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Physicochemical and Sensory Properties of Cookies Produced from African Yam Bean, Turmeric and Banana Flours

Igbabul, Bibiana Dooshima*[1], Omefe, Chinelo Juliet[2], Amove, Julius[3]

[123]Department of Food Science and Technology, Joseph Sarwuan Tarka University, Makurdi, Nigeria

***Corresponding Author**

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ABSTRACT

This study investigated physicochemical and sensory properties of cookies produced from African yam bean, turmeric and banana flours. Five blends were used: Sample A (control) contained 100% banana flour, while Samples B, C, D, and E incorporated 10%, 20%, 30%, and 40% African yam bean flour, respectively, with a constant 5% turmeric flour. The cookie samples were subjected to physicochemical and sensory analyses using standard procedure. The proximate analysis showed significant increases ($p<0.05$) in ash (4.14–5.69%), fat (6.47–16.57%), fibre (0.57–1.26%), and protein (2.20–10.94%) as African yam bean flour increased, while carbohydrates decreased (82.73–60.74%). Physical properties revealed a reduction in cookie weight (10.82–9.79 g), diameter (4.88–4.51 cm), and thickness (0.93–0.82 cm), with an improvement in the spread ratio (0.58–1.24). Sensory evaluation indicated that the control (100% banana flour) was most preferred, but all other cookies samples were within acceptable limits for appearance (7.27–8.33), taste (6.73–8.20), and crispiness (7.20–8.13). This study recommends the inclusion of African yam bean and turmeric flours at up to 30% substitution for banana flour in cookie formulations to enhance nutritional quality while maintaining consumer acceptability at affordable cost.

Keywords: African yam beanflour, turmeric flour, banana flours, cookies , quality

INTRODUCTION

Cookies are convenient, ready-to-eat baked products that are widely available in various shapes and sizes at an affordable cost and with appreciable nutritional value (Vijerathna et al., 2019). They are among the most popular bakery products consumed across all age groups in many countries due to their desirable sensory attributes and low water activity, which contributes to an extended shelf life (Bello et al., 2020). In Nigeria, reliance on imported wheat flour increases production costs. To address this, the government has partnered with research institutions to promote the use of composite flours in the manufacture of food products such as cookies and bread. Several studies have investigated the incorporation of composite flours in cookie production (Igbabul et al., 2015; 2019; Bello et al., 2020; Wabali et al., 2020). These efforts aim to improve the nutritional quality of cookies, enhance the utilization of local crops, and produce more affordable products.

African yam bean (Sphenostylis stenocarpa) is a nutrient-dense legume characterized by a balanced composition of macronutrients. The protein content of its raw seeds has been reported to range from approximately 22.3 to 24.6 grams per 100 grams, making it a valuable plant protein source (Akinmoladun & Oloyede, 2012). Carbohydrates constitute a major portion of its nutritional makeup, with about 52.8 grams per 100 grams of raw seeds. The fat content of African yam bean is relatively low, typically between 1.9 and 2.2 grams per 100 grams (Bamishaiye & Bamishaiye, 2021). This legume also contributes appreciable amounts of dietary fibre, estimated at 7.0 to 9.5 grams per 100 grams of raw seeds, which supports digestive health (Ogunsina & Ajibola, 2020). Ash content, an indicator of total mineral content, has been reported at about 3.5 to 4.2 grams per 100 grams (Oloyede, 2015). In addition, African yam bean provides vitamin C, with levels around 15–20 mg per 100 grams of raw seeds, adding to its overall nutritional benefits (Eke & Ofoegbu, 2015).

Turmeric (Curcuma longa L.) contains approximately 6.3-7.8 grams of protein per 100 grams of dried turmeric rhizome (Singh and Singh, 2018). The carbohydrate content is high, around 65.0-68.0grams per 100 grams (Srinivasan, 2015). Fat content of 5.0-6.0 grams per 100 grams (Gupta and Aggarwal, 2012). It also contains about3.0-6.0 grams of dietary fibre per 100 grams (Khanna and Tyagi, 2021). In terms of minerals, turmeric provides approximately 268 mg of calcium and 41 mg of iron per 100 grams (Gupta *et al*., 2022). It also contains small amounts of vitamins, with about 1.0 mg of vitamin C per 100 grams (Srinivasan, 2015).

Bananas (*Musa acuminata*) are a popular fruit known for their nutritional benefits. They are anexcellent source of carbohydrates (22.8 g), protein (1.1 g), ash content (0.8 g), fat content (0.3g) and dietary fibre (2.6 g) (USDA, 2020). In terms of vitamins, bananas provide approximately 8.7 mg of vitamin C per 100 grams and the mineral content in bananas includes about 5 mg ofcalcium and 0.26 mg of iron per 100 grams (USDA, 2020), high potassium content of 358 mg per 100 grams.

The incorporation of banana, African yam bean, and turmeric flours is expected to yield cookies with enhanced nutritional quality. Therefore, the objective of this study is to evaluate the nutritional composition and sensory attributes of cookies formulated from composite flours of African yam bean, turmeric, and banana.

MATERIALS AND METHODS

2.1 Source of Raw Materials

African yam beans, turmeric and banana were purchased from Railway Market, Makurdi Benue State. Baking ingredients and Equipment such as food processor, mixing bowls, etc were obtained in Food Processing Laboratory of Department of Food Science and Technology, Joseph Sarwuan Tarka University, Makurdi and all other chemical used were of analytical grade.

2.2 Sample Preparation

2.2.1 Preparation of African yam beans flour

The African yam bean flour was prepared using the modified method described by Igbabul *et al*. (2015). The African yam bean seeds were removed from pods and cleaned to remove foreign materials like sticks, broken pods. The cleaned beans were soakedin 0.1% sodium metabisulphite ($NaHSO_3$) solution in the ratio of (1:5 w/v) for 12 hours. The soaked beans were manually dehulled, drained and boiled at 100 ºC for 20 min. The dehulled and boiled bean seeds were spread on the tray to dry in an air draught oven (Gallenkamp 300plus series, England) at 60 ºC. The dried seeds were milled using attrition mill (Globe p44, China) and sieved using a 0.5 mm mesh sieve and packaged in airtight containers prior to production of cookies.

2.2.2 Preparation of Turmeric Flour

Turmeric rhizomes (*C. Longa* L.) was processed into flour according to method described by Park (2011). The turmeric roots were washed, cleaned, cut into small pieces using a sterileknife, dried using forced air-drying oven (LabTech LDO-030E, South Korea) at 60 ºC for 24 h, ground to a powder form using blender (Vitamix XL Variable Speed Blender, USA) and passed through a 0.5 mm sieve.

2.2.3 Preparation of banana flour

Banana flour was processed as described by Bakare *et al*. (2017). Mature banana was sorted, washed, peeled, manually sliced into cylindrical pieces of 2-mm thickness and samples were subjected to chemical pretreatments with 5 % potassium metabisulphite solution for 30 minutes, as well as steam blanching at 100°C for 2 min after which it was blotted dry with clean tissue paper to remove adhered surface water. The banana slices were placed on a foil paper placed on drying racks to avoids ticking together; it was then dried in a cross-flow Gallenkamp oven (Model OV-160 size 2BS, Weiss Technik UK Loughborough, Leicestershire, U.K.) at 70°C for 18 h. The dried chips were milled to flour in a Disc mill (Model FFC-15, Shandong-Jimo Agricultural Machinery,Qingdao City, Shandong Province, China) at 8800 rpm and sieved through a 0.5 mm mesh sieve (no.60.W.S. 8570 Tyler Blvd, Mentor, OH 44060).

2.3 Formulation of African Yam Bean, Turmeric and Banana Flour Blends for Cookies Production

The African yam beans, turmeric and banana flours were formulated in different proportions for cookies production. Sample A was made up of 100 % banana flour 0% African yam bean flour and 0% turmeric flour (100:0:0) and served as a control sample. Sample B on the other hand comprised of 85 % banana flour, 10% African yam bean flour,and 5% turmeric flour (85:10:5), sample C comprised of 75% Banana flour,20 % African yam bean flour and 5% turmeric flour (75:20:5), sample D was 60 % banana flour, 30 % African yam bean flour and 5% turmeric flour (60:30:5), and sample E comprised of 55% banana flour, 40 % African yam bean flour and 5% turmeric flour (55:40:5). The different formulated flours for the cookies production are shown in the Table 1.

Table 1: Formulation of flour Blends

Sample Code	Banana Flour (%)	African Yam Bean Flour (%)	Turmeric Flour (%)
A (control)	100	0	0
B	85	10	5
C	75	20	5
D	65	30	5
E	55	40	5

Key

A (control) = 100 % banana flour + 0% African yam bean flour + 0% turmeric flourB = 85 % banana flour + 10% African yam bean flour + 5 % turmeric flour

C = 75 % banana flour + 20% African yam bean flour + 5 % turmeric flour D = 65 % banana flour + 30 % African yam bean flour + 5 % turmeric flourE = 55 % banana flour + 40 % African yam bean flour + 5 % turmeric flour

2.4 Cookies production

Cookies were prepared according to the method of Chinma *et al.* (2012) with some modifications in the recipes: flour 100g, sugar 50g, vegetable shortening 50g, baking powder 3.3g, egg 26.5mL, salt 2g and the quantity of water varies. The dry ingredients (flour, sugar, salt and baking powder) were thoroughly mixed in a bowl by hand for three (3) minutes. Vegetable shortening was added and mixed until uniform. Eggs were added and the mixture kneaded. The batter was rolled and cut with a 50 mm diameter cookies cutter. The cookies were placed on baking trays, leaving 25 mm spaces in between and baked at 180 ºC for 10 mins in the baking oven. Following baking, the cookies were allowed to cool at ambient temperature, packed and stored at 23 ºC prior to subsequent analyses and sensory evaluation.

2.5 Analyses

2.5.1 Determination of Proximate Composition of Cookies

The proximate composition of the cookies; Moisture content, crude protein, crude fibre, fat, ash content were determined using the methods of AOAC (2015) and Carbohydrate content was determined by difference according to Ihekoronye and Ngoddy(1985) as follows:

$$\%\,Carbohydrate = 100 - (\%\,moisture + \%\,protein + \%fat + \%ash + \%fibre)$$

2.5.2 Determination of Physical Characteristics of the Cookies

The weight of the cookies was determined according to the method of Ayo *et al.,* (2007). The weights of cookies samples was determined with the aid of a weighing balance (model)immediately after cooling.

The diameter (D) of the cookies was determined according to the method of AACC (2000).Four cookies was placed edge to edge and their total diameter was measured with the aidof a ruler. The cookies was rotated at

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angles of 90° for duplicate reading. The experiment was repeated twice and average diameter was recorded in millimeter.

Thickness of the cookie's samples

The thickness of the cookies was determined according to the method of Ayo *et al.* (2007).The cookies thickness was measured with the aid of a digital Vernier caliper with 0.01mm precision.

The spread ratio was determined according to method of Okaka and Isieh (1990). The diameter and thickness of the unbaked cut out dough and baked dough was measured usingthe Vernier caliper.

2.5.3 Sensory evaluation of the cookies was carried out according to the method described by (Ihekoronye and Ngoddy, 1985). A panel of fifteen members consisting of students and members of staff in Food Science and Technology Department, Joseph Sarwuan Tarkaa University, Makurdi, Benue State Nigeria, were chosen based on their familiarity and experience with wheat-based cookies for sensory evaluation. Cookies produced from each flour blend, along with the reference sample was presented in coded form and was randomly presented to the panelists. The panelists were provided with potable water to rinse their mouth between evaluations. However, a questionnaire describing the quality attributes (appearance, taste, flavour, texture crispiness and overall acceptability) of the cookies was given to each panelist. Each sensory attribute was rated on a 9-point hedonic scale (1 = dislike extremely and 9 = like extremely).

2.6 Statistical Analysis

The data generated was subjected to analysis of variance (ANOVA) and means was separated using Fishers' Least Significant Difference while significance difference was tested at 5 % level of probability.

RESULTS AND DISCUSSION

3.1 Proximate Composition of Cookies Produced from African Yam Bean,Turmeric and Banana Composite Flours

Table 2 shows that the moisture content ranged from 3.90% in sample A to 4.82% in sample E, with a progressive increase across the samples. Ash content increased from 4.14% in sample A to 5.69% in sample E. Fat content ranged from 6.47% in sample A to 16.57% in sample E, with a significant rise observed as African yam bean flour was added. Fibre content varied between 0.57% in sample A and 1.26% in sample E. Protein content increased from 2.20% in sample A to 10.94% in sample E, while carbohydrate content showed a reverse trend, decreasing from 82.73% in sample A to 60.74% in sample E. These results indicate significant changes in the proximate composition of the cookies with varying proportions of the composite flours.The observed increase in moisture content across the samples is attributed to the higher hygroscopic nature of African yam bean and turmeric flours compared to banana flour. This aligns with the findings of Adebowale *et al.* (2021), who reported that legume flours tend to absorb more water, which contributes to higher moisture levels in composite food products. The rise in ash content reflects the mineral contributions from African yam bean and turmeric, consistent with observations by Nwachukwu *et al.* (2020), who demonstrated that adding legume flours significantly enhances the mineral profile of food products.

The notable increase in fat content can be linked to the inherent lipid-rich nature of African yam bean flour, as corroborated by Olaleye and Omotayo (2019), who noted that leguminous seeds contribute significantly to fat content in composite flour-based products. The gradual increase in fibre content is due to the fibrous properties of turmeric and African yam bean flours, which is supported by the work of Oboh *et al.* (2021), showing similar trends in composite flour-based snacks.

The rise in protein content reflects the high protein quality of African yam bean, as reported by Temegne *et al.* (2018), who highlighted its potential as a protein-rich legume. This protein enhancement can improve the nutritional value of cookies, aligning with findings from Ayinde *et al.* (2022), who demonstrated improved protein content in baked products fortified with legume-based flours. Conversely, the reduction in carbohydrate content is due to the dilution effect as more banana flour, a carbohydrate-rich base, is replaced by African yam bean and turmeric flours. Similar results were reported by Idowu *et al.* (2021), where the addition of legume flours reduced carbohydrate levels in baked goods. These changes highlight the potential of these composite flours to improve the nutritional profile of cookies, making them more suitable for diverse dietary needs.

Table 2: Proximate Composition (%) of Cookies Produced from African Yam Bean,Turmeric and Banana Composite Flours

Sample	Moisture	Ash	Fat	Fibre	Protein	CHO
A	3.90^{e}±0.01	4.14^{e}±0.03	6.47^{e}±0.03	0.57^{e}±0.02	2.20^{e}±0.01	82.73^{a}±0.08
B	4.02^{d}±0.03	4.47^{d}±0.02	9.81^{d}±0.01	0.66^{d}±0.01	4.39^{d}±0.01	76.66^{b}±0.01
C	4.12^{c}±0.02	5.06^{c}±0.01	11.62^{c}±0.03	0.78^{c}±0.01	6.65^{c}±0.01	71.88^{c}±0.06
D	4.42^{b}±0.01	5.37^{b}±0.02	15.57^{b}±0.01	0.96^{b}±0.01	8.74^{b}±0.01	64.95^{d}±0.02
E	4.82^{a}±0.02	5.69^{a}±0.01	16.57^{a}±0.03	1.26^{a}±0.02	10.94^{a}±0.01	60.74^{e}±0.02
LSD	0.05	0.05	0.08	0.04	0.03	0.16

Values are means ± standard deviations of duplicate determinations. Means in the same column with different superscripts are significantly ($p<0.05$) different

Keys

A (control) = 100 % banana flour + 0% African yam bean flour + 0% turmeric flour

B = 85 % banana flour + 10% African yam bean flour + 5 % turmeric flour

C = 75 % banana flour + 20% African yam bean flour + 5 % turmeric flour

D = 65 % banana flour + 30 % African yam bean flour + 5 % turmeric flour

E = 55 % banana flour + 40 % African yam bean flour + 5 % turmeric flour

CHO = Carbohydrates

3.2 Physical Properties of Cookies Produced from African Yam Bean, Turmeric and Banana Composite Flours

Table 3 shows that the weight of the cookies ranged from 10.82 g in Sample A to 9.79 g in Sample E. Diameter decreased progressively from 4.88 cm in Sample A to 4.51 cm in Sample E. Thickness ranged from 0.93 cm in Sample A to 0.82 cm in Sample E, showing a slight reduction across the samples. Spread ratio increased from 0.58 in Sample A to 1.24 in Sample E, indicating a significant increase with higher levels of African yam bean and turmeric flours. The observed variations in the physical properties of the cookies can be attributed to the compositional and functional differences introduced by the African yam bean and turmeric flours. The decrease in cookie weight across the samples can be linked to the lower bulk density of African yam bean and turmeric flours compared to banana flour. This finding aligns with Ojo *et al*. (2021), who reported reduced weight in cookies made from composite flours due to lower density components. The reduction in diameter observed with increasing substitution levels is indicative of lower dough spreadability. African yam bean and turmeric flours possess higher water-binding capacity, which likely restricted dough flow during baking. Similar results were reported by Chinma *et al*. (2020), who noted reduced cookie diameters with the incorporation of high-protein and high-fibre flours into baked goods.

The slight decrease in thickness across the samples may be attributed to the structural integrity provided by the composite flours, particularly the protein and fibre components. Adeola and Ohizua (2018) observed comparable trends in their study on cookies made from legume-based composite flours, where higher protein levels resulted in more compact cookies. The significant increase in spread ratio suggests improved dough relaxation with higher levels of African yam bean and turmeric flours. This trend is consistent with the findings of Ajayi *et al*. (2019), who reported enhanced spread ratios in cookies containing composite flours due to changes in dough viscosity and fat content. These results collectively highlight the impact of flour substitution on cookie properties, suggesting potential applications in functional food development.

Table 3: Physical Properties of Cookies Produced from African Yam Bean,Turmeric and Banana Composite Flours

Sample	Weight (g)	Diameter (cm)	Thickness (cm)	Spread ratio
A	10.82^{a}±0.02	4.88^{a}±0.01	0.93^{a}±0.08	0.58^{e}±0.01
B	9.90^{b}±0.01	4.79^{b}±0.01	0.91^{ab}±0.01	0.65^{d}±0.01
C	9.87^{bc}±0.01	4.71^{c}±0.01	0.88^{ab}±0.01	0.78^{c}±0.01
D	9.85^{c}±0.01	4.68^{c}±0.01	0.85^{ab}±0.00	0.95^{b}±0.01
E	9.79^{d}±0.01	4.51^{d}±0.01	0.82^{b}±0.01	1.24^{a}±0.01
LSD	0.03	0.03	0.11	0.03

Values are means ± standard deviations of duplicate determinations. Means in the same column with different superscripts are significantly ($p<0.05$) different

Keys

A (control) = 100 % banana flour + 0% African yam bean flour + 0% turmeric flour

B = 85 % banana flour + 10% African yam bean flour + 5 % turmeric flour

C = 75 % banana flour + 20% African yam bean flour + 5 % turmeric flour

D = 65 % banana flour + 30 % African yam bean flour + 5 % turmeric flour

E = 55 % banana flour + 40 % African yam bean flour + 5 % turmeric flour

3.3 Sensory Properties of Cookies Produced from African Yam Bean, Turmeric and Banana Composite Flours

Table 4 shows the sensory properties of the cookies. Appearance scores ranged from 8.33 in Sample A to 7.13 in Sample D. Taste scores decreased from 8.20 in Sample A to 6.73 in Sample E. Aroma scores ranged from 8.13 in Sample A to 6.60 in Sample E. Crispiness scores decreased slightly from 8.13 in Sample A to 7.20 in Sample D, with a slight improvement to 7.53 in Sample E. Overall acceptability scores ranged from 8.33 in Sample A to 7.00 in Sample E. The observed differences in sensory properties can be attributed to the functional and sensory characteristics of the African yam bean and turmeric flours. The slight decline in appearance scores with increasing substitution levels may be due to the darker color imparted by turmeric and African yam bean flours, which altered the visual appeal of the cookies. Similar results were reported by Adeola and Ohizua (2018), who found that the inclusion of legume and spice flours in baked products often affects appearance due to pigmentation.

The decline in taste and aroma scores reflects the impact of turmeric's strong flavor and aroma, which may not appeal to all consumers at higher inclusion levels. This aligns with findings by Ajayi *et al*. (2020), who noted that turmeric-enriched products tend to have lower sensory scores due to its distinct taste and aroma overpowering other flavors.

The crispiness scores showed minimal variation across the samples, likely due to the structural properties of banana flour, which maintained cookie texture despite the substitutions. Ojo *et al*. (2021) similarly observed that banana flour stabilizes crispiness in composite flour formulations.The overall acceptability scores suggest that while moderate substitution levels (e.g., Sample B) were well-received, higher levels (e.g., Sample E) reduced consumer preference. This trend is consistent with Chinma *et al*. (2012), who reported that consumer acceptability decreases as the proportion of less familiar or intense-tasting flours increases in baked products. These results highlight the importance of optimizing substitution levels to balance nutritional improvements with sensory appeal.

Table 4: Sensory Properties of Cookies Produced from African Yam Bean, Turmeric and Banana Composite Flours

Sample	Appearance	Taste	Aroma	Crispiness	Overall acceptability
A	$8.33^{a}\pm1.29$	$8.20^{a}\pm1.21$	$8.13^{a}\pm0.83$	$8.13^{a}\pm0.92$	$8.33^{a}\pm0.90$
B	$8.07^{ab}\pm0.59$	$7.73^{ab}\pm0.80$	$7.53^{ab}\pm0.83$	$8.00^{a}\pm0.53$	$7.87^{ab}\pm0.74$
C	$7.53^{bc}\pm1.06$	$7.20^{bc}\pm0.86$	$7.27^{bc}\pm0.88$	$7.73^{ab}\pm0.59$	$7.60^{ab}\pm0.63$
D	$7.13^{abc}\pm1.06$	$7.33^{abc}\pm1.18$	$7.00^{bc}\pm1.00$	$7.20^{b}\pm1.21$	$7.20^{b}\pm1.15$
E	$7.27^{c}\pm1.22$	$6.73^{c}\pm1.58$	$6.60^{c}\pm1.35$	$7.53^{ab}\pm0.99$	$7.00^{b}\pm1.73$
LSD	0.78	0.84	0.73	0.64	0.80

Values are means (n=15) ± standard deviations. Means in the same column with different superscripts are significantly ($p<0.05$) different

Keys

A (control) = 100 % banana flour + 0% African yam bean flour + 0% turmeric flour

B = 85 % banana flour + 10% African yam bean flour + 5 % turmeric flour

C = 75 % banana flour + 20% African yam bean flour + 5 % turmeric flour

D = 65 % banana flour + 30 % African yam bean flour + 5 % turmeric flour

E = 55 % banana flour + 40 % African yam bean flour + 5 % turmeric flour

CONCLUSION

The results of the study indicated that incorporating composite flours from African yam bean, turmeric, and banana significantly affected the proximate composition, physical characteristics, and sensory attributes of the cookies. Formulations with higher proportions of African yam bean flour (Samples D and E) exhibited increased levels of ash, fat, fibre, and protein, reflecting an enhanced nutritional profile compared with the control. Conversely, carbohydrate content decreased as the level of composite flour substitution increased. Sensory evaluation revealed that the control sample (Sample A) was the most preferred across all assessed attributes; nevertheless, all cookie samples were rated within acceptable sensory limits.

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