GSC Biological and Pharmaceutical Sciences

eISSN: 2581-3250 CODEN (USA): GBPSC2

Cross Ref DOI: 10.30574/gscbps

Journal homepage: https://gsconlinepress.com/journals/gscbps/

(Research Article)

Quality evaluation of flour and biscuits produced from wheat and African Yam Bean Tempeh Flours

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GSC Biological and Pharmaceutical Sciences, 2021, 17(01), 124–132

Publication history: Received on 03 September 2021; revised on 07 October 2021; accepted on 09 October 2021

Article DOI: https://doi.org/10.30574/gscbps.2021.17.1.0303

Abstract

Biscuits are foodstuffs that are consumed all over the world as snacks on wide range developing countries where protein and caloric malnutrition are prevalent. There is therefore need to feed on functional foods with improved formulations and substantial health benefits by world nutrition bodies due to different health problems related to food consumption. This study was carried out to evaluate the proximate and functional properties of the flour as well as evaluate the biscuit samples for physical properties, anti-nutrient content, minerals composition and anti-oxidant properties of biscuits produced from wheat flour fortified with African yam bean tempeh flour. The physical parameters varied from 3.12 – 4.22mm, 1.30 –2.81, 4.59 – 6.89g, 1.5 – 2.4mm and 1.25 – 3.65N for diameter, spread ratio, weight, height, and break strength. The proximate composition of the flour varied from 0.05 – 3.46%, 12.6 – 28.74%, 0.84 – 3.18%, 1.37 – 3.76%, 58.64 – 84.74% and 2.22 – 11.4% for ash, protein, crude fiber, crude lipid, carbohydrate and moisture of the flour, respectively. The functional properties ranged from 14.66 – 20.2%, 0.70 – 0.78 (g/ml), 0.71 – 10.57%, 18.08 – 41.03% and 0.71 – 0.74% for water absorption capacity, bulk density, oil absorption capacity, foam capacity and emulsion capacity, respectively. The anti-nutritional properties ranged from 0.067%, – 0.437mg/100g, 0.013 – 0.067%, 0.112 – 0.146%, 0.015 – 0.038%, 0.168 – 0.401, 0.040 – 0.401%, 0.017 – 0.040% for tannin, phytate, saponin, oxalate, alkaloid, phenol and flavonoids, respectively. The anti-oxidant properties were in the range of 0.081 – 0.465%, 0.026 – 0.047%, 0.035 – 0041 mg/100g for scavenging activity, reducing power assay and Beta carotene, respectively. The mineral contents - iron, magnesium, calcium and phosphorus ranged from 4.18 – 13.06, 2.70 – 32.17, 61.04 – 201.42 and 3.76 – 30.42%, respectively. These results suggest that the fortification of wheat flour with Africa yam bean flour can improve the nutritional quality of biscuits.

Keywords: Biscuits; wheat; African yam bean tempeh flour; Dietary fibre; Quality attributes

1. Introduction

Malnutrition is often used specifically to refer to under nutrition, where there are minimal calories, protein or micronutrients in the food eaten by people [1]. The problem of malnutrition persists in Africa, partly because animal protein is unaffordable to the majority of the population [2]. It is one problem made more critical, by the expensive rate of population increase in Africa, where up to 200 million people are currently suffering from malnutrition due to famine and ravages of war [3]. The latter has brought about limitations in the source of high biological value proteins since there is heavy loss of livestock. There is therefore need to open up other sources of protein to satisfy a burgeoning human population.

Biscuits are one of the popular cereal foods, apart from bread, consumed in Nigeria. They are ready-to-eat, convenient and inexpensive food products, containing digestive and dietary principles of vital importance [4]. They are nutritive snacks produced from unpalatable dough that is transformed into appetizing product through the application of heat in

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the oven [5]. Their good eaten quality makes them attractive for protein fortification and nutritional improvements, particularly in children feeding programs, for elderly and low income groups [6]. Biscuits are prepared with fortified or composite flour to increase their nutritive value [7]. In Nigeria, ready-to-eat baked products (snacks) consumption is continually growing and there has been increasing reliance on imported wheat [8].

Tempeh is an Indonesia word referring collectively to a variety of fermented foods (typically tender – cooked legumes) bound together by a dense mycelium of fragrant white *Rhizopus* mold into compact cakes [9]. The major desirable aspects of tempeh are its attractive flavor, texture and certain nutritional properties. Fresh tempeh has a limited shelf life. Irrespective of storage temperature, fresh tempeh eventually turns brown, the beans becomes visible due to senescence of the fungal mycelium, the material softens and ammoniacal odours emerge [10]. Before cooking, tempeh contains 19.5% protein, compared with 17.9% for hamburger and 21% for chicken, on average. With its high protein content, tempeh serves as a tasty protein complement to starchy staples, and can substitute for meat or fish [11].

The African Yam Bean (AYB) (*Sphenostylis stenocarpa Hochst ex. A. Rich.*) is one of the under-utilized tropical African tuberous legumes found in Nigeria, Central African Republic, Gabon, Zaire and Ethiopia [12]. It is of special value considering that it has duo food products (grain and tuber). The high protein composition of AYB makes it an important source of protein in the diet of many tropical countries. The tuberous roots have a protein composition of 11–19%, while the seed have a protein composition of 21–29% with 3,270 kcal/kg metabolizable energy. The amino acid composition indicates that its methionine and lysine levels are equal to or better than those of soybean. However, the undesirable properties of AYB are similar to those of soybean which are mainly the beany flavour, possession of anti-nutritional components [13][14] and hard-to-cook defect. Kinsella [15] determined that there are four critical criteria determining the acceptability of new foods or food ingredients. This includes the nutritional value, safety, acceptability and cost. Through proper processing techniques and handling procedures, AYB products can be a safe food source, which is a good source of fiber, carbohydrate and minerals [16].

Wheat (*Triticum aestivum*) is a staple food in many parts of the world. It is adaptable to the wide range of environmental conditions [17]. Wheat based foods are a major source of nutrients in many regions of the world. In addition, wheat is also generally used as a source of carbohydrate that generates high glycemic response after ingestion [18]. It is also a substantive source of protein, vitamins and minerals, when consumed as a major component of diet. It is used extensively in many parts of the world for preparation of different types of breads and many other confectionaries, because of the unique properties of its protein (Gluten) which combines strength and elasticity required to produce bread, cookies, cakes and pastries [19].

2. Material and methods

2.1. Sources of Raw Materials

The African Yam Bean (AYB) seeds, wheat grains and other baking ingredients used in this study were obtained from Mile One market, Rivers state.

2.2. Production of Wheat Flour

The whole wheat grains were processed using the method described by Enwere [16]. Grains were cleaned from dirt, by sorting out contaminants such as sand, sticks and leaves, thereafter washed and oven dried. The dried whole wheat was milled using attrition mill and sieved into fine flour of uniform particle size, by passing it through a 75µm mesh filter and then stored in an air-tight container.

2.3. Production of African Yam Bean Tempeh Flour

African Yam Bean Tempeh flour was processed using the method described by Njoku et al., [20]. The dehulled seeds were cooked at 100°C for 45 minutes, after which excess water was drained and the seeds were allowed to cool to room temperature (25 – 30°C). The cooked seeds were transferred into a plastic container with perforated covers and inoculated with 5ml of spore suspension containing 10^4 cfu g^{-1}. The inoculated seeds were fermented at 35°C for up to 48 hours Three hundred and fifty grams of bean seeds of good quality was measured and soaked in 1.5 litres of tap water for 12 hours. The soak-water was drained and the seeds were manually dehulled. After fermentation, the African Yam Bean tempeh was oven dried at temperature 170 – 230°C for 12 hours to reduce the moisture content and then ground using wooden mortar and pestle and then sieved repeatedly to remove testa using a 75µm mesh filter to produce a uniform texture and then stored in an air tight container.

2.4. Blend Formation

The Wheat Flour and African Yam Bean Tempeh Flour were mixed at various proportions of 90:10, 80:20, 70:30, 60:40, 50:50 and 100:0 %, with 100:0 serving as the control. The measurements were accurately weighed using a standard compact analytical balance, according to the different blend ratios.

2.5. Production of Biscuits

In the Ihekoronye [21] method of biscuit production, measured quantities of sugar and fat (Margarine) were mixed together in a plastic bowl to a creamy paste. Next, the flour blends, common salt and sodium-bicarbonate were all mixed together in specific ratios as shown in table 1 to produce the dough. The dough was mixed manually for 15 minutes until a uniform smooth paste was obtained. The paste was rolled on a rolling board sprinkled with some flour to a uniform thickness using a wooden hard roller. Circular biscuits were cut (using a circular biscuit cutter of diameter 4cm), placed on a greased baking tray and kept at a normal room temperature for 2 hours to allow proper dough leavening. The biscuits were baked in an oven at a temperature of 184°C for between 15-20 minutes until a very light brown colour was formed. Thereafter, the biscuits were removed, allowed to cool, packaged in polythene bags and stored at a temperature of (28°C) prior to subsequent analyses and evaluation.

Table 1 Recipe for Biscuit Production

Sample	Wheat flour (%)	AYB Tempeh Flour	Salt (NaCl) (g)	Sugar (g)	Fat (g)	Sodium – bicarbonate baking powder (g)
A	100	0	1.0	30.0	20.0	2.0
B	90	10	1.0	30.0	20.0	2.0
C	80	20	1.0	30.0	2 0.0	2.0
D	70	30	1.0	30.0	20.0	2.0
E	60	40	1.0	30.0	20.0	2.0
F	50	50	10	30.0	20.0	2.0

2.6. Analysis of Physical Properties of Biscuits

The physical properties of the biscuits such as diameter, height, spread ratio, break strength and weight were determined according to the method described by Ayo et al., [22].

2.7. Determination of Functional Properties of the Composite Flour

2.7.1. Water and Oil Absorption Capacity of the Composite Flour

"Briefly, 2g of the flour sample was mixed with 20ml distilled water for water absorption and 20ml of oil for oil absorption in a Moulinex blender (model dep 3, France) at high speed for 30 seconds, samples were allowed to stand at 30°C for 30 minutes and centrifuged at 10,000 rpm for 30 minutes. The volume of the supernatant in a graduated cylinder was noted and the means of triplicate determinations were reported" [23].

2.8. Foaming Capacity and Stability of Sample

"For stability, the flour sample (0.5g) was blended for 30 minutes in distilled water (40ml) at top speed in a Moulinex blender. The whipped mixture was transferred into a 100ml graduated cylinder. The blender was rinsed with 10ml distilled water which was gently added to the graduated cylinder. Foam volume in the cylinder was recorded per sample after 30 minutes standing. Triplicate measurement was made for each sample and the mean average was recorded" [24].

2.9. Emulsion Capacity and Stability

"A flour sample (2g) and distilled water (100ml) was blended for 30 minutes in a Moulinex blender (model dep 3, France) at high speed (Ca. 100rpm). After complete dispersion, oil was added from a burette in streams of about 5ml. Blending continues until there was separation into two layers. Emulsification determinations was carried out at 30°C and expressed as grams of oil emulsified by 1g flour. Briefly sample of 4g was dispensed in distilled water (100ml). 100ml of oil was added at the rate of 12.5 per second while blending. Each sample was blended in a Moulinex blender at high speed for additional 60 seconds and transferred into a 250ml graduated cylinder. Volumetric changes in foam, oil and aqueous layers were recorded after three hours. Triplicate measurement was made and average results were recorded" [25].

2.10. Bulk Density Determination

The bulk density was studied following the method of Bankole et al. [26]. 30g of the flour sample was weighed into 100ml gradual cylinder and the initial volume noted. The cylinder was tapped continuously for 100 times to a constant volume, and the final volume recorded. The bulk density was calculated as the mass of the sample, divided by the volume at the end of the tapping.

2.11. Analyses of Proximate Properties of Flour and Biscuit Samples

Proximate analysis was carried out on the flour and biscuit samples that were produced. The following; moisture, ash, crude fiber, fat, protein and carbohydrate contents, were determined using the method as described by AOAC [27].

2.12. Mineral Analyses

"The ash that was obtained from the ash analysis earlier was used in the determination of the mineral contents. The ash was placed in porcelain crucible and few drops of distilled water was added, followed by 2ml of concentrated hydrophobic acid and 10ml of 20% HNO_3, all were evaporated on the hot plate. The samples were filtered through whatman filter paper into 100ml volumetric flask. The mineral elements; iron, magnesium and calcium were determined by atomic absorbance spectrophotometer. The phosphorus in the sample filtrate was determined using Vanadomolybdate reagent at 400nm using colorimetric method (Colorimeter SP 20, Bausch and Lamb)" [27].

2.13. Statistical Analyses

All determinations were performed in triplicates and results were expressed as mean values ± standard deviation (SD). Data were subjected to statistical analysis using SPSS software, Two-way analyses of variance (ANOVA).

3. Results and discussion

Plate 1 shows the harvested Tempeh (A), the Wheat flour (B), African Yam Bean Tempeh flour (C) and Biscuit samples (D).

3.1. Physical Properties of Formulated Biscuits

Table 2 shows physical attributes of the biscuits fortified with AYBTF. A significant variation ($p \leq 0.05$) was noticed in the spread ratio, weight, height, diameter and break strength of the formulated biscuits. The least was observed in sample E. The reduction in the weight of the biscuit could be due to an increase in the fat content of the AYBTF, as fat is light in weight [22].

The decrease observed in spread ratio with increase in the inclusion of AYB in the blend is attributed to both the dilution of the gluten protein and the availability of minimal water for gluten hydration [28].

The spread ratio determines the quality of the flour and its ability to rise [29]. The break strength decreased from 3.65 – 1.9 with increased addition of AYBTF. This could be attributed to the increase in the percentage of fat from the AYBTF which dilutes the protein and carbohydrate level. All these determine the hardness of the biscuit [30]. Lastly, inclusion of AYBTF in the blend results in decrease in the spread ratio from 2.81 – 1.3. Likewise, it results in a noticeable increase in the diameter of the biscuit from 3.2 – 4.22 respectively. Therefore, there is a relationship between the spread ratio and the diameter of the biscuit.

Plate 1 Harvested Tempeh (A), the Wheat Flour (B), African Yam Bean Tempeh Flour (C) and Biscuit Samples (D)

Table 2 Physical Properties of Formulated Biscuits

Biscuit samples	Diameter (mm)	Height (mm)	Spread ratio	Weight (g)	Break strength (N)
A	3.15±0.02	2.0 ± 0.1	2.32 ± 0.02	6.41 ± 0.2	2.15 ± 0.04
B	3.54±0.03	1.8 ± 0.2	2.03 ± 0.03	5.99 ± 0.3	2.50 ± 0.04
C	3.87±0.01	1.9 ± 0.1	1.96 ± 0.04	5.98 ± 0.4	2.10 ± 0.05
D	4.18±0.03	1.8 ± 0.1	1.80 ± 0.2	5.48 ± 0.5	1.90 ± 0.04
E	4.22±0.03	1.5 ± 0.2	1.30 ± 0.03	4.59 ± 0.4	1.25 ± 0.02
F	3.12±0.02	2.4 ± 0.3	2.81 ± 0.04	6.89 ± 0.5	3.65 ± 0.05

Values are mean of triplicate determinations ± standard deviation

Key: A = 90% wheat flour / 10% African yam bean tempeh flour; B = 80% wheat flour / 20% African yam bean tempeh flour; C = 70% wheat flour / 30% African yam bean tempeh flour; D = 60% wheat flour / 40% African yam bean tempeh flour; E = 50% wheat flour / 50% African yam bean tempeh flour; F = 100% wheat flour / 0% African yam bean tempeh flour

3.2. Mineral Composition of the Biscuits

Table 2 shows the mineral content of the biscuit fortified with AYBTF. It was observed that formulated biscuits contained minerals such as Iron, Calcium, Magnesium and Phosphorus. These minerals were recorded lowest in the control (sample F) and highest in sample E. Calcium is regarded as the most abundant mineral in the biscuit, and it ranged from 61.04 – 201.42mg/100g.

Table 3 Mineral Content of formulated biscuits

	A	B	C	D	E	F
Fe	9.85 ±0.001	10.96 ±0.002	11.18 ±0.001	11.34 ±0.002	13.06 ±0.001	4.18 ±0.001
Mg	24.19 ±0.001	24.38 ±0. 001	26.16 ±0.002	26.69 ±0.001	32.17 ±0.002	2.70 ±0.002
Ca	140.09 ±0.001	147.12 ±0.001	152.68 ±0.001	161.09 ±0.002	201.42 ±0.006	61.04 ±0.001
P	22.60 ±0.001	23.31 ±0.001	23.72 ±0.002	24.08 ±0.001	30.42 ±0.002	3.76 ±0.001

Values are mean of triplicate determinations ± standard deviation

Key: Fe = iron, Mg = Magnesium, Ca = Calcium, P = Phosphorus; A = 90% wheat flour / 10% African yam bean tempeh flour; B = 80% wheat flour / 20% African yam bean tempeh flour; C = 70% wheat flour / 30% African yam bean tempeh flour; D = 60% wheat flour / 40% African yam bean tempeh flour; E = 50% wheat flour / 50% African yam bean tempeh flour; F = 100% wheat flour / 0% African yam bean tempeh flour

3.3. Proximate Evaluation of Formulated Flour and Biscuits

The proximate composition of the formulated flour and biscuits are shown in tables 4 and 5. The moisture content of the flour and biscuits ranged from 2.22 – 11.4% and 8.13 – 11.39%. It is lower than the values recommended by FAO [31]. Moisture content is an indicator of shelf life stability [32].

Table 4 Proximate Composition of African Yam Bean Flour and Wheat Flour

Parameter	African Yam Bean Flour				Wheat Flour			
	1	2	3	Mean±Sd	1	2	3	Mean±Sd
Ash	3.47	3.45	3.46	3.46 ±0.01	0.05	0.05	0.06	0.05 ±0.01
Protein	28.73	28.73	28.75	28.74 ±0.01	12.59	12.60	12.61	12.6 ±0.01
Crude Fibre	3.19	3.19	3.16	3.18 ±0.02	0.83	0.85	0.85	0.84 ±0.01
Crude Lipid	3.76	3.76	3.76	3.76 ±0.00	1.37	1.37	1.37	1.37 ±0.00
Carbohydrates	58.63	58.63	58.66	58.64 ±0.02	84.73	84.73	84.75	84.74 ±0.01
Moisture	2.22	2.22	2.23	2.22 ±0.01	11.40	11.40	11.40	11.4 ±0.00

Values are mean of triplicate determinations ± standard deviation

Table 5 Proximate Composition of Formulated Biscuits

Parameters	A	B	C	D	E	F
Moisture (%)	8.27 ±0.12	8.14 ±0.01	8.84 ±0.01	8.21 ±0.01	8.62 ±0.01	11.39 ±0.01
Ash (%)	3.97 ±0.01	3.85 ±0.01	3.87 ±0.01	3.98 ±0.01	3.76 ±0.01	0.48 ±0.01
Crude Fibre (%)	1.73 ±0.01	1.76 ±0.01	1.82 ±0.01	1.87 ±0.01	2.21 ±0.01	0.82 ±0.01
Crude Lipid (%)	1.26 ±0.00	1.29 ±0.00	1.32 ±0.00	2.34 ±0.00	3. 45 ±0.00	1.42 ±0.01
Crude Protein (%)	15.75 ±0.01	16.22 ±0.01	16.69 ±0.01	17.47 ±0.01	19.52 ±0.01	12.62 ±0.01
Carbohydrate (%)	56.78 ±.010	56.67 ±0.02	56.43 ±0.01	55.38 ±0.02	53.87 ±0.02	60.65 ±0.01

Values are mean of triplicate determinations ± standard deviation

Key: A = 90% wheat flour / 10% African yam bean tempeh flour; B = 80% wheat flour / 20% African yam bean tempeh flour; C = 70% wheat flour / 30% African yam bean tempeh flour; D = 60% wheat flour / 40% African yam bean tempeh flour; E = 50% wheat flour / 50% African yam bean tempeh flour; F = 100% wheat flour / 0% African yam bean tempeh flour

Increase in moisture content enhances contamination and chemical reaction that can lead to a reduction in the quality and stability of the food. The protein content of flour and biscuit ranged from 12.60 – 28.74% and 12.62 – 19.54%. AYBTF and biscuits produced from blended samples showed significantly higher ($P \leq 0.05$) protein content than the wheat flour and biscuit produced from the control. The increase in the protein could be due to increase in the proportion of AYB in the blend. This is an indication that the composite flour can serve as a cheap source of protein to consumers and will help in solving the problem of energy malnutrition in developing countries. Then carbohydrate content ranged from 65.64 – 84.70% and 69.78 – 74.03%. A significant increase (P ≤ 0.05) was observed in carbohydrate with equal decrease in the protein content of the AYB in the blend. This shows that AYB is a rich source of protein, therefore blending it with other foods will decrease the carbohydrate content of the food produced. The ash content ranged from 0.05 – 3.47% and 0.48 – 3.98%. The high ash content of the flour and biscuit could be attributed to the fact that AYB seeds are rich in ash, which is in line with the assertion of Ojukwu et al. [33]. Ash content of food is an index that could be used to determine the mineral composition of that food. Ash is also facilitates the metabolism of compounds such as fats and carbohydrates.

The crude lipid ranged from 1.37 – 3.76% and 1.26 – 3.45%. The blending of WF with AYBTF showed a significant increase in the lipid content of the biscuits. Fat plays a crucial role in foods as it gives flavour and soft texture to the foods which makes it invaluable in food formulation, such as snacks [34].

3.4. Functional Properties of AYBTF at various Blend Ratios

The functional properties of the flour are shown in table 6. A significant variation was observed among the samples where we saw that the bulk density ranged from 0.70 – 0.78g/ml. Bulk density is a measure of the heaviness of the flour and it is generally affected by the particle size. The low value of the bulk density observed in this study facilitates easy packaging and transportation, which improves overall cost efficiency of the end bakery product [35].

The water and oil absorption capacities of the blends ranged from 14.66 – 20.20% and 0.71 – 10.57%. It increased progressively as the level of the AYBTF increased in the flour blend. Sample F had the highest values both for oil and water absorption capacities. For OAC, sample B had the least value, while for WAC, sample A had the least value. Both the water and oil absorption capacities are reported to be influenced by the nature and behavior of the seed micro molecules, especially protein and the nature of starch [36]. For the OAC, a significant variation (p ≤ 0.05) existed among the blends, while for WAC, no significant difference (p ≥ 0.05) existed among the blends. Foam capacity ranged from 18.08 – 41.03%. Samples A, B, C and E did not differ significantly. Foaming capacity contributes to dough formation and stability of the flour. A high foaming capacity is a criterion for good quality product [37]. Emulsion capacity ranged from 0.71 – 0.74%, and there was no significant variation (p ≥ 0.05) in the emulsion capacity among flours. This suggests that the flour blends may be used as good emulsifying agents, thereby prolonging the shelf life of baked goods [38]. The emulsion capacity denotes the maximum amount of oil that can be emulsified by flour dispersion [39].

Table 6 Functional Properties of Wheat Flour and AYB Composite Flour

Sample	Water Absorption Capacity (%)	Bulk Density(g/ml)	Oil Absorption Capacity (%)	Foam Capacity (%)	Emulsion Capacity (%)
A	14.66 ±0.00	0.71 ±0.00	0.81 ±0.00	41.03 ±0.01	0.71 ±0.00
B	14.67 ±0.01	0.71 ±0.01	0.71 ±0.01	41.03 ±0.01	0.71 ±0.02
C	14.68 ±0.01	0.70 ±0.01	0.80 ±0.00	41.03 ±0.06	0.71 ±0.02
D	15.10 ±0.01	0.71 ±0.02	0.82 ±0.01	35.75 ±0.18	0.73 ±0.02
E	15.14 ±0.01	0.76 ±0.01	0.83 ±0.01	40.40 ±0.01	0.71 ±0.01
F	20.20 ±0.01	0.78 ±0.01	10.57 ±0.02	18.08 ±0.01	0.74 ±0.01

Values are mean of triplicate determinations ± standard deviation

Key: A = 90% WF / 10% AYBTF; B = 80% WF / 20% AYBTF; C = 70% WF / 30% AYBTF; D = 60% WF / 40% AYBTF; E = 50% WF / 50% AYBTF; F = 100% WF / 0% AYBTF

4. Conclusion

The effect of the ratio of the blend on the quality of the biscuit made from Wheat Flour fortified with African Yam Bean Tempeh Flour has been assessed. This study showed that biscuit manufactured from blends of Wheat – AYBTF, when compared with 100% Wheat biscuits, contained improved nutritional attributes, such as increased protein, fiber, mineral and carbohydrates composition, which are essential in diet. The AYBTF gave a smooth texture and aroma to the biscuit, in addition to a brown colour. Results from this study showed the efficacy of incorporating AYBTF with Wheat Flour for production of baked goods can serve as an industrial scale resource for biscuit industries. This is of good economic importance in many developing countries such as Nigeria, in promoting the utilization of African Yam Bean seeds.

Compliance with ethical standards

Acknowledgments

The authors highly appreciate the management of university of Port Harcourt, and the department of microbiology in particular for making their laboratories available for this work. We are immensely grateful.

Disclosure of conflict of interest

The authors have not declared any conflict of interests.

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