

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 (6.80g - 8.07g), thickness (0.86 - 0.96 cm) and spread ratio (3.76 - 4.08) significantly ($P < 0.05$) reduced with increased substitution with rice bran flour.

Keywords: Cookies; Protein; Fiber; Whole Wheat; Germinated Fluted Pumpkin Seed; Rice Bran

Introduction

The food industry produces a number of co-products with high nutritional value and great potential for reuse. A number of studies using industrial residues from food processing have been performed with this purpose [1,2]. Rice bran is an example of such co-products.

Cookies are low moisture baked ready-to-eat snacks made from unleavened dough and are usually consumed among all age groups in many countries particularly in parts of the world where there is prevalence of protein and calorie deficiency [3].

Wheat (*Triticum aestivum*) is grown more on 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 widely used crops in the world for human consumption [9], Paddy rice is milled to separate the rice kernel from the hull and bran. Human consumption of rice bran, a by-product of milled rice, has been limited primarily because of the rapid onset of rancidity, but methods to stabilize rice bran have been developed. However, most of the rice bran is still discarded, despite its high content of bioactive constituents. Rice bran is a rich source of dietary fiber, along with vitamins, minerals, and essential fatty acids [9]. Moreover, rice bran contains flavonoids that have been reported to reduce the risk of certain types of cancer and possess anti-inflammatory activity.

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 cereals do not contain some essential amino acids [11]. Moreover, intake of high dietary fiber is associated with lower risk of coronary heart disease, colon cancers and bowel disorders [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.

Objective of the Study

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.

Materials and Methods

Procurement of raw materials

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

Preparation of raw materials

Preparation of whole wheat flour

The method described by [1] was followed in the production 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°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.

Preparation of germinated fluted pumpkin seed flour

Germinated fluted pumpkin seed flour was prepared using the method described by [6]. The matured fluted pumpkin seeds were extracted from the pod and the seeds was germinated by arranging them in layers of sawdust and watering daily for seven (7) days. Sprouted seeds were selected, dehulled, cleaned and sliced into pieces. The sliced seeds were oven (model pp22 US, Genlab, England) dried at 50°C for 6 hours, milled in a laboratory miller (Cu-600 Glufex, Scientific, UK) and sieved through 500µm sieves. This was followed by defatting the flours in a Soxhlet apparatus using n-hexane at room temperature for eight (8) hours. The defatted flours were dried in an oven at 50°C to remove all traces of n-hexane, milled, packaged in polyethylene bags, labeled and stored in a cool, dry place.

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°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 packaged in polyethylene bags, labeled and stored in a cool, dry place.

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.

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 (2g), egg (31g), salt (1g), nutmeg (0.3g).

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].

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].

Determination of mineral content

Potassium, sodium, calcium, magnesium and phosphorus contents were determined using the method of [15].

Statistical analysis

The data obtained was subjected to analysis of variance of a completely randomized design using the Statistical Product for Service Solution version 23.0, while treatment means were separated using Duncan's multiple range test at 95% confidence level ($p < 0.05$).

Results and Discussion

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 weigh more than twice the calories per gram of protein and carbohydrate, and of all the food components, they contain the highest amount of calories. They are also useful in the transportation of fat-soluble vitamins (A, D, E and K) in 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 is crucial to the regulation and maintenance of the body. 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.

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 important for growth, robust immune system, maintenance of cells and averting cell 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.

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

Table 1: Proximate composition of cookies from whole wheat, germinated fluted pumpkin seed and rice bran composite flours (%).

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.

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 - 79.03 mg/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 sample 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 is involved in the mechanism of muscle contraction, and also in the transmission of nerve pulses. It plays a role in the cascade of blood clotting and in the metabolism of many 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 necessary for biochemical reactions in the body, helping to maintain muscle, improving the functioning of the nerves, as well as maintaining the heart rate and regulating blood sugar [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 raising blood pressure. A low intake of sodium and sufficient potassium contributes to dietary challenge humans have to face daily.

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.

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

Table 2: Mineral content of cookies from whole wheat, germinated fluted pumpkin seed and rice bran composite flours (mg/100g).

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.

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 - 3.92 cm. 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.

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

Table 3: Physical properties of cookies from whole wheat, germinated fluted pumpkin seed and rice bran composite flours.

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.

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.

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Author Contributions

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Ndah, Linus Sylvester: Formal analysis supervisor, investigation, visualization, writing review - editing, methodology.

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Conflict of Interest

The authors declare no conflict of interest.

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