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Evaluation of Functional and Sensory Attributes of Bread Samples Made from African Yam Bean (*Sphenostylis stenocarpa*) and Corn (*Zea mays*) Seeds Flour Blends.

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ABSTRACT

Background: *The development of new food products necessitates the need to evaluate their applicability in local diets.*

Objectives: *The study evaluated the functional and sensory properties of bread made from African yam bean (Sphenostylis stenocarpa) and corn (Zea mays) seeds flour blends.*

Materials and Methods: *African yam bean (AYB) (roasted at 191^{0}C for 40 min) and corn seeds (oven-dried at 50^{0}C for 24 h) were finely milled, and formulated into 5 flour samples in the ratios of 70): 30 (AYB: Corn), 50: 50 (AYB: Corn), 30: 70 (AYB: Corn), 100: 0 (AYB: Corn), and 100: 0 (AYB: Corn), to yield one-third ($^1/_3$) of the daily dietary fiber requirement (12.7 g) of a reference man (70 kg). The 5 samples and the control (wheat flour) were baked into bread and evaluated for functional and sensory attributes using standard procedures. Data generated were analyzed using the IBM Statistical Product for Service Solution (version 21.0) and presented as means and standard deviations. The means were compared with Analysis of variance and significance was accepted at $p < 0.05$.*

Results: *The functional properties of the bread samples ranged from 0.73 to 0.87g/ml bulk density, 1.77 to 3.09g/ml water absorption capacity, 0.86 to 2.16g/ml oil absorption capacity, 8.42 to 16.71% foam capacity, 1.18 to 3.43g/ml foam stability and 17.39 to 79.53^{o}C gelatinization temperature. There was a significant increase ($p <0.05$) of the oil absorption capacity, water absorption capacity, bulk density, foam capacity, and swelling index; and a decrease in the gelation temperature of composite samples. Sensory scores ranged from 4.80 to 7.70 taste, 4.03 to 7.73 flavor, 4.73 to 7.63 texture, 4.77 to 7.63 appearance, 4.80 to 7.33 mouthfeel, 4.73 to 7.61 general acceptability. There was a significant difference ($p <0.05$) between the control and the study samples.*

Conclusion: *The bread could increase available foods and add variety to consumer diets.*

INTRODUCTION

Bread is a fermented food product usually made from wheat flour, water, yeast, and salt by a series of processes involving mixing, kneading, proofing, shaping, and baking (Dewettinck *et al.,* 2008). It is an important staple food in both developing and developed countries, and a major source of carbohydrates, and energy. Bread can also contribute other nutrients like protein, fiber, vitamins, and minerals in the diets of many people worldwide (Aider *et al.,* 2012). It is a widely consumed ready-to-eat convenient food, most often taken solely, or as part of a meal for breakfast, lunch, and sometimes dinner. In Nigeria, bread is the second most widely consumed non-indigenous food product after rice (Oluwajoba *et al.* (2012). It is consumed extensively in most homes, restaurants, and hotels. Previously produced from wheat as major raw material, it is relatively expensive as wheat is imported into the country (Edema *et al.,* 2005). The importation of wheat flour takes a significant part of the national income given the existing nutrition challenges in the country. Currently, Nigeria is listed second to Somalia in the mass undernutrition of its citizens [National Nutrition and Health Survey, 2018]. Evidence suggests that there is existing food insecurity and undernourishment in the country, with as much as 21.4%, and 14.6% of Nigerians food insecure, and undernourished respectively (Sasu, 2022; Knoema, 2022). These people are constantly hungry, without food, money, and other resources. The level of undernourishment is accelerating with an annual rate of 5.65% (Knoema, 2020). The situation is aggravated by the increasing population and subsequent rise in food demand, coupled with non-consumption of indigenous food, widespread intake of highly refined and processed high-fat foods with gross inactivity due to market globalization, industrialization, and urbanization which pre-disposes many to increased health challenges.

Efforts to improve food security through the development of new foods from indigenous food crops are pertinent. The substitution and gradual replacement of wheat flour with indigenous flour will help to conserve the country's resources to allow for improved intervention in nutrition. Already, bread can be made from flour from other food crops such as maize, barley, oat, or cassava in combination with wheat flour. Nigeria is blessed with abundant food crops most of which are threatened by extinction due to non-consumption and adoption of a westernized diet. Examples include African yam bean, pigeon pea, millet, sesame seeds to mention but a few. These crops can be used with popular crops like corn, oat, barley, cassava, potatoes, etc. to formulate, composite flours of high nutrient density. Corn or Maize (*Zea mays*) for instance is the second most widely produced cereal crop globally. It has varied nutrients compositions including carbohydrates, fat, fiber, and many important vitamins and minerals, like potassium, phosphorus, zinc, calcium, iron, thiamine, niacin, vitamin B6 and folate (Watson, 1997). Although corn flour is nutritionally superior to other cereals in many ways, it has a very low protein value (Mejia, 2003). Its protein is made up of zein, which is low in two essential amino acids, lysine, and tryptophan, a characteristic that can be corrected by grinding the whole corn to obtain flour that contains more protein, fiber, starch, vitamins, and minerals (Mejia, 2003). African yam bean (*Sphenostylis stenocarpa*) is a lesser-known and underutilized legume that is very rich in protein, carbohydrate, vitamins, and minerals (Wokoma and Aziagba, 2001). It is a tuberous legume, that belongs to the class *Magnoliopsida;* order *Fabales;* family *Fabaceae;* subfamily *Papilionoideae;* and genus *Sphenostylis.* Its duo-food products (grain and tuber) make it an economic crop with high nutrient density. It has also been reported to contribute to the management of chronic diseases like diabetes, hypertension, and cardiovascular diseases (Enwere, 2018; Henry-Unaeze and Ngwu, 2018; 2020; Ndidi *et al*., 2014; Ojinnaka *et al*., 2017; Onuoha *et al*., 2017). The high protein composition suggests a good protein source in the diets of population groups of many tropical countries. Usually, African yam bean (AYB) seeds can be roasted and eaten with palm kernels as snacks or boiled and eaten with local seasoning, starchy root crops, and fruits (Eneche, 2006). The basic challenge to AYB wide consumption is the anti-nutrient contents of the seed and the hardness of the seed which results in longtime cooking (Aremu and Ibirinde, 2012; Abioye *et al*., 2015). This necessitates alternative processing and utilization method to prevent non-consumption and promote cultivation. The combination of popular cereal (corn) with a lesser-known legume (AYB) with high protein value is a value addition strategy that will supplement the amino acids that are deficient in corn, improve nutrient intake and provide variety in food products. Development of new foods requires ascertaining the physicochemical attributes and consumer acceptability, it is thus necessary to evaluate the functional and sensory properties of corn and AYB seeds flour made baked bread.

MATERIALS AND METHODS

Study design: The study employed an experimental study design.

Collection and identification of raw materials

Corn and African yam bean (AYB) seeds were purchased from different stalls in New Market Aba, Abia State Nigeria. The seeds were identified by an agronomist E. N. in the Department of Crop and Soil, Michael Okpara University of Agriculture, Umudike.

Raw material preparation

Processing of corn and AYB seeds into flour: The seeds of corn and AYB were sorted to remove stones and other extraneous materials, washed with tap water, and drained in a colander. Gallenkemp oven (300 Plus, England) was used to dry the corn seeds at 50 ºC for 24h. The seeds were finely milled in an attrition mill (7hp China), placed in an air-tight container, and stored inside the refrigerator. AYB seeds were roasted at 191^{0}C on the medium gas mark for 40mins with continuous stirring, then milled finely into flour, packaged in polyethylene bags, and refrigerated until use.

Formulation of composite flour: The method described by Henry-Unaeze and Ngwu (2020) was adopted to formulate the flour samples into ratios of 70%(AYB): 30%(Corn), 50%(AYB): 50%(Corn), 30%(AYB): 70%(Corn), 100%(AYB), and 100% (Corn), and measured in quantities of 70.85g (70% AYB:30% corn), 82.84g (50% AYB:50%corn), 94.81g (30% AYB:70% corn), 52.87g (100%AYB), 112.79g (100% corn) that will contribute 1/3 (12.7g) of the daily dietary fiber intake of a reference man (70kg). The samples were coded as B01, B02, B03, B04, and B05 respectively. The control B06 was 100% wheat flour (118.69g) calculated from Food and Agriculture Organization, (1998) to provide 12.7g dietary fibre and coded as sample B06.

Preparation of the bread samples

Sanfuel and Darko (2010) straight dough method of baking bread was used to produce bread from the study samples. All the ingredients (flour, sugar, egg, milk, yeast, fat, salt, and water) were mixed for 5minutes in a plastic bowl into a dough, covered with a damp clean muslin cloth, and allowed to prove for 55mins at 29^{o}C. The dough was knocked back and molded into a loaf, placed in a bread tin, further proved in a prolonged cabinet for 90mins at 85 relative humidity, and baked at 250^{o}c for 45 minutes. The bread was removed from the oven, placed in a rack to cool, and packaged in Ziploc bags ready for use.

Determination of functional properties of bread samples made from African yam bean and corn seeds flour blends: The functional properties (bulk density, water absorption capacity, oil absorption capacity, foam capacity, foam stability, swelling index, and gelatinization temperature) were determined using Onwuka (2005) methods.

Determination of sensory properties of bread samples made from African yam bean and corn seeds flour blends: Sensory evaluation was performed on the bread samples using 30 panelists comprising of students randomly selected from the College of Applied Food Sciences and Tourism, Michael Okpara University of Agriculture, Umudike. The bread samples were evaluated for color, flavor, texture, taste, and general acceptability with a 9-point Hedonic scaling ranging from 1= disliked extremely and 9 = Liked extremely as described in (Iwe, 2010).

Statistical analysis: Data generated were analyzed using analysis of variance (ANOVA), and means were separated using Duncan's Multiple Range Test (DMRT) at a 5% level of probability ($p \leq 0.05$). The IBM Statistical Product for Service Solution version (23.0) was used for the analysis.

RESULTS

The functional properties of bread samples made from African yam bean and corn seeds flour blends are presented in Table I. Bulk density (BD) of all the samples ranged from 0.73 to 0.87g/ml. There was no significant ($p \leq 0.05$) difference between samples B0I ((30% AYB: 70% corn flour) and B03 (70% AYB: 30% corn flour); B02 (50% AYB: 50% corn flour) and B04 (100% AYB flour); and B05 (100% Corn flour) and B06 (100% wheat flour) respectively. The water absorption capacity (WAC) of all the bread samples was significantly different at $p \leq 0.05$, and ranged from1.77 to 3.09g/ml. The oil absorption capacity of the bread samples ranged from 0 86 to 2.16g/ml and were significantly different at $p \leq 0.05$. The foam capacity, foam stability, and gelation temperature ranged from 8.42 to 16.71%, 1.18 to 3.34g/ml, and 17.38 to 79.53^{o}C respectively, and were significantly different at $p \leq 0.05$.

Table 1: FUNCTIONAL PROPERTIES OF BREAD SAMPLES MADE FROM AFRICAN YAM BEAN AND CORN SEEDS FLOUR BLENDS

Sample	Bulk density (g/ml)	Water Absorption capacity (g/ml)	Oil Absorption Capacity (g/ml)	Foam Capacity (%)	Foam Stability (g/ml)	Gelatinization Temperature (^{0}C)
B01	0.87^a ±0.02	2.22^c ±0.01	2.01^c ±0.01	9.32^d ±0.02	3.43^a±0.03	60.90^d ±0.02
B02	0.82^{ab} ±0.01	2.24^c ±0.01	2.10^b ±0.01	8.74^e ±0.01	3.11^b±0.03	63.00^c ±0.00
B03	0.87^a ±0.01	3.09^a ±0.03	2.16^a ±0.01	12.53^b±0.01	2.27^c±0.01	79.53^a ±0.03
B04	0.82^{ab} ±0.03	1.91^d ±0.01	0.86^e ±0.03	8.42^f ±0.01	2.22^d±0.01	17.39^e ±2.14
B05	0.73^c ±0.03	3.02^b ±0.01	2.10^b ±0.01	10.40^c±0.01	1.18^f±0.01	62.54^c ±0.01
B06	0.77^c ±0.01	1.77^e ±0.01	1.16^d ±0.01	16.71^a±0.01	1.48^e±0.01	75.70^b ±0.01

Values are mean ± standard deviation of duplicate samples.
$^{a-f}$ Means with similar superscripts within the same column are not significantly different ($p \leq 0.05$)
Key: B01– (30% AYB: 70% corn flour)
B02– (50% AYB: 50% corn flour)
B03– (70% AYB: 30% corn flour)
B04– (100% AYB flour)
B05– (100% Corn flour)
B06– Control (100% Wheat flour)

The sensory properties scores of bread samples made from AYB and corn seeds flour blends show a significant difference at p≤0.05. The scores ranged from 4.80 to 0.07 taste, 4.03 to 7.73 flavor, 4.73 to 7.63 texture, 4.77 to 7.63 appearance, 4.80 to 7.33 mouth feel, and 4.73 to 7.61 general acceptability. Taste (6.03), texture (6.13), and appearance (5.80) scores of sample B05 (100% Corn flour) were rated second to the reference/control sample B06 (100% Wheat flour) which scored 7.07, 7.63, and 7.63 respectively; while B01 (30% AYB: 70% corn flour) had flavor (6.03) and general acceptability (6.09) second to the reference sample B06 (100% Wheat flour) scores of 7.73 and 7.73 respectively .

Table 2 Sensory Attributes of Bread samples made from African Yam Bean and Corn Seeds Flour Blends

Sample	Taste	Flavor	Texture	Appearance	Mouthfeel	GA. CAL
B01	6.07^b ±2.00	6.03^b ±1.77	5.27^{bc} ±1.78	5.13^b ±2.19	7.97^a±17.37	6.09^b±4.06
B02	5.60^{bc}±1.89	5.20^{bc} ±1.81	5.40^{bc} ±1.92	5.10^b ±2.01	5.23^a ±2.05	5.31^{bc}±1.49
B03	4.97^c ±2.28	4.03^d ±2.08	4.77^c ±1.91	4.77^b ±2.57	5.10^a ±2.47	4.73^c±1.82
B04	4.80^c ±2.19	4.47^c ±2.03	4.73^c ±2.29	5.07^b ±2.32	4.80^a ±2.72	4.77^c±1.93
B05	6.30^b ±2.00	5.83^b ±2.18	6.13^b ±2.11	5.80^b ±2.02	5.66^a ±1.95	5.95^{bc}±1.81
B06	7.70^a ±1.86	7.73^a ±1.60	7.63^a ±1.65	7.63^a ±1.97	7.33^a ±2.17	7.61^a±1.64

Values are mean ± standard deviation of duplicate samples.
$^{a-c}$ Means with similar superscripts within the same column are not significantly different ($p > 0.05$)
Key: B01– (30% AYB: 70% corn flour)
B02– (50% AYB: 50% corn flour)
B03– (70% AYB: 30% corn flour)
B04– (100% AYB flour)
B05– (100% Corn flour)
B06– Control (100% Wheat flour)
GA.CAL – General Acceptability Calculated (i.e. Average of the five sensory Attributes)

DISCUSSION

The result showed significant differences ($p<0.05$) in the functional parameters of the bread samples. All the study samples except sample B05 had higher bulk density than the reference sample, but comparable to the 0.65 to 0.85 g/ml obtained in Omidiran et al. (2021) and 0.32 to 0.51g/cm^3 in Okafor and Ugwu (2014). This could be attributed to the fiber contents of the study samples and in line with Akubor's (2007) description of bulk density as an indication of the porosity of a product and a function of flour wettability which influence packaging design and is used in determining the required type of packaging material. The water absorption capacity of all the study bread samples was higher when compared with the reference sample B06 (100% wheat flour) and those reported by Omidiran et al (2021) but similar to Dogo *et al*. (2018) where there was an increase of water absorption capacity with increase in African yam bean. The samples' high water absorption capacity (WAC) could be due to differences in processing methods and crop type. WAC is indicated when flour is incorporated into aqueous food formulation especially, those involving dough handling. Butt and Baool (2010) revealed that high WAC is good for baked products which require hydration to improve handling features. Oil absorption capacity (OAC) reflects the emulsifying capacity of flour (Kaur *et al*., 2010) The oil absorption capacity (0.86 mg) of sample B04 (100% AYB flour) was lower than the Control B106 (100% Wheat flour) 1.16 mg/100g and all the other samples. There was a significant difference ($p<0.05$) among the samples analyzed except B102 (50% AYB: 50% corn flour) and B105 (100% corn flour) which did not differ from each other. Fat absorption is desired in bakery products, the OAC of the samples suggests that they have good flavor, increased palatability, and shelf life as discoursed by Aremu *et al*. (2007). Higher oil absorption capacity suggests better mouthfeel and flavor retention. The foam capacity of the different bread samples varied significantly ($p< 0.05$) and was all lower than the reference sample B06 (100% Wheat flour). The result contravenes Ajani *et al*. (2016) that reported decreases in foaming capacity with an increase in composite flour. The foam stability is the ability of the protein to stabilize against gravitational and mechanical stress. The foam stability of the composite samples was higher than the pure samples. Increasing substitution of AYB with corn increased the foam stability value of the products, although B05 ((100% corn flour)) had the lowest foam stability value. This is because of the high corn flour content in the sample. The significant difference ($p<0.05$) among the samples is in agreement with the works of Ajani *et al*. (2016) and Dogo *et al*. (2018) in the functional properties of wheat and corn flour blends. The ability of the gel structure to provide a metric to hold water, oil, flavor, and other additives is very useful in a variety of food products. The gelatinization temperature of the bread samples was significantly different from each other, comparable to the range 71.33 to 79.33^{0}C obtained by Omidiran et al. (2021) for yam starch, and lower than 80°C-90°C for soy protein gel (Raize, 2006). However, it is in line with the work of Ajani *et al*. (2016) and Okafor and Ugwu (2014) in the baking of ready-to-eat snacks produced from breadfruit, cornflour, and coconut flour.

There was a significant difference($p\leq0.05$) in the sensory parameters of all the study samples. The flavor of sample B03 (70% AYB: 30% corn flour) was disliked by all the panelists and sample B01 (30% AYB: 70% corn flour) had the highest mouthfeel score (7.97) compared to other bread samples including the reference sample B06 (100% wheat flour bread). A good mouthfeel indicates that the product is soft and can easily be chewed and acceptable to children and consumers with chewing problems (older persons). Samples B03 (70% AYB: 30% corn flour) and B04 (100% AYB flour) were generally not acceptable to the panelist, B02 (50% AYB: 50% corn flour) was neither liked nor disliked, while samples containing higher corn contents B01 (30% AYB: 70% corn flour) and B05(100% corn) were acceptable to the panelists. This is an indication that consumers prefer products with similar organoleptic properties to the control/reference. The general acceptability of the bread samples shows that higher substitution of AYB with cornflour (at 50 to 70% levels) leads to a significant ($p <0.05$) increase in general acceptability. This could be attributed to the reduction in the strong flavor of AYB which was not appreciated by the panelists.

CONCLUSION

Consumer nutrition knowledge and the interest to improve health through the consumption of nutrient-dense foods is on a steady increase. Consequently, the quest to increase the variety of available nutrient-dense meals initiated the employment of indigenous food crops in making convenient foods. This study bread samples made from nutritious African yam bean and corn seeds flour blends will not only increase nutrient density, but can add variety to daily meals, contribute to a reduction in the importation of wheat flour (as indigenous food crops are used in place of wheat); increase consumption and cultivation of the indigenous food crops, can also be used in the production of other local meals and bakery products such as fufu, biscuits, cookies, doughnuts, pie crust, and cakes. Nutrition education on the new foods will be communicated to the consumers through seminars, radio jingles, and workshops to encourage utilization.

Conflict of interest

None

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Author Contribution

H.N. articulated the title, directed the review, experimentation, manuscript, and final write-up, A.R. conducted the review and participated in the experimentation. Both authors endorsed the work.

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