% air potato and 50% cassava flour fermented by yeasts from stale bread, F<sub>2</sub>- 40% air potato flour + 40% wheat flour + 20% cassava flour fermented by yeasts from stale bread, values with the same superscript have no difference at p≤0.05 level of significance. Bread products A<sub>1</sub>- C<sub>1</sub> and A<sub>2</sub>- C<sub>2</sub> are control bread products while D<sub>1</sub>- F<sub>1</sub> and D<sub>2</sub>- F<sub>2</sub> are test bread products respectively.

and improvement of its nutritive value [3,5,20]. It was generally observed that variations in the species of the yeast isolate clones used in the fermentation of the different composite flour blends had a direct relationship on the quality of bread products produced; this was also similar in the findings of [20,21]. However, since the identification of the yeast isolates used was only done at the genus level (*Saccharomyces* spp), several recent Nigerian literature texts from research findings in [2-5,20,21] have revealed that different species of *Saccharomyces* ferment flour blends and other carbohydrate substrates differently and hence produce varying degrees of textures, appeal and aroma of the products fermented.

Moreso, the findings of [5,7] revealed that the variations in the population of the different isolates in the genus *Saccharomyces* spp in Palm wine and Stale bread isolated across different Nigerian states effected a wide range array of products produced in fermentation of carbohydrate substrates used. In similar findings that agree with the assertion above, high populations of *Saccharomyces carlsbengensis* and *Saccharomyces cerevisiae* were abundant in palm-wine while *Saccharomyces globus* was the most abundant specie of *Saccharomyces* isolated from stale bread; this explains differences in dough formation, fermentation time and arrays of by-products formed in the fermented products of these findings [7,17]. Therefore, since palm wine and stale bread were the sources of yeasts used in the fermentation of different flour blends adopted in this study, the variations in the taste, aroma, appeal and texture of the bread products is justified as the recent findings cited above suggests that the yeasts

isolated in this study has varying population clones of *Saccharomyces* [5,7,17].

In the findings of [21-23], the yeast isolated from stale bread *Saccharomyces globus* was discovered to be less osmophilic (less sugar loving affinity) and less hydrophilic; hence products fermented by this yeast had poor dough qualities, less impacted taste flavors and less acceptability. The same finding in [21-23] also suggests that products fermented by isolates of *Saccharomyces carlsbengensis* and *Saccharomyces cerevisiae* had better dough qualities, good impacted taste flavors and a favorable acceptability; this is mainly because palm wine contains high sucrose levels (10-12%) and these yeast species are highly osmophilic and hydrophilic.

Consequently, the bread products F<sub>1</sub> and E<sub>1</sub> are the most acceptable of the bread products fermented by yeasts from palm wine; a closer observation at the composite flour blends of these two products (composite blends E and F) reveals that the two blends (E and F) contains proportionate amount by mass of high sugar rich flour contents with blends E (50% Air potato/50% Cassava) and F (40% Air potato, 40% wheat, 20% cassava) having high combined levels of sugar, fibers and protein levels; hence encouraging optimal dough formation of the bread products F<sub>1</sub> and E<sub>1</sub> by the yeast isolates from palm wine (*Saccharomyces carlsbengensis* and *Saccharomyces cerevisiae*). This was justified in the findings of [12-14,24].

Similarly, the product D<sub>2</sub> was the most acceptable test product fermented by yeasts from stale bread; in a recent finding cited earlier

[23], it was also discovered that asides been less osmophilic, the yeast from stale bread (*Saccharomyces globus*) requires higher concentrations of mineral elements (particularly calcium and sodium) and mild protein levels for its metabolism. Interestingly, the composite blend D (50% Air potato/ 50% wheat) is rich in high mineral element levels and has mild protein concentrations as reflected in the proximate and mineral elements evaluation in the results section. This explains the excellent acceptability of the bread D<sub>2</sub> fermented by yeast from stale bread as described also in the findings of [21-23, 25]. A closer look at the acceptability of the control bread products will reveal that bread A<sub>2</sub> also had a favorable acceptability index due similar reasons as blend A is composed of 100% Air potato [24-26].

## 5. CONCLUSION

The high acceptability indexes obtained from the different bread products containing air potato flour in the findings of this research consolidated the recent research efforts channeled towards discovering other alternative flour sources to wheat flour. The findings of this research has given an insight into the enormous potential of air potato flour supplemented with wheat and cassava flours respectively to produce widely accepted bread products. These findings also reveal the potential alternative sources of yeasts isolate clones that can specifically used in fermenting different flour blends for commercial production of widely accepted bread products by prospective consumers in Nigeria.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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