Scientia Africana, Vol. 25 (No. 1), February, 2026. Pp 35-48
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PHYSICOCHEMICAL, NUTRITIONAL AND ANTIOXIDANT PROPERTIES OF BISCUITS PRODUCED FROM AFRICAN YAM BEAN TEMPEH FLOUR AND WHEAT FLOUR

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Received: 18-11-2025
Accepted: 13-01-2026

https://dx.doi.org/10.4314/sa.v25i1.3

Journal Homepage: http://www.scientia-african.uniportjournal.info
Publisher: Faculty of Science, University of Port Harcourt.

ABSTRACT

Foods rich in carbohydrates but low in protein have been identified as a contributing factor in malnutrition. To improve the situation, this study investigated the use of wheat flour fortified with protein-rich African yam bean Tempeh flour, to formulate biscuits with improved nutritional qualities. Six biscuit samples were produced from wheat (Triticum aestivum) and African yam bean seeds (Sphenostylis stenocarpa). The samples were prepared at different proportions (90:10, 80:20, 70:30, 60:40, 50:50 and 100%) and were subjected to chemical, anti-nutrient, anti-oxidant, mineral evaluations using standard methods of analysis. 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. Anti-oxidant properties ranged from 0.081 – 0.465%, 0.026 – 0.047%, 0.035 – 0.041mg/100g for scavenging activity, reducing power assay and Beta carotene, respectively. 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. pH value was 6.4 – 6.5. This study showed that the biscuits produced from the fortified flour blend were nutritionally better in all the parameters evaluated than biscuits produced from 100% wheat flour, therefore the possibility of producing nutritious biscuits from wheat flour fortified with African yam bean Tempeh flour is recommended to weary consumers and population set, whose health have been compromised, such as those suffering from protein energy malnutrition, diabetes and obesity.

Keywords: African, antioxidant, bean, biscuits, flour, nutritional, physicochemical, tempeh, whole-wheat, yam.

INTRODUCTION

The increase in snacks intake among people especially in developing countries, may be attributed to socio-economic development. Snacks often contain high calories and fat, but low protein and vitamin content (Sisay et al., 2024). Blending of wheat with low cost legume flour such as African yam bean tempeh flour in the production of biscuit will help in reducing the problem of protein insufficiency in such developing countries like Nigeria.

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 (Al-Mansoori et al., 2025). They are nutritive snacks produced from unpalatable dough that is transformed into appetizing product through the application of heat in the oven (Okunola et al., 2023). High demand for biscuits makes them attractive for protein fortification and nutritional improvements, particularly in children feeding programs, for elderly and low income groups (Garcia-Guttierrez et al., 2024). Biscuits are prepared with fortified or composite flour to increase their nutritive value. In Nigeria, ready-to-eat baked products (snacks) consumption is continually growing and there has been increasing reliance on imported wheat (El-Gwad et al., 2024).

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 (Barbosa-Canovas et al., 2025). 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 (Barbosa-Canovas et al., 2025). 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 (Teoh, 2024; Ratnaningsh et al., 2025).

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 (Dziki, 2023).. It is of special value considering that it is a duo food product (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 (Palanga et al., 2025) and hard-to-cook defect. Laureati, (2024) reported that there are four critical criteria that influences 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 (Palanga et al., 2025)

Wheat (*Triticum aestivum*) is a staple food in many parts of the world. It is adaptable to the wide range of environmental conditions (Dziki, 2023). 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 (Ade et al., 2012). 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 (Yousif *et al.,* 2025).

MATERIALS AND METHODS

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.

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Production of Wheat Flour

The whole wheat grains were processed using the method described by Enwere (1998). 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.

Production of African Yam Bean Tempeh Flour

African Yam Bean Tempeh flour was processed using the method described by Njoku et al., (1991). The dehulled seeds were cooked at 100^{o}C for 45 minutes, after which excess water was drained and the seeds were allowed to cool to room temperature (25 – 30^{o}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^{o}C for 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^{o}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.

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.

Production of Biscuits

In the Davidson (2023) 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^{o}C for 15-20 minutes until a very light brown colour was formed.

Storage

Biscuit samples were packaged and stored in polythene bags for five weeks at 28^{o}C, and 80% relative humidity, prior to subsequent analyses and evaluation

Determination of the Physical Characteristics of the Biscuits

As described by Ayo et al., (2007), "The weight of the biscuit was determined using a weighing balance with an accuracy of 0.1mg". The diameter of the biscuit was measured with a calibrated ruler. Three rows of the five well-formed biscuit were made and the height was measured. The biscuits were arranged horizontally edge to edge and the sum of the diameter was measured. The spread ratio was calculated as diameter divided by the height".

Spread Ratio = Diameter/Height

Weighing
(Quality products were used and good personal hygiene was observed)

↓

Sugar + fat
(Good personal hygiene was observed)

↓

Addition of composite flour
(Wheat flour + African yam bean tempeh flour)

↓

Common salt + sodium bicarbonate + water

↓

Mixing (Kenwood mixer model HM400)
(Proper equipment setting, supply of quality water, transfer equipment were sanitized)

↓

Cutting (Sanitized circular biscuit cutter used, good personal hygiene observed)

↓

Baking (Oven) 185°C for 15 – 20 minutes

↓

Cooling
(Good personal hygiene and manufacturing practices observed)

↓

Packaging (HDPE film)
(Proper personal hygiene and handling was observed)

↓

Storage
(Stored at recommended temperature)

Figure 3: Flow Chart for Biscuit Production

Anti-Nutrient Analyses

Determination of Alkaloid Content

Briefly, 5g of each sample was added to 50ml of 10% acetic acid in ethanol. The mixture was properly shaken and allowed to stand for 4 hours before filtering. The filtered sample was evaporated to one quarter of its original volume and drops of ammonium hydroxide were added to precipitate the alkaloids. The precipitate was filtered off with a pre-weighed filter paper and washed with a 1% ammonium hydroxide solution. The precipitate was oven dried for 30 minutes at 60°C and then weighed. The alkaloid content of the samples was determined using the equation below: % Alkaloid = $W_2 - W_1/W \times 100$, Where W is the initial weight of sample, W_1 refers to the

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weight of empty filter paper and W_2 refers to the weight of filter paper + the precipitate" (Onwuka, 2005).

Oxalate Determination in the Samples

In a 250 ml beaker with a cover glass, total oxalate was extracted from 1g of the sample to be analyzed and was added to 50ml HCL (2M) in a water bath at 80^{o}C for 15 minutes. Upper layer was collected after centrifugation for 15min at 300 rpm and filtered through a 0.45um cellulose acetate membrane. A 20µl sample was injected into HPLC system (Waters$^{(R)}$ chromatography system, Milford, U.S.A.) with UV detector (water(R), 486), set at 210nm. The chromatographic separation was carried out on a 300 x 7.8mm Biorad Amine ion exclusion column (HPX-87H), using an isocratic elution at 0.5ml/min with 0.0125m sulphuric acid in each sample was determined against a standard calibration curve of oxalic acid (100-500µg/ml) and expressed as mg oxalate in 100g sample. All samples were analysed and extracted in duplicate.

The percentage retention was defined as the amount of oxalate left in the sample after cooking. Percentage loss of oxalate was calculated as % TR = Oxalate content per g of cooked food x g of food cooking x 100 / Oxalate content per g of raw food x g of food before cooking" (Savage, Vanhanen, Mason & Ross, 2000).

Determination of Flavonoids in the samples

One gram of the biscuit sample was extracted in a soxhlet extractor with 100ml of ethanol for 1 hour and the extract was filtered. One millilitre of the extract was placed in a 10ml volumetric flask. Distilled water was added to make 5ml, and 0.3ml $NaNO_2$ (1:20), 3ml $AlCl_3$ (1:10) was also added. Five minutes later, 2ml (1M) litre of sodium hydroxide (NaOH) was added and it was totally made up to 10ml with distilled water. The solution was properly mixed and the absorbance was measured against the blank at 510nm with a M8500 UV-VISBLE Spectrophotometer (Taizhou Radio Factory). The flavonoid content was calculated using the linear equation below on the calibration curve. $A = 0.01069C – 0.001163$, r = 09998, Where A is the absorbance; C is the flavonoid content in Ug g^{-1}" (Enujiugha, 2010).

Determination of Tannin in the Samples

Five hundred milligram of the biscuit sample was weighed and put into a 100ml plastic bottle, 50ml of distilled water was added and shaken for 1 hour in a mechanical shaker. This was filtered into a 50ml volumetric flask that made up a mark. Thereafter, 5 ml of the filtrate was pipetted out into a tube and mixed with 3ml of 0.1M $FeCl_3$ in 0.IN hydrochloric acid and 0.008M potassium ferrocynide. The absorbance was measured with spectrophotometer at 120nm wavelength, within 10 minutes. A blank sample without extract was also prepared and absorbance was recorded at the same wave length.

A standard was prepared using tannic acid to obtain 10ppm and the absorbance was measured at the same wavelength of 120nm" (Oyeyinka et al. 2013). "In this method, ten grams of the sample was boiled with 50ml of ether for 15 minutes. Five milliliter of the extract was pipetted into a 50ml of ether flask, 10ml of distilled water was added, 2ml of ammonium hydroxide solution was also added. Thereafter, 5ml of concentrated amyl alcohol was added. The sample was made up to the mark and left to react for 30 minutes. The absorbance of the solution was recorded by using a spectrophotometer at wavelength of 505nm" (Obadoni & Ochuko, 2001).

Analyses of Anti-Oxidants

Determination of Scavenging Superoxide Radical of the samples

Briefly, five grams of each sample was dissolved in 100ml of methanol to achieve a concentration of 50mg/ml. The mixture was filtered through Whatman No.1 filter paper with a vacuum pump. Then, 10µl, 20µl, 30ul 40µl and 50µl aliquots of each extract was further diluted with methanol to achieve final concentrations of 50µg/ml, 100µl/ml, 150µ/ml, 200µl/ml and 250µl/ml, respectively.

Finally, 0.1ml of 0.3mM 22-diphenyl-1-picrylhydrazyl radical (DPPH) (in methanol) was added to each of the reaction mixtures and the whole set up was properly shaken and left in the dark for 30 minutes.

After the incubation period, the spectrophotometer was stabilized against a 2,2-diphenyl-1-picrylhydrazyl radical control (that is 1Ml of methanol), and the absorbance of each mixture was read using the spectrophotometer at 517nm. The scavenging activity was calculated with the equation below; % Scavenging Activity = Absorbance of control – Absorbance of sample/ Absorbance of control x 100" (Mensor, Menezes, Leitao, Reis, Santos, Coube & Leitao, 2001).

Reducing Power Assay Determination

"Two (2g) of each biscuits sample was dissolved in 40ml of methanol to give a stock concentration of 50mg/ml. The mixture was left overnight and then filtered through Whatman No.1 filter paper with a vacuum pump. The filtrate was brought up to 50ml with methanol to achieve a concentration of 40mg/ml, and then diluted to the following concentrations: 5mg/ml 10mg/ml, 15mg/ml, 20mg/ml, and 25mg/ml. The resulting solutions were used for the reducing power assay analysis. Briefly, 1ml of the extract, 0.5ml of phosphate buffer (0.2m, pH 6.6 and 2.5ml of potassium ferricyanide (instead of potassium hexacyanoferrate) solutions (1% in water) was placed in a test tube and incubated for 20 minutes at 50°C. The tubes were allowed to cool in crushed ice and 0.5ml of trichloroacetic acid (10% in H_20) was added to each tube. After centrifugation at 3,000g for 10 minutes, 1ml of the supernatant was mixed with an equal volume of distilled water and 0.1ml of ferric chloride solution (0.1% in water). The mixture was incubated for 10min and the absorbance was measured at 700nm using an UV spectrophotometer. A high reaction mixture indicated a greater reducing power" (Zhang, Wang & Xu, 2008).

Statistical Analyses

The results obtained were subjected to analyses of variation (ANOVA), and Duncan multiple range test (Duncan, 1995) was used to separate means where significant difference existed.

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

Table 2: Physical Properties of Formulated Biscuits

Biscuit samples	Diameter (cm)	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

Key:

A = 90% WF / 10% AYBTF'; B = 80% WF / 20% AYBTF; C = 70% WF / 30% AYBTF

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D = 60% WF / 40% AYBTF; E = 50% WF / 50% AYBTF; F = 100% WF / 0% AYBTF
AYBTF = African Yam Bean Tempeh Flour; WF = Wheat Flour

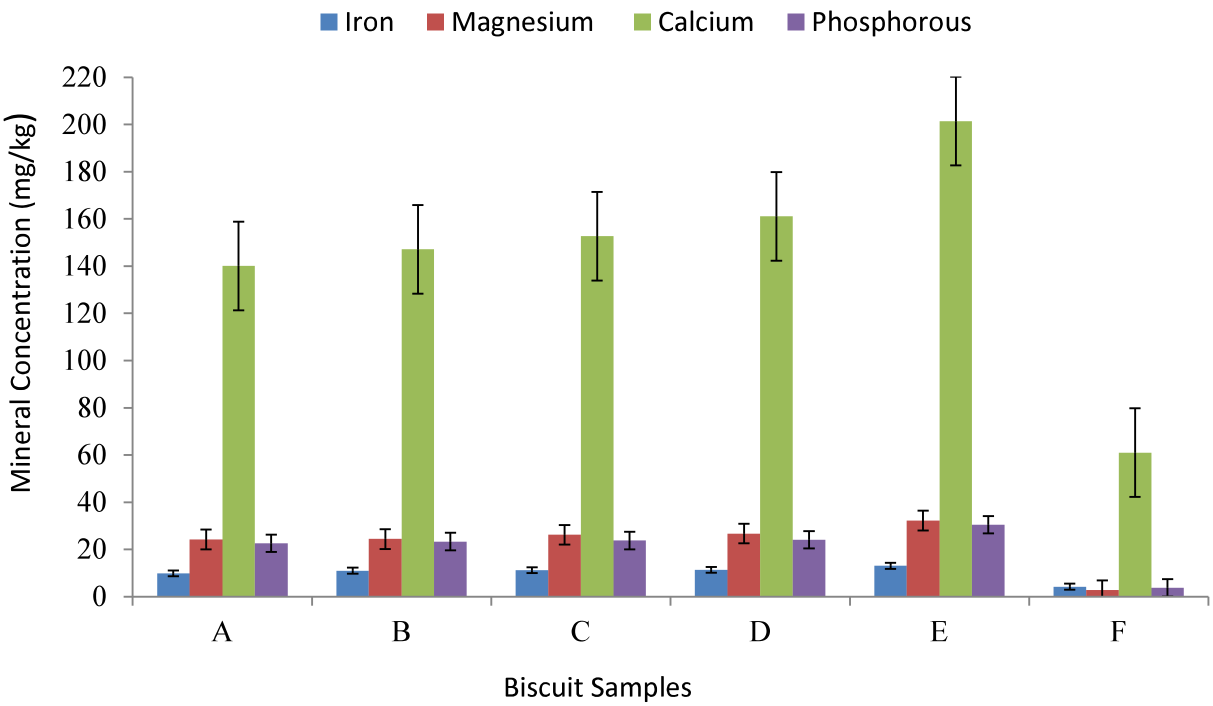

Figure 1: Mineral Content of Formulated Biscuits

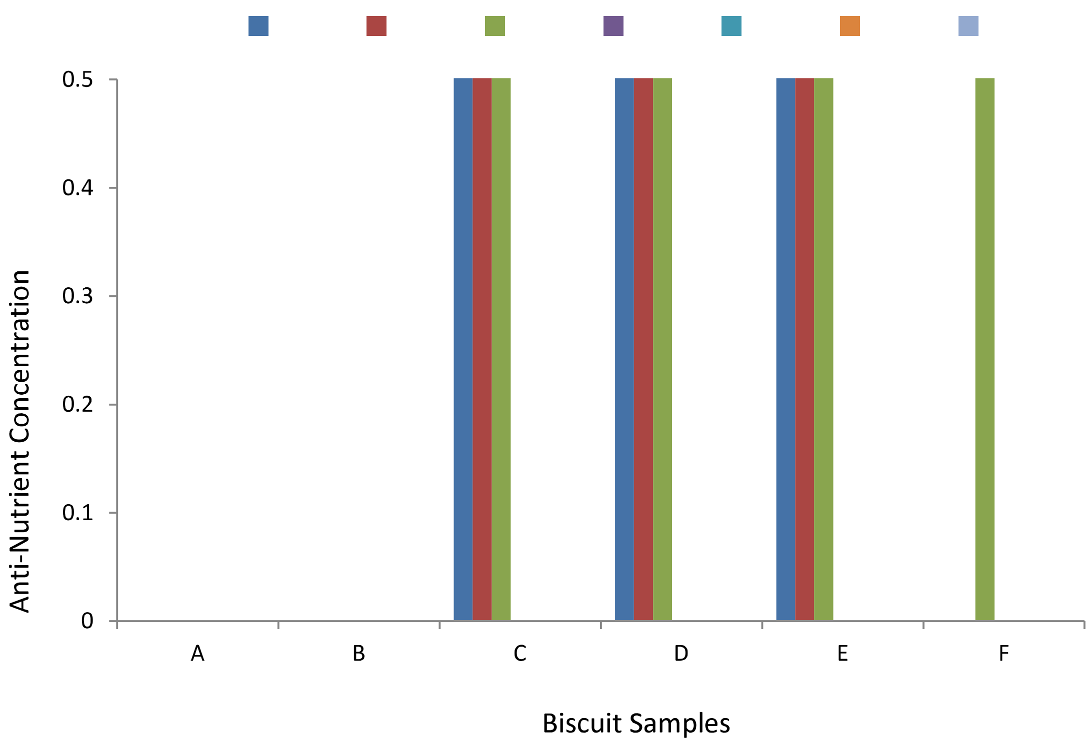

Figure 2: Anti-nutrient Composition of Formulated Biscuit

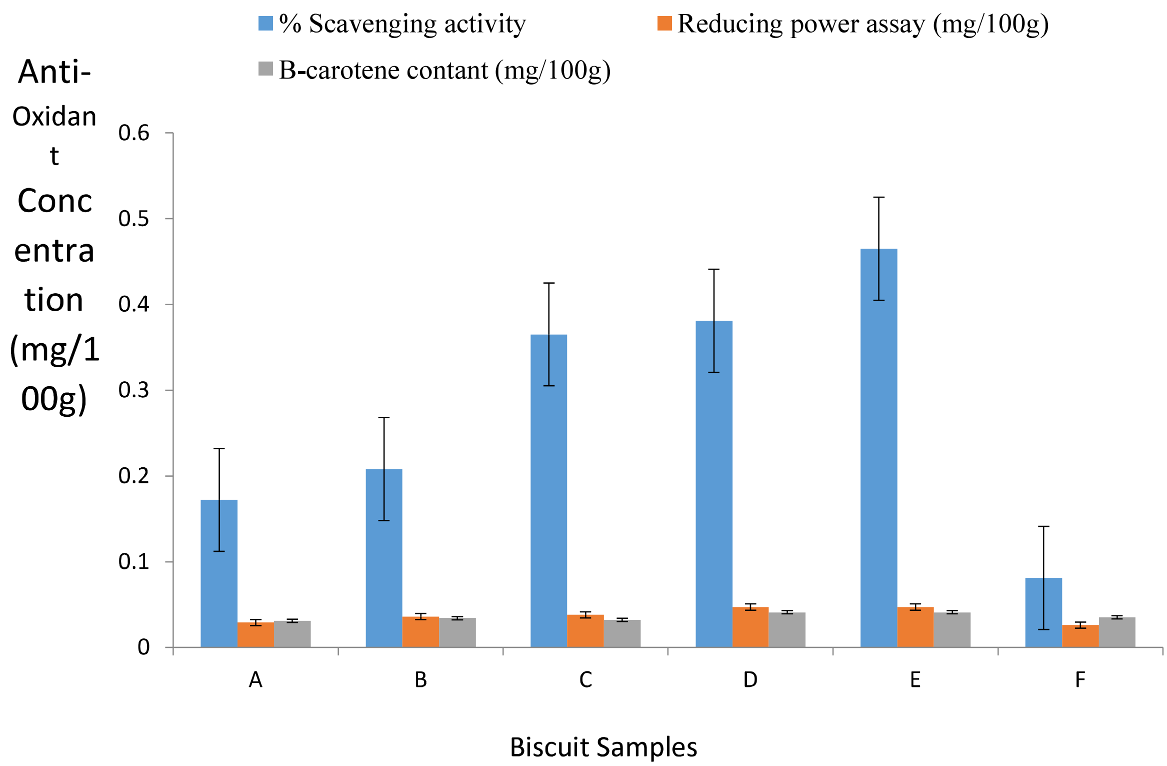

Figure 3: Antioxidants Properties of Formulated Biscuit

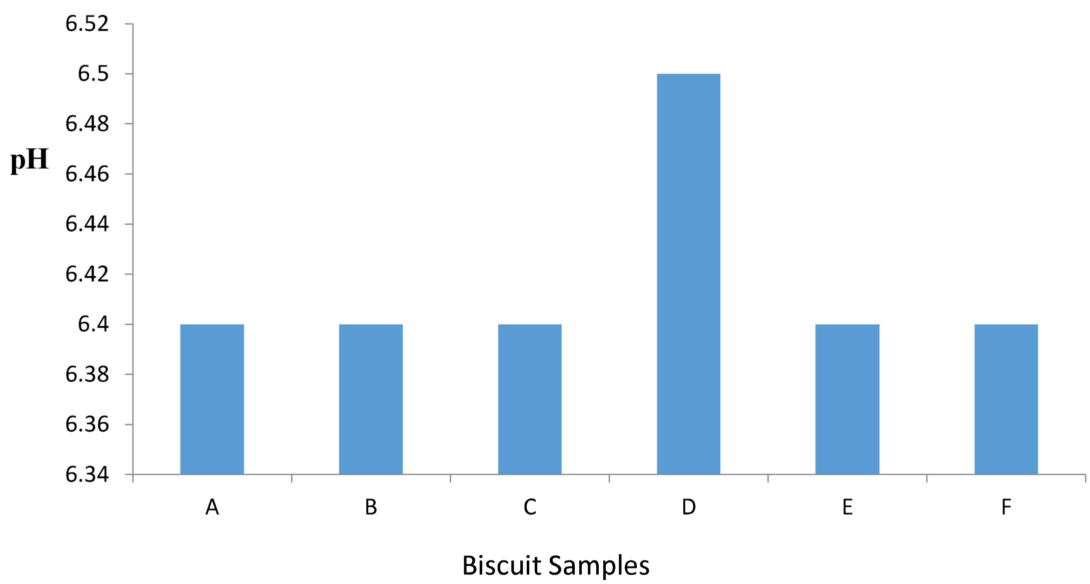

Figure 4: pH of Formulated Biscuit

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DISCUSSION

DPPH (2,2-Diphenyl-1-picryhydrazyl radical) radical is an oil-soluble free radical that is commonly used in the laboratory to evaluate the antioxidant activity of foods, plant extracts and biological samples. It's becomes a stable product after accepting an electron or hydrogen from an antioxidant. DPPH radical is stable in methanol and show maximum absorbance at 517nm. When DPPH encounters a proton donating substance such as an antioxidant, the radical would be scavenged and the absorbance is reduced. Therefore, the antioxidant activity of the substance can be expressed as it ability in scavenging the DPPH radical (Ajibola, Fashakin, Fagbemi, & Aluko, 2011). The DPPH radical scavenging activities of the formulated biscuit sample are shown in figure 2. The supplemented biscuits exhibited stronger DPPH radical scavenging activity than the biscuit produced from the un-supplemented flour (control). The highest DPPH radical scavenging activity was observed in sample E while sample F showed the least DPPH scavenging activity. This trend is consistent with the reducing power assay and B- carotene constant for both un-supplemented and supplemented biscuit samples. Sample E had the highest reducing power assay, B – carotene constant exhibited the highest DPPH radical activity, lowest B-carotene constant and lowest reducing power assay was recorded for sample F. Statistical analyses showed that, there was a very high negative correlation ($r = -1.000$) between the DPPH radical scavenging activity, reducing power. However, a high positive relationship ($r = 0.866$) was observed between scavenging activity and B- carotene content at ($p < 0.005$) of the biscuits in sample E.

The Reducing properties of antioxidants are generally associated with the presence of reductones, which has antioxidant activity by breaking the free radical chain through electron transfer reactions (Roginsky, 2003). In this research work, the ability of the biscuits extracts to act as a reducing agent by transforming the Fe^{3+} ferricyanide complex to the ferrous state (Fe^{2+}) was measured at 700nm. An increase in absorbance indicated better reducing power of the biscuits extracts. The high ferric reducing power (0.46mg/100g) of sample E could be attributed to a high proportion of protein and amino acid in African yam bean such amino acids include leucine, lysine, methionine, tryrosine, isoleucine, histidine and tryptophan, statistically, a very high significant negative relationship was observed between RPA and SA ($r = -1.000$) and between RPA and CC ($r = -0.866$) this shows that African yam bean is a good source of antioxidant.

Beta carotene is the precursor of vitamin A. It will be an advantage in solving the Vitamin A Deficiency (VAD) problems which is common in developing countries like Nigeria among children & pregnant women providing about 66% of Vitamin A in their diets. The carotenoids are micro-antioxidants that have integral role in regulating vital metabolic reactions in the body (Abiaka, Olusi, & Simbeye, 2002). Nowadays, the major interest in carotenoids found in plants is not only due to their pro-vitamin A activity but also their anti-oxidative action of scavenging oxygen radicals and reducing oxidative stress in the organism (Rao, & Shen, 2002). Epidemiological evidence also suggests that, foods that are rich in carotenoids protect the body against some chronic diseases; including certain type of cancer, cardiovascular disease and age- related macular degeneration (National Research Council, 1982). In the present research, it has been observed that sample D and E had the highest value of B-carotene 0.04/ 100g and 0.047mg/100g. Increase in the level of AYBTF in flour blends used for biscuit production, increased the B-Carotene content of the biscuits. This result is in line with the observation of Adegunwa et al. (2014), which states that, the increase in content of B-Carotene in the biscuit is due to the fact that Africa yam bean is a rich source of B- carotene which is a precursor of Vitamin A (Adegunwa et al., 2012). Vitamin A is known for maintenance of vision and foetus development.

The pH value of a food is a direct function of the free hydrogen ion present in that food. The acids present in foods releases these hydrogen ions, which give acid foods their distinct sour flavor. pH is an important parameter in the formulation of biscuits. The values of the pH observed for biscuits produced in this research are within the values reported by Grah, Beugre, Yapo, Dakia, & Niaba (2014). The pH of the biscuit produced in this research ranged from 6.4 to 6.5. It was observed that almost all the biscuit samples made of varying proportion of WF and AYBTF had similar pH value of 6.4, except sample D (60% WF/ 40% AYBTF) which had a different pH value of 6.5. There was no significant difference in the pH of the biscuits. It was also noted that the pH increased with higher substitution with African yam bean tempeh flour. Thus, the biscuit samples are considered non- acidic products.

Anti-nutrients are natural or synthetic compounds that reduce the nutritional values of food by reducing the bioavailability, digestibility and utilization of nutrients. There was a significant difference ($p<0.05$) in the level of all the anti-nutrients that were evaluated, between the biscuit samples produced from the control (100% wheat flour) and biscuit samples produced from blending wheat flour with African yam bean tempeh flour from 10-50% level of inclusion.

Tannin was observed to be significantly higher in all the biscuit samples than any other anti-nutrient. It was also observed that biscuits samples produce from the whole wheat flour had the lowest anti-nutritional content. Blending the wheat flour with African yam bean flour resulted in a significant increase in the level of the anti-nutrients. It was also observed, that the level of anti-nutrients in biscuit samples produced from the blended flour, increased as the percentage inclusion of African yam bean tempeh flour increased. This showed that, African yam bean is rich in anti-nutrients. This result however is similar to the findings of Adeola and Ohizua, (2018) who studied the anti-nutrients of cookies produced from unripe banana, pigeon pea and sweet potato. They observed that, increase in the proportion of blended flour led to increase in the level of the anti-nutrients in cookies made from blended flour samples.

From the result of the mineral analyses, sample F (biscuits produced from 100% wheat flour) had the least value in all the minerals that were evaluated {Magnesium (2.70mg%), Calcium (61.02mg), Phosphorus (3.76mg) and Iron (4.18mg/l)}, while biscuits that were produced from flour blends had the highest mineral content, magnesium (24.19 to 32.17), calcium (140.09-201.42), phosphorus (22.60 to 30.42) and iron (9.85 to 13.06). Statistical analyses showed a significant ($p<0.05$) difference between biscuits produced from wheat flour and biscuits produced from the blended flour samples in terms of mineral content. It was also observed that there was no significant difference ($p<0.05$) in the content of some minerals among the blended samples, such minerals like Phosphorus, Magnesium and Iron. In phosphorus, samples B and C had almost the same values of (23.31 and 23.72), in magnesium, samples C and D had values of (26.16 and 26.69). Finally in iron, samples C and D also had similar values (11.18 and 11.34). Apparently, this indicates that African yam bean is a good source of minerals. Moreover, there is an even distribution of the minerals in African yam bean. This result is in line with earlier reports that African yam bean is a good source of minerals (Palanga et al., 2025)

However, from the result of the physical analyses of biscuits, the replacement of wheat flour with AYBTF resulted in decrease in the weight of the biscuits. The weight of the biscuits ranged from (4.59 to 6.89g). The control sample F (100% WF) had the highest weight. The weight of the biscuit decreased with increase in AYBTF with the biscuit produced from sample E (50%WF: 50% AYBTF) having the lowest weight. The decrease in the weight of the biscuits could be due to the increase in the fat content of the blended African yam bean tempeh flour, as fat is lighter in weight (Ayo et al., 2007). These results were similar to those of Bambara groundnut-maize flour (Akpapunam & Darbe,

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1994), Millet-Sesame flour (Alobo, 2001), and Amaranth-wheat flour (Ayo, 2001; Agu & Okoli, 2014)

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. 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.

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