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*Full Length Research Article*

# Proximate and Sensory Qualities of Biscuits from Wheat, Soybean and Fermented Rice Bran Flours

***Ezegbe, C. C. and Nwokedi, P. A.**

Department of Food Science and Technology, Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Anambra State.
*Corresponding author email: cc.ezegbe@unizik.edu.ng
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**Abstract**
This study evaluated the proximate and sensory qualities of biscuits produced from composite flours of wheat, soybean, and fermented rice bran. The research aimed to enhance the nutritional profile of biscuits by utilizing locally available and underutilized ingredients while reducing reliance on 100% wheat flour. Eight different biscuit formulations were prepared by varying the ratios of wheat (40 – 100), soybean (0 – 20), and fermented rice bran (0 – 40) flours using mixture design (Extreme Vertices). Proximate analysis revealed that the sample with the highest inclusion of soybean and rice bran (40% wheat, 40% soybean, 20% fermented rice bran) significantly ($p<0.05$) recorded highest protein (22.87%), fat (10.14%), ash (4.65%), and fiber (4.76%) contents, while the 100% wheat sample (WFS3) recorded the highest carbohydrate content (71.25%). Sensory evaluation showed that biscuits made entirely from wheat and those with higher wheat content were more preferred in terms of (scores): appearance (6.30 – 8.30), taste (7.30 – 8.70), flavour (7.20 – 8.80), and overall acceptability (7.20 – 8.60). However, biscuits with soybean and fermented rice bran also performed reasonably well with an overall acceptability (6.60 – 8.60), texture (7.30 – 8.70) and mouth feel (6.00 – 8.30). The findings suggest that incorporating soybean and fermented rice bran into biscuit production can significantly improve nutritional value while maintaining acceptable sensory qualities.
**Kerwords:** Biscuit, rice bran, soybean, sensory quality, nutritional

## Introduction

Biscuits are widely consumed baked products valued for their convenience, long shelf life, and sensory appeal (Han *et al*., 2025). They are typically produced from wheat flour, sugar, fat, and other minor ingredients (Ezegbe *et al*., 2023), which contribute to their desirable texture, taste, and appearance. The quality of biscuits is largely determined by the functional properties of the flour used, particularly gluten, which provides structure and influences dough handling and final product characteristics. Biscuits are extensively consumed largely as a result of their relatively low price compared to other baked items and their widespread availability (Ezegbe *et al*., 2024). However, there is an increasing demand for more nutritious biscuits which has stimulated interest in the use of composite flours as partial substitutes for wheat flour in biscuit production (Roldán *et al*., 2026). Many plant produces have been used in making composite flours with wheat flour for baked food products.

Soybean flour, a legume-based ingredient, is commonly incorporated into biscuit production to supply essential amino acids that are missing in wheat flour (Mouafo *et al*, 2024). Being rich in high-quality protein, soybean flour enhances the nutritional value of biscuits. It also contributes a distinct flavor and texture, improving the overall taste and quality of the final product. Soybeans are an incredible source of protein for animals and humans. They're also a major source of edible oils and fats (Mouafo *et al*, 2024). Soybean can be processed into different forms like soymilk, soy sauce, tofu, soy sprouts, and soy flour. Its protein content, which makes up around 40% of the total solids, plays a vital role in enriching baked goods made from cereals. Additionally, soybean is rich in vitamins and minerals while being relatively low in crude fiber (Okoye *et al*., 2008). By processing and milling soybean into flour, and then partially replacing or complementing wheat flour with soybean protein in bakery products, the nutritional quality of biscuits can be significantly improved (Okoye *et al.,* 2008).

Rice bran is a significant byproduct of the rice milling industry (Manakla *et al*., 2026) with an annual global production capacity of up to 29.3 million tons (Sohail et al., 2017). Rice, scientifically known as *Oryza sativa*, is a crucial staple food for a large part of the global population, particularly in regions like East and South Asia, the Middle East, Latin America, and the West Indies. In fact, it provides more than one-fifth of the calories consumed worldwide. It is cultivated in at least 114 countries, with a global production of around 645 million tons. The rice bran, is the brown outer layer of the rice kernel and consists of the pericarp, aleurone, subaleurone layer, and germ. Rice bran contains a good amount of essential nutrients such as protein (12-15%), fat (15-20%), and dietary fibre (20-30%). These values can vary based on the type of rice and processing methods used. It is also rich in minerals like potassium (K), calcium (Ca), magnesium (Mg), and iron (Fe). Moreover, rice bran holds promise as a functional ingredient for humans due to the presence of antioxidants like tocopherols, tocotrienols, and γ-oryzanol, which can help combat life-threatening

disorders (Manakla *et al*., 2026). Rice bran when fermented using a functional instant yeast, exhibits high cholesterol removal and strong antimicrobial activity (Sohail *et al*., 2017).

During the rice processing or milling, various materials are produced, including milled rice, bran, and husk. In developing countries, rice bran is typically a byproduct of the milling process that is more or less discarded and it is to a large extent not utilized as food for humans. So, it is great to see that rice bran, which might have been previously overlooked, is being recognized for its potential utilization in various ways (Mian *et al.,* 2014). Hence this study aimed at analysing the quality of biscuits produced from blends of wheat, fermented rice bran and soybean flour.

## Materials and Methods

### Source of Raw Materials

The major source of soybean seeds and wheat flour is main market, Onitsha, while rice bran was from Coscharis Rice Mill, Igbariam all in Anambra State. All the chemicals and equipment used in this study were of analytical grade and were all made available from the Food Science and Technology Laboratory, Nnamdi Azikiwe University, Awka, Anambra State.

### Sample Preparation

### Preparation of soybean flour

The procedure described by Singh *et al*. (2019) was adopted. The soybean seeds were sorted to remove impurities. The clean soybeans were conditioned by soaking in water for 12 h, in order for the soybeans to absorb water and become soft to aid the milling process. The conditioned soybeans were dehulled by rubbing between the palms with minimum pressure in order to remove the shell. The dehulled soybeans were placed in a tray and were dried in an oven at 65°C for 6 h. The dried and dehulled soybeans were ground into fine powder using a grain mill to create a smooth consistency. The ground soybean was sieved using a sieve of 400 micrometer to remove any coarse particles and ensure uniform texture. The sieved soybean was placed and closed in an airtight container.

### Preparation of wheat flour

Already processed wheat flour (Golden Penny wheat flour – Batch: 0313, Expiry date.: 22/08/2026; Address: 1 Golden Penny Place, Wharf Road, Apapa, Lagos State, Nigeria) was purchased from the Onitsha main market, Anambra State and it was sieved using a sieve of 3.5 micrometer, then it was stored in a close and air-tight container, from where it was taken when needed for analysis.

### Rice bran fermentation

The rice bran was gotten from Coscharis rice mill, Igbariam, Anambra State. The procedure outlined by Christ-ribeiro *et al.* (2021) was adopted with little modifications. The rice bran was sieved through a 0.50 mm sieve. It was sterilized in a pressure cooker (110 °C for 4 min) and cooled to 30 °C). Yeast (*Saccharomyces cerevisiae*) was hydrated with sterile water for one hour. The rice bran was thoroughly mixed with the yeast (3%). The rice bran was placed in an incubating tray, in such a way that 1cm

height was maintained. It was then incubated at (30 ˚C for 6 h) in an Esco horizontal heating incubator. The fermented rice bran was dried in an oven at 105 ˚C for 4 h. It was grinded into flour and was stored in high-density polythene from where it was collected when it was needed for production.

**Experimental Design**

A mixture design (Extreme vertices design) was adopted for this experiment as shown in Table 1. Three raw materials – wheat, soybean and fermented rice bran were used, hence the reason for using a mixture design. Wheat was used as the base raw material. The boundaries used for the different raw materials were 40 -100 for wheat, 0 – 20 for soybean and 0 – 40 for fermented rice bran. Eight runs were generated from the design.

**Table 1: Layout of the experimental design (Mixture design)**

| Sample Code | Std Order | Run order | Pt Type | Blocks | Wheat | Soybean flour | Fermented rice bran |
|---|---|---|---|---|---|---|---|
| WFS1 | 4 | 1 | 1 | 1 | 40 | 20 | 40 |
| WFS2 | 8 | 2 | -1 | 1 | 55 | 15 | 30 |
| WFS3 | 1 | 3 | 1 | 1 | 100 | 0 | 0 |
| WFS4 | 5 | 4 | -1 | 1 | 85 | 5 | 10 |
| WFS5 | 6 | 5 | -1 | 1 | 75 | 15 | 10 |
| WFS6 | 7 | 6 | -1 | 1 | 65 | 5 | 30 |
| WFS7 | 2 | 7 | 1 | 1 | 80 | 20 | 0 |
| WFS8 | 3 | 8 | 1 | 1 | 60 | 0 | 40 |

**Keys:**
Std Order = Standard Order, Pt Type = Point type.
WFS1 = 40 % Wheat:40 % Soybean: 20 % Fermented Rice Bran.
WFS2 = 55 % Wheat:30 % Soybean: 15 % Fermented Rice Bran.
WFS3 = 100 % Wheat: 0 % Soybean: 0 % Fermented Rice Bran.
WFS4 = 85 % Wheat:10 % Soybean: 5 % Fermented Rice Bran.
WFS5 = 75 % Wheat:10 % Soybean: 15 % Fermented Rice Bran.
WFS6 = 65 % Wheat:30 % Soybean: 5 % Fermented Rice Bran.
WFS7 = 80 % Wheat: 0 % Soybean: 20 % Fermented Rice Bran.
WFS8 = 60 % Wheat:40 % Soybean: 0 % Fermented Rice Bran.

**Table 2: Recipe for biscuit**

| Ingredient | Amount |
|---|---|
| Composite flour (See Table 1 for ratio of wheat : fermented rice bran : and soybean flours). | 100 g |
| Sugar | 50 g |
| Margarine | 50 g |
| Whole egg | 25 ml |
| Water | 12 ml |
| Milk | 25 g |
| Salt | 2 g |
| Baking Powder | 2 g |
| Vanilla flavor | 2 g |

**Source: Ezegbe *et al.* (2023)**

**Production of the biscuits**

Biscuits were made using the technique adapted from Ezegbe *et al.* (2023) with a few changes to the recipe. The dry ingredients—wheat flour, soybean flour, fermented rice bran, vanilla flavor, milk, salt, sugar and baking powder (Table 2) —were completely mixed by hand in a bowl. Margarine was added and mixed thoroughly. The mixture was then combined with egg and water and kneaded. The dough was rolled and a biscuit cutter was used to cut the dough. The biscuits were put on baking sheets (falcon parchment paper) and baked for varying times (30 minutes) and temperature (220°C). The baked biscuits were allowed to cool to room temperature, then placed in plastic bags and kept for later testing.

**Proximate analysis of the produced biscuit**

The proximate composition (moisture, ash, crude fibre, crude protein, fat and carbohydrate contents) of the biscuit samples was analyzed following the procedure reported by Ezegbe *et al*. (2023). Moisture content was determined using the oven-drying technique, in which samples were dried in a hot air oven (Gallenkamp 300 plus series, Widnes, Cheshire, U.K.) at 105 °C until a constant weight was obtained. Fat content was quantified using the Soxhlet extraction method with petroleum ether (Loba Chemie, Mumbai, India) as the extracting solvent. Ash content was measured by incinerating the samples in a muffle furnace (Hasthas, Servell Engineers, Chennai, India) at 600 °C for 5 hours. Protein content was determined using the micro-Kjeldahl method, applying a nitrogen-to-protein conversion factor of 6.25. Carbohydrate content was subsequently

estimated by difference, calculated as 100 minus the sum of moisture, ash, fat, and protein values.

**Sensory Evaluation of the produced biscuit**

Sensory evaluation was done for the produced biscuit samples with 20 semi-trained panelists (10 male and 10 female) from Nnamdi Azikiwe University Community, Awka, Anambra state. A 9-point hedonic scale was used with the rating 9 as like extremely and 1 as dislike extremely. The biscuits produced were evaluated based on its quality characteristics of colour, flavour, taste, aroma, texture, overall acceptability. Sensory evaluation of the biscuit samples was conducted between 10:00 a.m. and 12:00 noon in a well-lit, odour-free sensory laboratory. Panelists were instructed not to eat, smoke, or consume strongly flavoured foods or beverages at least 2 hours before the assessment. Samples were coded with random three-digit numbers and presented in randomized order at room temperature (29°C±2°C). Clean potable water was provided for mouth rinsing before and between sample evaluations to minimize flavour carryover effects. Panelists evaluated samples independently under controlled conditions without discussion.

**Ethical Approval**

The ethical approval was given by the Department of Food Science and Technology, Nnamdi Azikiwe University, Awka, Anambra State on 18th April 2024 (NAU/FST/ETH/2024/04/002).

**Statistical analysis**

All experimental data obtained from the analyses were statistically evaluated using Analysis of Variance (ANOVA). Differences among means were further compared using Duncan's Multiple Range Test at a 5% significance level with the aid of Predictive Analytics Software (PASW, version 17).

**Results**

The result for proximate composition of biscuits produced from wheat, soybean and fermented rice bran are presented in Tables 3. The proximate composition of biscuits made from various blends of wheat, soybean, and fermented rice bran showed variation across different samples (Table 3). There were significant ($p<0.05$) differences among the samples for the different proximate parameters (Moisture, protein, fat, ash, crude fibre and carbohydrate). Moisture content ranged from 9.09% in sample WFS3 (100% wheat) to 12.14% in sample WFS2 (55 % Wheat:30 % Soybean: 15 % Fermented Rice Bran). Protein content exhibited a significant ($p<0.05$) variation amongst samples and were in the range of 10.19% in sample WFS3 (100 % Wheat: 0 % Soybean: 0 % Fermented Rice Bran) to 22.87% in sample WFS1 (40 % Wheat:40 % Soybean: 20 % Fermented Rice Bran). Fat content varied significantly ($p<0.05$) from 3.10% in sample WFS3 (100 % Wheat: 0 % Soybean: 0 % Fermented Rice Bran) to a higher value of 13.08% in sample WFS8. The ash content across the samples significantly ($p<0.05$) varied and ranged from 3.12% in sample WFS2 (55 % Wheat:30 % Soybean: 15 % Fermented Rice Bran) to 4.65% in sample WFS1 (40 % Wheat:40 % Soybean: 20 % Fermented Rice Bran), while crude fibre content significantly ($p<0.05$) varied and

spanned from 3.03% in sample WFS8 (60 % Wheat:40 % Soybean: 0 % Fermented Rice Bran) to 4.76% in sample WFS1 (40 % Wheat:40 % Soybean: 20 % Fermented Rice Bran). Lastly, carbohydrate varied significantly and the content ranged from 45.84% in sample WFS1 to a peak of 71.25% in sample WFS3 (100 % Wheat: 0 % Soybean: 0 % Fermented Rice Bran) .

**Table 3: Proximate composition of biscuits from wheat, soybean and fermented rice bran**

| Sample | Moisture (%) | Protein (%) | Fat (%) | Ash (%) | Fibre (%) | CHO (%) |
|---|---|---|---|---|---|---|
| WFS1 | $11.76^{b}\pm0.09$ | $22.87^{a}\pm0.21$ | $10.14^{d}\pm0.04$ | $4.65^{a}\pm0.05$ | $4.76^{a}\pm0.05$ | $45.84^{h}\pm0.15$ |
| WFS2 | $12.14^{a}\pm0.01$ | $20.17^{b}\pm0.04$ | $11.55^{b}\pm0.02$ | $3.12^{h}\pm0.02$ | $3.45^{d}\pm0.04$ | $49.58^{g}\pm0.01$ |
| WFS3 | $9.09^{g}\pm0.01$ | $10.19^{f}\pm0.01$ | $3.10^{h}\pm0.03$ | $3.33^{f}\pm0.04$ | $3.04^{ab}\pm0.04$ | $71.25^{a}\pm0.06$ |
| WFS4 | $9.87^{f}\pm0.21$ | $11.47^{e}\pm0.04$ | $4.41^{f}\pm0.02$ | $3.24^{g}\pm0.01$ | $3.75^{c}\pm0.05$ | $67.27^{b}\pm0.16$ |
| WFS5 | $10.46^{e}\pm0.04$ | $13.33^{c}\pm0.01$ | $7.21^{e}\pm0.02$ | $3.53^{e}\pm0.04$ | $3.23^{e}\pm0.01$ | $62.26^{d}\pm0.06$ |
| WFS6 | $11.24^{c}\pm0.03$ | $18.03^{ab}\pm0.01$ | $11.31^{c}\pm0.01$ | $4.12^{b}\pm0.03$ | $3.07^{ab}\pm0.04$ | $52.24^{e}\pm0.12$ |
| WFS7 | $12.00^{a}\pm0.14$ | $13.05^{d}\pm0.11$ | $4.20^{g}\pm0.03$ | $3.76^{d}\pm0.04$ | $4.36^{b}\pm0.06$ | $62.64^{c}\pm0.02$ |
| WFS8 | $10.76^{d}\pm0.04$ | $18.05^{ab}\pm0.08$ | $13.08^{a}\pm0.06$ | $4.02^{c}\pm0.02$ | $3.03^{ab}\pm0.04$ | $51.08^{f}\pm0.08$ |

Values are means ± Standard deviation. Means with different letters along a column showed significant difference at $p<0.05$.

**Keys:** CHO = Carbohydrate
WFS1 = 40 % Wheat:40 % Soybean: 20 % Fermented Rice Bran.
WFS2 = 55 % Wheat:30 % Soybean: 15 % Fermented Rice Bran.
WFS3 = 100 % Wheat: 0 % Soybean: 0 % Fermented Rice Bran.
WFS4 = 85 % Wheat:10 % Soybean: 5 % Fermented Rice Bran.
WFS5 = 75 % Wheat:10 % Soybean: 15 % Fermented Rice Bran.
WFS6 = 65 % Wheat:30 % Soybean: 5 % Fermented Rice Bran.
WFS7 = 80 % Wheat: 0 % Soybean: 20 % Fermented Rice Bran.
WFS8 = 60 % Wheat:40 % Soybean: 0 % Fermented Rice Bran.

The result of the sensory evaluation of biscuits produced from wheat, soybean and fermented rice bran are presented in 4. The sensory evaluation of biscuits made from varying proportions of wheat, soybean, and fermented rice bran revealed notable significant ($p<0.05$) differences across the samples in terms of their appearance, taste, texture, mouthfeel, flavour, and overall acceptability (Table 4).

**Table 4: Sensory quality of biscuits from wheat, soybean and fermented rice bran**

| Sample | Appearance | Taste | Texture | Mouthfeel | Flavour | Overall Acceptability |
|---|---|---|---|---|---|---|
| WFS1 | $6.80^{c}\pm0.63$ | $7.00^{b}\pm0.17$ | $7.80^{ab}\pm0.63$ | $7.20^{b}\pm0.03$ | $6.90^{b}\pm0.03$ | $6.60^{b}\pm0.96$ |
| WFS2 | $6.70^{c}\pm0.52$ | $7.30^{ab}\pm0.67$ | $8.70^{a}\pm0.52$ | $6.00^{ab}\pm0.01$ | $7.50^{ab}\pm1.08$ | $7.30^{ab}\pm0.10$ |
| WFS3 | $8.30^{a}\pm0.67$ | $8.70^{b}\pm0.66$ | $8.30^{a}\pm0.67$ | $8.20^{a}\pm0.03$ | $8.80^{a}\pm0.08$ | $8.50^{a}\pm0.02$ |
| WFS4 | $7.30^{ab}\pm0.78$ | $8.00^{a}\pm0.82$ | $7.30^{ab}\pm0.78$ | $7.00^{b}\pm0.01$ | $7.20^{ab}\pm0.10$ | $7.20^{ab}\pm0.08$ |
| WFS5 | $8.80^{a}\pm0.76$ | $8.10^{a}\pm0.87$ | $7.80^{ab}\pm0.76$ | $7.80^{b}\pm0.06$ | $8.20^{a}\pm0.01$ | $8.60^{a}\pm0.03$ |
| WFS6 | $8.30^{a}\pm0.07$ | $7.30^{ab}\pm0.67$ | $8.30^{a}\pm0.67$ | $8.30^{a}\pm0.07$ | $7.30^{ab}\pm0.07$ | $8.30^{a}\pm0.10$ |
| WFS7 | $6.30^{c}\pm0.08$ | $8.30^{a}\pm0.78$ | $8.50^{a}\pm0.78$ | $6.30^{ab}\pm0.08$ | $8.30^{a}\pm0.16$ | $7.30^{ab}\pm0.11$ |
| WFS8 | $7.80^{b}\pm0.06$ | $6.80^{b}\pm0.24$ | $7.80^{b}\pm0.76$ | $7.80^{b}\pm0.76$ | $6.80^{b}\pm0.11$ | $7.80^{ab}\pm0.02$ |

Values are means ± Standard deviation. Means with different letters along a column showed significant difference at $p<0.05$.

**Keys:**

WFS1 = 40 % Wheat:40 % Soybean: 20 % Fermented Rice Bran,
WFS2 = 55 % Wheat:30 % :Soybean: 15 % Fermented Rice Bran,
WFS3 = 100 % Wheat: 0 % Soybean: 0 % Fermented Rice Bran,
WFS4 = 85 % Wheat:10 % Soybean: 5 % Fermented Rice Bran,
WFS5 = 75 % Wheat:10 % Soybean: 15 % Fermented Rice Bran,
WFS6 = 65 % Wheat:30 % Soybean: 5 % Fermented Rice Bran,
WFS7 = 80 % Wheat: 0 % Soybean: 20 % Fermented Rice Bran,
WFS8 = 60 % Wheat:40 % Soybean: 0 % Fermented Rice Bran

**Discussion**

**Proximate Composition of biscuits from Wheat, Soybean and Fermented Rice Bran**

The proximate composition of biscuits from wheat, soybean, and fermented rice bran shows distinct trends across the samples, aligning with similar findings from previous studies. The moisture content, ranging from 9.09% in WFS3 (100 % Wheat: 0 % Soybean: 0 % Fermented Rice Bran) to

12.14% in WFS2 (55 % Wheat:30 % Soybean: 15 % Fermented Rice Bran), indicates that the inclusion of fermented rice bran and soybean tends to affect moisture retention. Higher moisture levels in sample WFS2 (55 % Wheat:30 % Soybean: 15 % Fermented Rice Bran) could be attributed to the hydrophilic nature of soybean, which has been observed by researchers like Adeola and Aworh (2019), who reported that legume-based flours generally have higher moisture due to protein-water interactions. The lower moisture in sample WFS3 (100 % Wheat: 0 % Soybean: 0 % Fermented Rice Bran), composed entirely of wheat, aligns with typical findings in wheat-based cookies, where reduced water activity contributes to a crisper texture (Ajibola *et al*., 2020).

Protein content, varying from 10.19% in WFS3 (100 % Wheat: 0 % Soybean: 0 % Fermented Rice Bran) to 22.87% in WFS1, reflects the influence of soybean as a protein-rich legume. The high protein content in WFS1 (40% soybean) is comparable to findings by Udeh and Ekpo (2021), who reported increased protein levels in composite flours containing soy. The presence of fermented rice bran could have also contributed to higher protein content in certain samples, which agrees with the work of Shah *et al*. (2018), who found that fermentation can enhance the bioavailability of proteins by reducing antinutritional factors like phytates.

The fat content, ranging from 3.10% in WFS3 (100 % Wheat: 0 % Soybean: 0 % Fermented Rice Bran) to 13.08% in WFS8 (60 % Wheat:40 % Soybean: 0 % Fermented Rice Bran), shows a direct relationship with the level of soybean inclusion, as soybean is known for its high oil content (Okoye *et al*., 2022). The higher fat content in WFS8 (60 % Wheat:40 % Soybean: 0 % Fermented Rice Bran) is consistent with previous studies on soybean-enhanced products, where soybean contributes significantly to fat content due to its natural lipid composition (Oyewole *et al*., 2020). On the other hand, the lower fat content in wheat-dominant samples like WFS3 (100 % Wheat: 0 % Soybean: 0 % Fermented Rice Bran) aligns with findings by Anuonye *et al*. (2016), where wheat flour alone exhibited lower lipid levels.

Ash content, which measures the mineral content, varies from 3.12% in WFS2 (55 % Wheat:30 % Soybean: 15 % Fermented Rice Bran) to 4.65% in WFS1 (40 % Wheat:40 % Soybean: 20 % Fermented Rice Bran), with the higher ash values associated with increased soybean and rice bran inclusion. Soybean is particularly rich in minerals such as calcium and magnesium, while fermented rice bran contributes additional trace minerals, as noted by Olaofe and Adeyeye (2020). These findings are consistent with earlier research by Madukwe *et al*. (2019), who observed elevated ash content in composite flours containing legumes and cereal bran due to their inherent mineral profiles.

Fibre content also shows variability, ranging from 3.03% in WFS8 (60 % Wheat:40 % Soybean: 0 % Fermented Rice Bran) to 4.76% in WFS1 (40 % Wheat:40 % Soybean: 20 % Fermented Rice Bran), with higher

fibre in samples containing a greater proportion of fermented rice bran. Fermented rice bran is known to enhance dietary fibre content, as fermentation breaks down complex carbohydrates, releasing more accessible fibre components (Akinjayeju *et al*., 2020). The trend observed here aligns with the work of Chikwendu *et al*. (2019), which highlighted the positive impact of bran fermentation on fibre levels in cereal-based foods.

Finally, carbohydrate content ranges from 45.84% in WFS1 (40 % Wheat:40 % Soybean: 20 % Fermented Rice Bran) to 71.25% in WFS3 (100 % Wheat: 0 % Soybean: 0 % Fermented Rice Bran). The lower carbohydrate levels in samples with higher soybean content reflect the displacement of carbohydrate-dense wheat by protein- and fat-rich soybean, a trend also observed by Ekop *et al*. (2017) in similar composite flour studies. Conversely, the higher carbohydrate content in WFS3 (100 % Wheat: 0 % Soybean: 0 % Fermented Rice Bran), which is 100% wheat, is expected, as wheat flour is predominantly composed of carbohydrates.

**Sensory Quality of biscuits from Wheat, Soybean and Fermented Rice Bran**

Appearance scores range from 6.30 in WFS7 to 8.80 in WFS5. The higher scores for appearance in samples like WFS3 (100 % Wheat: 0 % Soybean: 0 % Fermented Rice Bran) 8.30 and WFS5 (8.80) reflect consumer preference for biscuits made from 100% wheat (WFS3) or a high proportion of wheat, which tend to have a more familiar and appealing look. This is in line with findings from Olagunju *et al*. (2020), who noted that cookies with higher wheat content typically have a golden-brown color and smooth surface, which consumers find attractive.

Taste scores vary from 6.80 in WFS8 (60 % Wheat:40 % Soybean: 0 % Fermented Rice Bran) to 8.70 in WFS3 (100 % Wheat: 0 % Soybean: 0 % Fermented Rice Bran). The high taste score of WFS3 (100 % Wheat: 0 % Soybean: 0 % Fermented Rice Bran) aligns with the study by Akubor *et al*. (2017), which reported that wheat-based cookies are generally more palatable due to their familiar flavor. The slightly lower scores for taste in samples with higher soybean and fermented rice bran content, such as WFS1 (40 % Wheat:40 % Soybean: 20 % Fermented Rice Bran) and WFS8 (60 % Wheat:40 % Soybean: 0 % Fermented Rice Bran), could be attributed to the distinct taste profile of fermented ingredients, which may not be as widely accepted by consumers

Texture scores range from 7.30 in WFS4 to 8.70 in WFS2 (55 % Wheat:30 % Soybean: 15 % Fermented Rice Bran), showing a preference for the texture of biscuits with moderate soybean content (30% in WFS2). This aligns with the work of Oluwatoyin *et al*. (2019), who found that moderate inclusion of soybean improves the texture of cookies by adding a soft and crumbly feel due to the fat content in soybean. The lower texture scores in some samples, like WFS4, could be due to the reduced gluten content, leading to a firmer or coarser texture, as noted by Chukwu and Ihedioha (2021) in similar composite flour studies.

Mouthfeel scores range from 6.00 in WFS2 (55 % Wheat:30 % Soybean: 15 % Fermented Rice Bran) to 8.30 in WFS6 (65 % Wheat:30 % Soybean: 5 % Fermented Rice Bran). Samples like WFS6 (65 % Wheat:30 % Soybean: 5 % Fermented Rice Bran), which scored highest for mouthfeel, likely benefited from the balance of wheat and soybean, leading to a smoother and creamier feel. This result is consistent with the work of Igbabul *et al*. (2018), who noted that composite flours with moderate levels of fat from legumes can enhance the mouthfeel of baked products. The lower mouthfeel score in WFS2 (55 % Wheat:30 % Soybean: 15 % Fermented Rice Bran) could be due to the higher bran content, which might result in a grainier texture.

Flavour scores range from 6.80 in WFS8 (60 % Wheat:40 % Soybean: 0 % Fermented Rice Bran) to 8.80 in WFS3 (100 % Wheat: 0 % Soybean: 0 % Fermented Rice Bran). The high score for WFS3 (100 % Wheat: 0 % Soybean: 0 % Fermented Rice Bran) again reflects the preference for the flavor of 100% wheat biscuits, while the lower scores in samples like WFS8 (60 % Wheat:40 % Soybean: 0 % Fermented Rice Bran) may be due to the unique flavors introduced by the fermented rice bran and soybean, which some consumers might find unfamiliar or less appealing. This observation is supported by the findings of Arise *et al*. (2020), who reported that the fermentation process can introduce strong flavors that might not appeal to all consumers.

Overall acceptability follows a similar trend, with scores ranging from 6.60 in WFS1 (40 % Wheat:40 % Soybean: 20 % Fermented Rice Bran) to 8.60 in WFS5 (75 % Wheat:10 % Soybean: 15 % Fermented Rice Bran). The high acceptability of WFS5 and WFS3 (100 % Wheat: 0 % Soybean: 0 % Fermented Rice Bran) aligns with their superior scores in other sensory parameters, particularly appearance, taste, and flavour. Consumers generally prefer biscuits with a balanced taste, familiar texture, and appealing appearance, which is why wheat-dominant samples tend to score higher overall. This is consistent with research by Ayo *et al*. (2019), who found that consumer acceptability is typically higher for wheat-based cookies due to their familiar sensory attributes.

In summary, the sensory evaluation reveals a clear preference for biscuits with a higher wheat content, likely due to the familiarity of wheat-based products in terms of taste, texture, and appearance. While the addition of soybean and fermented rice bran contributes to nutritional improvements, it can also introduce changes in sensory properties that may not appeal to all consumers, particularly in terms of taste and flavour. These findings are consistent with existing research on the sensory attributes of composite flour-based biscuits.

**Conclusion and Recommendations**

This study has shown that biscuits can be successfully produced from blends of wheat, soybean and fermented rice bran flours. The inclusion of soybean and fermented rice bran notably influenced the moisture, protein, fat, ash, fiber, and carbohydrate content of the

biscuits. Higher protein and fat levels were observed in samples with greater soybean content, while carbohydrate content decreased with increased soybean inclusion. Sensory evaluations indicated a strong consumer preference for biscuits with higher wheat content due to familiar taste and texture profiles, although some formulations benefited from the nutritional enhancements provided by soybean and fermented rice bran. For best sensory appeal, it is recommended to use 75 % Wheat:10 % Soybean: 15 % Fermented Rice Bran for biscuit production. Future studies are recommended to explore the optimization of wheat, soybean, and fermented rice bran ratios to balance nutritional benefits with sensory acceptance.

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**Author's contribution**

Clement Chinedum Ezegbe: Conceived and designed the experiment, interpreted the data, supervised the research, proof read and edited the article. Nwokedi Amara performed the experiments, analyzed the data, and wrote the article. Both authors read and authorized the publication of the article.

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