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Research Article

Physicochemical Properties of Protein- and Fiber-Rich Cookies from Whole Wheat, Germinated Fluted Pumpkin Seed and Rice Bran Flour Blends

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Abstract

This study aimed at investigating the use of whole wheat, germinated fluted pumpkin seed and rice bran composite flours in the production of cookies. Protein- and fiber--rich cookies were produced using wheat, germinated fluted pumpkin seed and rice bran flour blend in ratios; 100: 0: 0, 85: 10: 5, 80: 10: 10 and 75: 10: 15 and were labelled A, B, C and D respectively. Sample A (100% whole wheat flour) served as control. The proximate composition, mineral content and physical properties of the cookies were determined using standard methods. The moisture, ash, fat, protein fiber and carbohydrate content ranged from 5.20 -.7.30%, 1.45 - 2.81%, 5.85 - 8.08%, 7.89 - 11.30%, 1.80 - 5.48% and 66.17 - 77.81% respectively. For minerals, there was significant ($p<0.05$) increase in calcium (57.15 - 79.03 mg/100g), magnesium (34.61 - 50.41 mg/100g), sodium (3.55 - 3.99 mg/100g), potassium (76.87 - 103.30 mg/100g) and phosphorus (3.37 - 4.95 mg/100g) with increased substitution with rice bran flour. However, diameter, (3.24 - 3.92 cm), weight (6.80 g - 8.07 g), thickness (0.86 - 0.96 cm) and spread ratio (3.76 - 4.08) of the cookies significantly ($P<0.05$) reduced with increased substitution with rice bran flour. The utilization of these underutilized food sources for the production of protein- and fiber-rich cookies could enhance their economic value while contributing to value addition across the agro-food chain.

Keywords

Cookies, Protein, Fiber, Whole Wheat, Germinated Fluted Pumpkin Seed, Rice Bran

1. Introduction

The food industry generates a wide range of nutrient-rich co-products that offer significant potential for valorization and sustainable reuse. Consequently, numerous studies have investigated the utilization of food processing residues as valuable resources for the development of new products and applications [1, 2]. Rice bran is an example of such co-products.

Cookies are low-moisture, ready-to-eat baked products prepared from unleavened dough and are widely consumed by individuals across different age groups. They are particularly important in regions where protein-energy malnutrition and inadequate calorie intake remain prevalent, owing to their convenience, relatively long shelf life, and potential to serve as nutrient-dense food products [3].

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Wheat (*Triticum aestivum*) is cultivated over a larger land area than any other food crop [1]. Wheat, though a major global staple, has limitations in protein quality due to its low levels of essential amino acids such as lysine and threonine. Whole wheat flour is recognized for its improved nutritional value over refined flour, as it retains the bran, germ, and endosperm, thereby preserving essential vitamins (especially B-vitamins), minerals (iron, magnesium), and dietary fiber [4].

Fluted pumpkin (*Telfairia occidentalis*) seed is one of the locally available, most common and underutilized food sources in the Southern part of Nigeria with a very high protein content of about 27% protein [5] and a relatively even distribution of amino acid. The presence of antinutrients especially phytic acid, limits the utility of fluted pumpkin seeds as a source of protein. However, these antinutrients can be removed by processing [6, 7]. Research indicates that germination enhances the protein quality and vitamin levels in certain cereals and legumes [8] while also helping to reduce the antinutritional factors.

Rice is one of the most widely cultivated and consumed staple crops worldwide [9], During rice milling, paddy rice undergoes processing to separate the edible rice kernel from the hull and bran layers. Despite its considerable nutritional value, the utilization of rice bran for human consumption has remained limited, largely due to its high susceptibility to rancidity and subsequent deterioration during storage, but methods to stabilize rice bran have been developed. Despite its rich content of bioactive compounds, a substantial proportion of rice bran is still discarded. Rice bran is a rich source of dietary fiber, along with vitamins, minerals, and essential fatty acids [9]. Furthermore, rice bran contains flavonoid compounds that have been associated with a reduced risk of certain types of cancer and are recognized for their potential anti-inflammatory properties.

The integration of legumes or other protein-rich seeds into cereal formulations helps to improve the nutritional quality of such food items [10], thereby helping to prevent protein energy malnutrition as most cereal grains are deficient in certain essential amino acids [11]. Moreover, a high intake of dietary fiber has been associated with a reduced risk of coronary heart disease, colorectal cancer, and various bowel disorder [12]. Production of cookies with flour blends of whole wheat, germinated fluted pumpkin seed and rice bran is nutritionally advantageous and could be a way of adding value to rice bran which is regarded as waste. The objective of the study was to produce protein- and fiber-rich cookies from blends of whole wheat, germinated fluted pumpkin seed and rice bran flours and evaluate their quality parameters.

2. Materials and Methods

2.1. Procurement of Raw Materials

Rice bran was procured from a rice mill in Ini L.G.A while wheat grains and matured fluted pumpkin seeds were purchased from Itam market, Itu L.G.A, both in Akwa Ibom State, Nigeria. All reagents and chemicals used were of analytical grade.

2.2. Preparation of Raw Materials

2.2.1. Preparation of Whole Wheat Flour

The method described by [1] was followed in the preparation of whole wheat flour. The whole wheat grains were cleaned from dirt by sorting out contaminants such as sands, sticks and leaves, and were later washed and oven (model pp22 US, Genlab, England) dried at a temperature of 55^{o}C for 6 hours. The whole wheat was later milled using attrition mill (model SK-30-SS) and sieved through a 2 mm mesh sieve, packaged in an air tight sealed container for subsequent use.

2.2.2. Preparation of Germinated Fluted Pumpkin Seed Flour

Germinated fluted pumpkin seed flour was prepared using the method described by [6]. Matured fluted pumpkin seeds were extracted from the pods and subjected to germination by arranging them in layers of sawdust and watering them daily for seven (7) days. Following germination, the sprouted seeds were carefully selected, dehulled, cleaned, and sliced into smaller pieces for further processing. The sliced seeds were dried in an oven (Model PP22 US, Genlab, England) at 50 ℃ for 6 h. The dried seeds were subsequently milled using a laboratory mill (CU-600 Glufex Scientific, UK) and passed through a 500 µm sieve to obtain a uniform flour. The resulting flour was defatted using a Soxhlet apparatus with *n*-hexane as the extraction solvent at room temperature for 8 h. Following defatting, the flour was oven-dried at 50 ℃ to remove residual *n*-hexane. The dried defatted flour was then milled, packaged in polyethylene bags, properly labeled, and stored in a cool, dry place until further analysis.

2.2.3. Preparation of Rice Bran Flour

Preparation of rice bran flour was done according to the method of [13]. The rice bran was destoned, oven dried at 60^{0}C for 3 hours, milled using an attrition mill (model SK-30-SS). and sieved through a 200 µm mesh size to produce fine rice bran flour. The rice bran flour was packagesd in polyethylene bags, labeled and stored in a cool, dry place.

2.3. Formulation of Composite Flours

Four different proportions of whole wheat, germinated fluted pumpkin seed and rice bran flours were formulated, with 100% whole wheat flour serving as the control (Sample A). The rest of the samples were designated as B (85: 10: 5), C (80: 10: 10) and D (75: 10: 15) of whole wheat, germinated fluted pumpkin seed and rice bran flours respectively.

2.4. Formulation of Ingredients and Cookies Preparation

The method described by [14] was used to formulate the ingredients as well as produce cookies from blends of whole wheat, germinated fluted pumpkin seeds and rice bran flours. Ingredients used were: flour (100g), milk powder (7.8g), hydrogenated vegetable oil (40g), baking powder (1g), vanilla essence (2 g), egg (31g), salt (1g), nutmeg (0.3g).

2.5. Determination of Proximate Composition of the Cookies

Moisture, crude protein, crude fat, total ash, crude fiber and carbohydrate contents were determined using the method of [15].

2.6. Determination of Physical Properties of the Cookies

Weight, diameter, thickness and spread ratio of the cookies were determined according to the method described by [16].

2.7. Determination of Mineral Content

Potassium, Sodium, Calcium, Magnesium and Phosphorus contents were determined using the method of [15].

2.8. Statistical Analysis

The data obtained were subjected to analysis of variance (ANOVA) using a completely randomized design (CRD) with Statistical Package for the Social Sciences (SPSS), version 23.0. Treatment means were separated using Duncan's multiple range test (DMRT) at a 95% confidence level, with statistical significance established at $p < 0.05$.

3. Results and Discussion

3.1. Proximate Composition of Cookies from Whole Wheat, Germinated Fluted Pumpkin

Seed and Rice Bran Composite Flours

The proximate composition of cookies from whole wheat, germinated fluted pumpkin seed and rice bran composite flours is shown in Table 1. The moisture content of the cookies ranged from 5.20-7.30% with sample D (75% whole wheat, 10% germinated fluted pumpkin seed, 15% rice bran flour cookie) having the highest moisture content of 7.30% while sample A (100% whole wheat flour cookie) recorded the lowest moisture content (5.20%). This could be due to the fact that the rice bran absorbed moisture; increasing freshness and reducing the recrystallization of amylopectin during storage which could play a role in modulating the staling mechanism of baked product [17]. These relatively low values for moisture content indicate that the cookies could be shelf stable with a long storage life These range of values for moisture content are higher than the values reported by [18] for novel cookies from whole wheat, African yam bean and rice bran composite flours, as well as the values reported by [19] for cookies from whole wheat, orange fleshed sweet potato, defatted peanut and rice bran composite flour.

The ash content of the cookies ranged from 1.45 -2.81% with sample D (75% whole wheat, 10% germinated fluted pumpkin seed, 15% rice bran flour cookie) having the highest ash content (2.81%) while the lowest was recorded in sample A (100% whole wheat flour cookie) (1.45%). Ash content indicates an estimate of the mineral content in a given quantity of food substance. Rice bran is rich in mineral content [20]. This could be responsible for the increase in ash content as the level of substitution with rice bran flour increased. The ash content was similar to the range of values reported by [19] for cookies from whole wheat, orange fleshed sweet potato, defatted peanut and rice bran composite flour, but lower compared to the values obtained by [18] for novel cookies from whole wheat, African yam bean and rice bran composite flours.

Fat content of the cookie samples ranged from 5.85 - 8.08%. The highest value was observed in sample D (75% whole wheat, 10% germinated fluted pumpkin seed, 15% rice bran flour cookie) while the lowest fat content was observed in sample A (100% whole wheat flour cookie). The fat content increased with inclusion of germinated fluted pumpkin seed flour and increased substitution with rice bran flour. Fluted pumpkin seed is an oil-rich seed [6] and rice bran is also rich in oil [9]. The fat content was higher than the range of values (2.68 - 4.72%) reported by [18] for novel cookies from whole wheat, African yam bean and rice bran composite flours. Fats provide more than twice the energy per gram compared with proteins and carbohydrates, making them the most energy-dense of the major food components. In addition to serving as a concentrated source of energy, dietary fats facilitate the absorption and transport of fat-soluble vitamins, including vitamins A, D, E, and K, within the body.

The protein content of the cookies ranged from 7.89 - 11.30% with sample B (85% whole wheat, 10% germinated fluted pumpkin seed, 5% rice bran flour cookie) recording the highest value, while the lowest was observed in sample A (100% whole wheat flour cookie). The inclusion of germinated fluted pumpkin seed flour was seen to have increased the protein content of the cookies as fluted pumpkin seed is rich in protein [6]. The range of values for protein obtained in this study was lower than the range reported by [19] for cookies from whole wheat, orange fleshed sweet potato, defatted peanut and rice bran composite flour, as well as the values reported by [18] for novel cookies from whole wheat, African yam bean and rice bran composite flours. Protein plays a vital role in the regulation, growth, repair, and maintenance of body tissues and physiological functions. Quality of snacks as well

as consumers' health can be enhanced by fortification with protein from selected sources [21].

The crude fiber content of the cookie samples varied significantly (P<0.05) and ranged from 1.30- 5.48% with sample D (75% whole wheat, 10% germinated fluted pumpkin seed, 15% rice bran flour cookie) having the highest fiber content and sample A (100% whole wheat flour cookie) having the lowest fiber content. The fiber content increased with increased inclusion of rice bran flour. The higher fiber content in samples containing rice bran flour may increase the water absorption capacity of the flour. Dietary fiber provides protection by increasing fecal bulk which dilutes the increased caloric bile acid concentration that occurs with a high fat diluent. The rice bran enriched cookie samples may be helpful in treatment of constipation and other ailments related to fast food habit. The values for fiber content obtained in this study was lower than the range of values reported by [18] for novel cookies from whole wheat, African yam bean and rice bran composite flours, as well as the values reported by [19] for cookies from whole wheat, orange fleshed sweet potato, defatted peanut and rice bran composite flour.

The carbohydrate content varied significantly (P<0.05) and ranged from 66.17-77.81%. It was observed that sample A (100% whole wheat flour cookie) had the highest carbohydrate content while sample D (75% whole wheat, 10% germinated fluted pumpkin seed, 15% rice bran flour cookie) had the lowest carbohydrate content. The carbohydrate content of the samples depended on other parameters as it was calculated by difference. The carbohydrate contents of the cookies were higher than the values reported by [19] for cookies from whole wheat, orange fleshed sweet potato, defatted peanut and rice bran composite flour, but within the range of values reported by [18] for novel cookies from whole wheat, African yam bean and rice bran composite flours. Therefore, the relative high carbohydrate content of the cookies makes it a cheap source of carbohydrate.

Table 1. *Proximate Composition of Cookies from Whole Wheat, Germinated Fluted Pumpkin Seed and Rice Bran Composite Flours (%).*

Parameters	SAMPLE			
	A	B	C	D
Moisture	5.20 ± 0.09^{c}	6.53 ± 0.11^{a}	6.59 ± 0.15^{b}	7.30 ±0.50^{b}
Ash	1.45 ± 0.11^{c}	1.92 ± 0.11^{c}	2.05 ± 0.05^{a}	2.81 ± 0.11^{b}
Fat	5.85 ± 0.06^{a}	6.48 ± 0.17^{a}	6.97 ± 0.011^{b}	8.08 ± 0.09^{c}
Protein	7.89 ± 0.17^{c}	11.30 ± 0.11^{b}	10.78 ± 0.14^{a}	10.16 ± 0.17^{b}
Crude Fiber	1.80± 0.17^{d}	4.20 ± 0.17^{b}	5.00 ± 0.11^{a}	5.48 ± 0.10^{c}
Carbohydrate	77.81± 0.26^{a}	69.57 ± 0.34^{d}	68.61 ± 0.28^{c}	66.17±0.17^{b}

[1] Values are means ± standard deviations of triplicate determinations. Means with different superscript on the same row are significantly (P <0.05) different.

Key:

A = 100% whole wheat (Control)

B = 85% whole wheat, 10% germinated fluted pumpkin seed, 5% rice bran

C = 80% whole wheat, 10% germinated fluted pumpkin seed, 10%, rice bran

D = 75% whole wheat, 10% germinated fluted pumpkin seed, 15% rice bran

3.2. Mineral Content of Cookies from Whole Wheat, Germinated Fluted Pumpkin Seed *and Rice Bran Composite Flours*

The mineral content of cookies from whole wheat, germinated fluted pumpkin seed and rice bran composite flours are shown in Table 2. Minerals are essential nutrients that play vital roles in growth and development, immune system function, cellular maintenance, and protection against cellular damage. [22]. All the minerals analyzed for were seen to increase in content as the level of incorporation of rice bran flour increased and with the inclusion of germinated fluted pumpkin seed flour. This could be due to the fact that both rice bran and fluted pumpkin seed are rich in minerals [6, 20].

Calcium content ranged from 57.15-79.03mg/100g. The highest calcium content was observed in sample D (75% whole wheat, 10% germinated fluted pumpkin seed, 15% rice bran flour cookie) while the lowest was observed in ample A (100% whole wheat flour cookie). The calcium content of the cookie samples was higher than the range of values reported by [19] for cookies from whole wheat, orange fleshed sweet potato, defatted peanut and rice bran composite flour, and that reported by [18] for novel cookies from whole wheat, African

yam bean and rice bran composite flours. Calcium plays essential roles in several physiological processes, including muscle contraction and the transmission of nerve impulses. It is also involved in the blood coagulation cascade and contributes to the regulation and metabolism of various hormones.

The magnesium content of the cookie samples varied significantly (P<0.05) and ranged from 34.61-50.41 mg/100g. The magnesium content of the cookie samples was lower than the range of values reported by [18] for novel cookies from whole wheat, African yam bean and rice bran composite flours. Magnesium is an essential mineral involved in numerous biochemical reactions and physiological processes in the body. It contributes to the maintenance of normal muscle function, supports proper nerve function, helps regulate heart rhythm, and plays an important role in maintaining normal blood glucose levels [23]. Therefore, sample D (75% whole wheat, 10% germinated fluted pumpkin seed, 15% rice bran flour cookie) would be the most beneficial for magnesium intake.

The sodium content varied significantly (P<0.05) and ranged from 3.55-3.99 mg/100g. The sodium content was higher than the range of values reported by [19] for cookies from whole wheat, orange fleshed sweet potato, defatted peanut and rice bran composite flour, as well as the values reported by [18] for novel cookies from whole wheat, African yam bean and rice bran composite flours. Sodium plays an important role in the regulation of blood pressure, with excessive intake being associated with elevated blood pressure. Maintaining a low dietary sodium intake alongside adequate potassium consumption is an important nutritional consideration for promoting cardiovascular health.

The potassium content of the cookie samples ranged from 76.87-103.30 mg/100g. Sample D (75% whole wheat, 10% germinated fluted pumpkin seed, 15% rice bran flour cookie) had the highest potassium content. The potassium content was higher compared to the values reported by [18] for novel cookies from whole wheat, African yam bean and rice bran composite flours, as well as the values reported by [19] for cookies from whole wheat, orange fleshed sweet potato, defatted peanut and rice bran composite flour. Potassium plays an important role in reducing blood pressure.

The phosphorus content ranged from 3.37-4.95 mg/100g. Sample D (75% whole wheat, 10% germinated fluted pumpkin seed, 15% rice bran flour cookie) with the highest incorporation of rice bran flour had the highest phosphorus content. Phosphorus is vital in building and maintaining bones and teeth; it is also an important component of nucleic acids and phospholipids. As a coenzyme, it functions in energy metabolism and also buffers intracellular fluid.

Table 2. *Mineral Content of Cookies from Whole Wheat, Germinated Fluted Pumpkin Seed and Rice Bran Composite Flours (mg/100g).*

Parameters	SAMPLE			
	A	B	C	D
Calcium	57.15 ± 0.05^{c}	68.91 ± 0.57^{b}	71.48 ± 0.09^{a}	79.03 ± 0.57^{b}
Magnesium	34.61 ± 4.49^{d}	44.92 ± 0.91^{a}	48.12 ± 0.00^{b}	50.41 ± 0.51^{c}
Sodium	3.55 ± 0.28^{c}	3.91 ± 0.00^{d}	3.94 ± 0.14^{b}	3.99 ± 0.07^{a}
Potassium	76.87 ± 0.11^{b}	86.58 ± 0.17^{b}	96.36 ± 0.15^{b}	103.30 ± 0.57^{a}
Phosphorus	3.37 ± 0.10^{b}	4.86 ± 0.05^{a}	4.87 ± 0.05^{a}	4.95 ± 0.05^{a}

[2] Values are means ± standard deviations of triplicate determinations. Means with different superscript on the same row are significantly (P <0.05) different.

Key:

A = 100% whole wheat (Control)

B = 85% whole wheat, 10% germinated fluted pumpkin seed, 5% rice bran

C = 80% whole wheat, 10% germinated fluted pumpkin seed, 10%, rice bran

D = 75% whole wheat, 10% germinated fluted pumpkin seed, 15% rice bran

3.3. Physical Properties of Cookies from Whole Wheat, Germinated Fluted Pumpkin Seed and Rice Bran Composite Flours

The physical properties of the cookie samples are shown in Table 3. The cookie samples did not vary significantly (P<0.05) in diameter, weight, thickness and spread ratio.

The weight of the cookie samples ranged from 6.80 - 8.07g. The highest value for weight was observed in sample A (100% whole wheat flour cookie) while sample D (75% whole wheat, 10% germinated fluted pumpkin seed, 15% rice bran flour cookie) had the lowest value for weight. The weight of the cookies gradually decreased with increase incorporation of rice bran flour. This higher weight of the control sample is an

inkling of the binding properties of wheat flour and of the cookie's texture. The weight of the cookies was higher compared to the values reported by [18] for novel cookies from whole wheat, African yam bean and rice bran composite flours, as well as the values reported by [19] for cookies from whole wheat, orange fleshed sweet potato, defatted peanut and rice bran composite flour.

The diameter of the cookies ranged from 3.24-3.92cm. Thickness and diameter of the cookie samples decreased with increased incorporation of rice bran flour.

Spread ratio, calculated by dividing diameter by thickness is an important property in determining the quality of flour used for the production of cookies. Cookies with higher spread ratios are more desirable than those with lower spread ratios. The spread ratio of sample B (85% whole wheat, 10% germinated fluted pumpkin seed, 5% rice flour bran) was the highest. As reported by [24], lower viscosity of dough makes cookies to spread at faster rate and conversely.

Table 3. *Physical Properties of Cookies from Whole Wheat, Germinated Fluted Pumpkin Seed and Rice Bran Composite Flours.*

Parameters	SAMPLE			
	A	B	C	D
Diameter (cm)	3.92 ± 0.00[a]	3.74 ± 0.00[a]	3.45 ± 0.00[a]	3.24 ± 0.00[a]
Weight (g)	8.07 ± 0.00[a]	7.77 ± 0.00[a]	7.13 ± 0.00[a]	6.80 ± 0.00[b]
Thickness (cm)	0.96 ± 0.00[a]	0.90 ± 0.00[a]	0.88 ± 0.00[a]	0.86 ± 0.00[a]
Spread ratio	4.08 ± 0.00[a]	4.15 ± 0.00[a]	3.92 ± 0.00[a]	3.76 ± 0.00[a]

[3] Values are means ± standard deviations of triplicate determinations. Means with different superscript on the same row are significantly ($P < 0.05$) different.

Key:

A = 100% whole wheat (Control)

B = 85% whole wheat, 10% germinated fluted pumpkin seed, 5% rice bran

C = 80% whole wheat, 10% germinated fluted pumpkin seed, 10%, rice bran

D = 75% whole wheat, 10% germinated fluted pumpkin seed, 15% rice bran

4. Conclusion

From the result obtained from the study, substitution of whole wheat flour with germinated fluted pumpkin seed flour and rice bran flour in cookies production increased the nutritional quality (especially protein, fibre and minerals). Therefore, production of cookies with flour blends of whole wheat, germinated fluted pumpkin seed and rice bran will not only improve the nutritional quality of the product but also enhance the utilization of under-utilized seeds such as fluted pumpkin seed, as well as rice bran which is considered by some as a waste product from rice milling.

Abbreviations

L.G. A	Local Government Area
ANOVA	Analysis of Variance
CRD	Completely Randomized Design
SPSS	Statistical Package for the Social Sciences
DMRT	Duncam's Multiple Range Test

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Author Contributions

Udoh Iniobong Enefiok: Conceptualization, Data curation, Investigation, Methodology, Resources, Writing – review & editing, Supervision Writing – original draft

Ndah Linus Sylvester: Investigation, Methodology, Supervision, Visualization, Writing – review & editing

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Conflicts of Interest

The authors declare no conflicts of interest.

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