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Evaluation of Nutritional and Functional Characteristics of Biscuits Enriched with Groundnut-Wheat Composite Flour

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Abstract

Biscuits can be made from batters, soft dough, or hard dough, depending on the enrichment criteria. Since the body is unable to produce minerals, they are necessary for proper bodily function. Micronutrients must be supplied from the diet because they are needed in trace amounts. The study aimed to determine the chemical and functional characteristics of biscuits manufactured using groundnut and wheat flours. Flour samples from different groundnuts were made using normal processes, mixed with wheat flour to make biscuits, and then examined for mineral, functional, and proximate qualities. In the process of making biscuits, groundnut flour was utilised to substitute 10%, 20%, 30%, and 40% of the wheat flour, while 100% wheat flour served as a control. The AOAC approach was used to determine the levels of protein, carbohydrate, fibre, fat, moisture, and ash. A split-plot design with complete randomisation was used for the experiment. Analysis of variance was used to examine the collected data (ANOVA). At $p < 0.05$, significance was acknowledged. The biscuits' proximate composition varied from 8.75% to 11.02 protein, 75% to 19.11% fat, 1.54% to 3.24% crude fibre, 6.26 to 8.01% ash, and 49.53% to 57.36% carbohydrate. The calcium, phosphorus, iron, magnesium, and potassium contents of the biscuit samples were also noted. According to the flour's functional characteristics, its bulk density ranged from 0.65 to 0.70 g/cm3, its capacity to absorb water ranged from 1.95 to 2.42 g/g, and its capacity to absorb oil ranged from 1.95 to 2.42 g/g. It is possible to substitute groundnut flour with wheat flour to make biscuits more nutritious. Comparing the biscuits to those made with just wheat flour, the nutritious content of the groundnut with wheat composite flours was higher. The customers should be informed of the nutritional and health benefits of groundnut flour.

Keywords: Groundnut Flour, Chemicals, Minerals, Biscuits, Functional Characteristics

Introduction

Background of the Study

Biscuits are a ready-to-eat, quick, and pricey snack item that is widely appreciated, particularly among youngsters in Nigeria and other nations. Ingredients used to make biscuits include sugar, water, oil, and wheat flour. Biscuits can be categorised based on the method used to shape them, as well as the extent of enrichment and processing. Biscuits can be made from batters, soft dough, or hard dough, depending on the enrichment criteria (Emojorho *et al*., 2024). Since the body is unable to produce minerals, they are necessary for proper bodily function. Micronutrients must be supplied from the diet because they are needed in trace amounts (Aniemena *et al*., 2024) [6]. The selection of ingredients and production methods, such as roll and cut, shape and slice, and scoop and bake, play a crucial role in biscuit quality (Ayo *et al*., 2024) [9].

Attempts have been made to encourage the use of composite flour, which entirely or partially replaces wheat flour in baked goods with flours generated from locally grown crops with high nutritional value (Aniemena *et al*. 2024) [6]. By employing composite flour, we may reduce our reliance on wheat imports for baked goods production, conserve foreign exchange, and engage our youth in productive activities (Anene *et al*., 2023; Aphiar *et al*., 2024) [4, 7].

Globally, cereal-legume-based foods are important sources of affordable dietary energy and nutrients (Anene *et al*., 2023) [4]. From a nutritional perspective, it is beneficial to consume mixtures of cereals and legumes as they provide a balance in diet (Anene *et al*., 2023) [4]. Rice, which makes up 95% of all cereals ingested, is one cereal grain that is essential to human nutrition. It is mostly used in households, where it is cooked, pounded, fried, and consumed with soup or stew. Cereal grains have been the principal component of the human diet and have played a major role in shaping human civilisation for thousands of years. More than 50% of the world's daily caloric intake is derived directly from cereal grain consumption (Okonwu *et al*., 2022) [24]. Cereals are high in cysteine and methionine, but they are not able to supply all the nutrients needed for proper nutrition since they lack certain key amino acids, like lysine (Anene *et al*., 2023) [4]. In Nigeria, biscuits and other western-style baked goods like bread and cakes made with wheat flour are highly consumed, particularly by youngsters (Ayo *et al*., 2003) [8]. One of the main issues with using wheat flour is its low protein level in comparison to other plant-based protein sources (such as peanuts).

In an effort to improve the nutritional value of baked goods, fortification of wheat flour with high-protein legume flours has been studied for a long time. However, because they are not consumed by everyone and because dietitians are reluctant to recommend snack or dessert foods as a source of protein, the usage of high-protein biscuits has received less attention.

Short stature, a slender frame, low energy levels, and swelling legs and abdomen are some signs of extreme undernourishment, also referred to as hunger. It results in significant clinical effects, including death, increased hospitalisation, physical weakness, a low standard of life, and socioeconomic problems (Fan *et al*., 2022) [18]. Infections and colds are also common among people. Malnutrition can be classified into two categories: protein-energy malnutrition and micronutrient malnutrition.

One or more of the necessary micronutrients are absent in a micronutrient shortage or a diet. Micronutrient malnutrition is linked to 10% of all child deaths, so those working in child welfare are particularly concerned about it. Micronutrients can be obtained from plant sources, particularly legumes, which, when combined with cereals in the diet, provide a large proportion of essential amino acids, minerals, vitamins, and trace elements necessary for proper growth and development of the body. The micronutrient that is deficient determines the symptoms of the deficiency. In both industrialised and developing nations, almost two billion people of all ages suffer from micronutrient deficiencies.

They are known to have a significant influence on global health, causing certain diseases and exacerbating others. Iodine, iron, zinc, calcium, selenium, fluorine, and vitamins A, B1, B2, B3, B6, and C are important micronutrients. Numerous specialised micronutrients, such as vitamins A, D, C, E, B6, and B12, folate, zinc, iron, copper, and selenium, are necessary for the complex, integrated immune system. These nutrients play important, frequently cooperative roles at every stage of the immune response. The daily micronutrient intakes required to sustain immune function may exceed the currently suggested dietary requirements, yet adequate levels are necessary to ensure the normal function of immune cells and physical barriers (Gombart *et al*., 2022). There are two types of protein-energy malnutrition: kwashiorkor (a shortage of protein) and marasmus (a loss of calories and protein). Kwashiorkor, also known as wet protein energy malnutrition, is a kind of PEM that is mainly defined by a lack of protein.

This illness can emerge at any point during a child's formative years; however, it typically manifests about 12 months after breastfeeding is stopped. A legume crop primarily farmed for its edible seeds, peanuts are often referred to as groundnuts and are taxonomically categorised as *Arachis hypogaea* L. It is categorised as an oil crop due to its high oil content, as well as a grain or legume. The proper consumption of indigenous foods that are high in key nutrients like protein has been replaced by Western dietary habits like snacking due to the high expense of living in most developing nations, particularly Nigeria. Our foreign reserves have been depleted as a result of our over-reliance on wheat flour for baked goods. For baked goods, groundnut composite flour must be used. Nigeria will be able to import less wheat and produce more groundnuts as a result. In addition to preserving our foreign income, it will lessen our over-reliance on wheat flour for baked goods. Improving the quality characteristics of flour-based products has always been a key focus in the food industry. This ensures better nutritional value, functionality, and consumer acceptance of baked goods (Sabbaghi, 2021a; Sabbaghi, 2021b) [25, 26]. The study's goal is to create and assess biscuits using combinations of peanut and wheat flour. Because groundnut flour is rich in both protein and micronutrients, biscuits with a high protein content will be made. It will help reduce the threat of malnutrition. The biscuits will lessen the problems of malnutrition, protein-energy malnutrition, and vitamin and mineral deficiencies in both adults and children in underdeveloped nations.

Material and Methods

Source of Raw materials

Groundnuts, wheat flour, and other ingredients were bought from Delta State's Ozoro market.

Peanut Flour Production

Whole peanuts were initially roasted for 40 to 60 minutes at 350 degrees Celsius over an open flame in order to create peanut flour. The peanuts were then mashed in a blender to enhance the de-fatting process and reduce their size. To remove the majority of the peanut oil and create a free-flowing flour, the peanuts were allowed to soak in n-hexane (at a ratio of 1:2g/ml seed to solvent) for 12–16 hours (for an entire night) after grinding (Nwatum *et al*., 2020) [20].

Formulation of composite flour blends: Groundnut flour mixes will be made with increasing percentages of groundnuts (0, 10, 20, 30, and 40%). To create a uniform mixture, the flours will be properly combined. The samples will be labelled and kept in an airtight container at room temperature (30 ± 2°C) until they are needed to make bread.

Biscuit Production

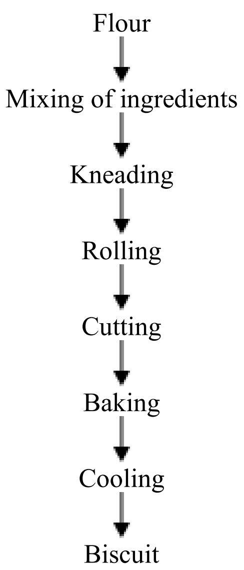
The ratios of groundnut flour to wheat flour utilised to make the biscuits were 40% groundnut to 60%, 30% groundnut to 70%, 20% groundnut to 80%, 10% groundnut to 90%, and a 100% wheat biscuit served as the control. With a few minor adjustments, the biscuits were made using the technique outlined by Emojorho *et al*. (2023) [12]. The flours were used to replace 10, 20, 30, and 40% wheat flour in a food blender set to full speed (120 rpm) for 10 minutes. The biscuits were made in accordance with the Emojorho (2023) protocol. A mixer was used to cream sugar and fat together. Then came the addition of the other dry ingredients. The eggs were next added, and then the five millilitres of water. Using a dough mixer, the doughs were combined for half an hour. A hand biscuit cutter was used to cut the dough into shapes. After putting the cutout dough on oiled trays, it was baked at 200°C for 20 minutes. The hot cooked biscuits were placed in a high-density polyethylene (HDPE) bag after cooling for fifteen minutes. The control was a biscuit made entirely of wheat flour. The production flow chart for biscuits is displayed in Fig 1.

Methods of analysis

Proximate Analysis: The AOAC (2023) [1] approach was used to determine the levels of protein, carbohydrate, fibre, fat, moisture, and ash.

Evaluation of functional properties

The water and oil absorption capacities were assessed using the method outlined by Sathe and Salunkhe (1981) [27]. The lowest gelation concentration was found using a modified version of the Coffmann and Garcia (1977) approach. Utilising the method described by Narayara and Narasinga (1989) [23], the bulk density was ascertained.



Source: Emojorho (2023)

Fig 1: Flow chart for the production of biscuits

Mineral Determination

To establish the potassium content, atomic absorption spectrophotometry, as described by James (1996) [21], was employed. Calculating the calcium content was done using Kirk and Sawyer's (1991) [22] approach. The techniques outlined by the AOAC (2023) [1] were used to ascertain the samples' iron (Fe) and magnesium (Mg) concentrations. The APHA (1995) [3] method was used to determine phosphorus.

Data and Experimental Design

A split-plot design with complete randomisation was used for the experiment. Analysis of variance was used to examine the collected data (ANOVA). Significantly different means were distinguished using the least significant difference (LSD) test. At $p < 0.05$, significance was acknowledged.

Result and Discussion

Proximate Composition of Biscuits from Blends of Groundnut and Wheat Flour

Table 1: Proximate Composition of Biscuit Samples from blends of wheat and groundnut flour

Sample	Moisture	ASH	Fibre	FAT	Protein	CHO
W	$10.00^{a}\pm0$	$6.26^{e}\pm0$	$1.54^{e}\pm0$	$16.01^{e}\pm0$	$8.75^{e}\pm0$	$57.46^{a}\pm0$
WE1	$9.15^{c}\pm0$	$7.39^{b}\pm0$	$1.74^{d}\pm0$	$17.08^{d}\pm0$	$10.01^{d}\pm0$	$54.63^{b}\pm0$
WE2	$9.32^{b}\pm0$	$7.01^{d}\pm0$	$2.01^{c}\pm0$	$17.69^{c}\pm0$	$10.54^{c}\pm0$	$53.42^{c}\pm0$
WE3	$9.32^{b}\pm0$	$7.22^{c}\pm0$	$2.79^{b}\pm0$	$18.43^{b}\pm0$	$11.02^{a}\pm0$	$51.01^{d}\pm0$
WE4	$9.07^{d}\pm0.02$	$8.01^{a}\pm0$	$3.24^{a}\pm0$	$19.11^{a}\pm0$	$11.22^{b}\pm0$	$49.53^{e}\pm0$

The duplicate determinations' means ± standard deviation are used to express the values. Values in the same column that have distinct superscript letters are significantly ($p<0.05$) different. There is no significant difference ($p>0.05$) between values in a column that have the same superscript letter. keys W = 100 per cent wheat flour, WG1 = 90:10 groundnut flour, WG2 = 80:20 groundnut flour, WG3 is equal to 70 wheat: 30 groundnut flour, and WG4 is equal to 60 wheat: 40 groundnut flour.

The biscuits' moisture level varied between 9.07 and 10.00 per cent. The biscuits with the highest moisture content were made with only wheat flour. However, when the amount of wheat flour in the biscuit samples increased, the moisture content decreased. The biscuits with 40% groundnut flour had the highest moisture content. The biscuit samples varied significantly from one another.

The biscuits had ash concentrations ranging from 6.26 per cent to 8.01 per cent. The findings were above the 0.50 to 2.50% ash levels for idlis made with a composite flour of black gram, African yam bean, and pigeon pea that were reported by Anene *et al*. (2023) [4]. The enhanced biscuits had a higher ash content. "As the amount of groundnut flour in the biscuits increased, so did the values. "At 6.26 per cent, the biscuit made entirely of wheat flour had the least amount of ash. The biscuits with 40 per cent groundnut flour had the highest ash content (8.01 per cent), whereas the biscuits made with 100 per cent wheat flour had the lowest ash amount (6.26 per cent). "Because groundnut flour had a higher ash content than wheat flour, the addition effect caused the ash contents to increase significantly ($p<0.05$) as the amount of groundnut flour in the biscuits increased." There was a significant difference ($P < 0.05$) in the amount of ash in the biscuit samples.

According to Table 1, the biscuits' fibre contents varied from 1.54 to 3.24%. For noodles made from composite flours, the range of values was somewhat greater than the 1.10 to 2.95 per cent reported by Emojorho *et al*. (2024). The biscuits that were supplemented had increased fibre levels. "As the amount of groundnut flour in the biscuits increased, so did the values." At 149.94 mg/100g, the biscuit made entirely of wheat flour had the least amount of fibre. The biscuits with 40% debittered groundnut flour had the highest fibre content (3.24%), whereas the biscuits made with 100% wheat flour had the lowest fibre content (1.54%). "Because groundnut flour had a higher potassium content than wheat flour, the addition effect caused the fibre contents to increase significantly (p<0.05) as the amount of groundnut flour in the biscuits increased." There was a significant difference (P < 0.05) in the fibre content between the biscuit samples.

The biscuits' fat percentages varied from 8.75% to 19.11% (Table 1). The enhanced biscuits had a higher fat content. The findings exceeded the 3.68 to 9.37% fat content for composite flour reported by Emojorho *et al*. (2024). "As the amount of groundnut flour in the biscuits increased, so did the values." At 149.94 mg/100g, the biscuit made entirely of wheat flour had the least amount of fat. While the biscuits with 40% debittered groundnut flour had the highest fat content, the biscuits made with 100% wheat flour had lower fat amounts. "Because groundnut flour had a higher potassium content than wheat flour, the addition effect caused the fat contents to increase significantly (p<0.05) as the amount of groundnut flour in the biscuits increased." There was a significant difference (P < 0.05) in the fat content of the biscuit samples.

The biscuits' protein percentages varied from 8.75% to 11.02% (Table 1). The enhanced biscuits had increased protein levels. The results were marginally greater than the 1.04–10.61 per cent protein content of cupcakes that Aniemena *et al*. (2024) [6] reported. "As the amount of groundnut flour in the biscuits increased, so did the values." At 8.75%, the biscuit made entirely of wheat flour had the lowest protein concentration. The protein level of the groundnut flour biscuits was greater (8.75–11 mg/100g) than that of the biscuits made with 100% wheat flour (8.75%), and the biscuits with 40% debittered groundnut flour had the highest value (11.22). "Because groundnut flour had a higher protein content than wheat flour, the addition effect caused the protein contents to increase significantly (p<0.05) as the amount of groundnut flour in the biscuits increased." There was a significant difference (P < 0.05) in the protein content of the biscuit samples. According to Table 1, the biscuits' carbohydrate amounts varied from 49.53% to 57.36%. The results were nearly identical to the 45.83 to 64.46 per cent carbohydrate levels for biscuits made with a wheat and orange seed composite flour that were reported by Emojorho *et al*. (2024) and 46.20 to 66.74 reported by Nwatum *et al*. (2020) [20] for cookies produced from wheat, peanut and avocado composite flours. The enhanced biscuits had a decreased carbohydrate content. "The values dropped as the biscuits' groundnut flour content rose." At 57.36%, the biscuit made entirely of wheat flour had the highest carbohydrate load. Compared to biscuits made entirely of wheat flour (57.46 per cent), those made with groundnut flour had reduced carbohydrate levels (49.53 to 54.63%). Because groundnut flour had less carbohydrate than wheat flour, the dilution effect caused the carbohydrate levels to drop significantly (p<0.05) as the amount of groundnut flour in the biscuits increased. There was a significant difference (P < 0.05) in the amount of carbohydrates in the biscuit samples (Emojorho *et al*., 2023 [12]; Emojorho *et al*., 2024).

Functional Properties of Flour Samples from Blends of Wheat and Groundnut Flour

Table 2: Functional properties of wheat and groundnut composite flours from blends of wheat and groundnut

Sample	BD	WAC	OAC	LGC
W	0.7^{a}±0	1.95^{e}±0.01	1.3^{e}±0	5^{b}±0
WE1	0.68^{b}±0	1.99^{d}±0.01	1.5^{d}±0	5^{b}±0
WE2	0.67^{c}±0	2.08^{c}±0.01	1.65^{c}±0.07	5^{b}±0
WE3	0.65^{d}±0	2.31^{b}±0.01	1.8^{b}±0	5.0^{b}±0
WE4	0.65^{e}±0	2.42^{a}±0.01	1.9^{a}±0	10^{a}±0

The bulk densities of the flours ranged from 0.65 to 0.70 g/cm³. The results were comparable to the 0.635 to 0.765 g/cm3 for cupcakes made with a wheat and garri composite flour that Aniemena *et al*. (2024) [6] reported. The highest figure was 0.70 g/cm³ for wheat flour. As the amount of groundnut flour increases, the bulk density decreases. Due to their low bulk density, the flours can be employed in food formulation without fear of retrogradation. The bulk density of a flour sample reveals its weight (Emojorho and Okonkwo, 2022) [11]. Porosity and bulk density are said to be adversely correlated (Emojorho and Okonkwo, 2022) [11]. Bulk density could be used to determine how much packing flours require based on the weight that the samples could support if stacked directly on top of one another. Higher bulk density flours promote fat absorption (Emojorho and Okonkwo, 2022) [11]. It is possible that flours with a high capacity to absorb water are used to make baked goods, processed cheese, sausage, doughs, and soups (Emojorho and Okonkwo, 2022) [11].

Water absorption capacities (WACs) for the flours ranged from 1.95 to 2.42 g/g. At 2.42 g/g WAC, the composite flour containing 40% groundnut flour achieved the highest value, surpassing the figure of 1.95 g/g for 100% wheat flour. The values were comparable to the 1.96–2.88 g/g water absorption capacity for wheat and orange seed flours reported by Emojorho and Okonkwo (2022) [11]. The water-absorbing properties of certain flours offer a useful clue as to whether or not proteins can be added to watery food compositions, especially those that require working with dough. Protein-water interactions affect properties like hydration, swelling power, solubility, and gelation (Emojorho and Okonkwo, 2022) [11]. The water absorption capacity of seed flour indicates how much water it can absorb. Flour with a high rate of water absorption is suitable for bakery products because hydration improves the handling qualities of the final product.

The least amount of oil may be absorbed by wheat flour (1.95 g/g). The oil absorption capacity of the samples varied between 1.95 and 2.42 g/g. As the amount of groundnut flour increased, so did the values. Wheat flour's fibre content, which is insoluble in cold water, may have affected its capacity to absorb water and oil (Emojorho and Okonkwo, 2022) [11]. The ability of flour to absorb oil is important because it improves mouthfeel and maintains food flavour (Emojorho and Okonkwo, 2022) [11]. Given that oil absorption is advantageous in baked items and sausage, groundnut flours could be useful in this respect (Emojorho and Okonkwo, 2022) [11]. The ability of flour to absorb oil is one indicator of its tendency to do so (Emojorho and Okonkwo, 2022) [11]. The main chemical component affecting the capacity to absorb oil is protein, which has residues of both hydrophilic and hydrophobic amino acids. The more hydrophobic amino acid residues a protein contains, the more oil-absorbing capacity it has. The ability to absorb water is essential when making foods that are ready to consume. A high absorption capacity may guarantee product cohesion (Emojorho and Okonkwo, 2022) [11].

The least gelation concentration (LGC), or the lowest protein concentration at which gel remained in the inverted tube, served as a gauge of gelation capability. For wheat flour, the LGC of 5% was similar to that of composite flour that contained up to 30% sa flour. 40% groundnut flour composite flour had the greatest LGC value (10%). As the concentration of gelation decreases, the gelling ability of the protein constituent increases (Emojorho and Okonkwo, 2022) [11]. The main factors influencing the development of flour gel are the amount and composition of different food components, including proteins, carbohydrates, and fats, as well as how these components interact (Emojorho and Okonkwo, 2022) [11].

Mineral composition of biscuit samples from blends of groundnut and wheat flour

Table 3: Mineral composition of Biscuits from composite flours of wheat and groundnut

Sample	Magnessium	Phosphoros	Potassium	Calcium	Iron
W	$126.75^{e}\pm0.06$	$40.68^{b}\pm0.03$	$149.94^{e}\pm0.06$	$0.23^{e}\pm0.01$	$1.87^{c}\pm0.02$
WG1	$130.36^{d}\pm0.04$	$43.07^{b}\pm0.04$	$173.25^{d}\pm0.04$	$3.54^{d}\pm0.02$	$1.95^{bc}\pm0.04$
WG2	$148.05^{c}\pm0.06$	$46.95^{ab}\pm0.05$	$182.67^{c}\pm0.05$	$6.75^{c}\pm0.04$	$1.97^{ab}\pm0.02$
WG3	$151.25^{b}\pm0.06$	$45.64^{ab}\pm7.03$	$190.21^{b}\pm0.03$	$16.41^{a}\pm0.01$	$1.96^{b}\pm0.05$
WG4	$168.34^{a}\pm0.04$	$51.96^{a}\pm0.05$	$195.54^{a}\pm0.04$	$12.76^{b}\pm0.03$	$2.05^{a}\pm0.02$

Mineral Composition of Biscuit

Table 3 displays the mineral makeup of the biscuits made with mixtures of wheat and groundnut (peanut) flour. According to Table 3, the biscuits' magnesium amounts varied from 126.75 mg/100g to 168.34 mg/100g. The results were less than the orange seed with wheat composite flour values of 127.76 to 244.21 mg/100g recorded by Emojorho *et al*. (2023b) [15]. At 126.75 mg/100g, the biscuits made entirely of wheat had the lowest magnesium concentration, while the one made with 40% groundnut flour had the greatest amount. (168.34 mg/100 g). Significant ($p<0.05$) variations were seen in the biscuits' magnesium levels. Because groundnut flour had a higher magnesium content than wheat flour, there was an extra effect that caused the magnesium contents to rise significantly ($p<0.05$) as the amount of groundnut flour in the biscuits rose.

According to Table 3, the biscuits' phosphorus concentrations varied from 40.64 mg/100g to 51.97 mg/100g. For sweet potato-based composite flour, the values exceeded the 12.36 to 18.52 mg/100g of phosphorus published by Chiedu *et al*. (2023) [10]. "The higher the amount of groundnut flour in the biscuits, the higher the values of the phosphorus content." At 40.68 mg/100g, the biscuit made entirely of wheat flour had the lowest phosphorus concentration. "Because groundnut flour had a higher phosphorus content than wheat flour, the addition effect caused the phosphorus contents to increase significantly ($p<0.05$) as the amount of groundnut flour in the biscuits increased." The biscuit samples' phosphorus contents varied substantially ($P < 0.05$).

According to Table 3, the biscuits' potassium concentrations varied from 149.94 mg/100g to 195.54 mg/100g. The readings were less than the 5.03 to 6.02 mg/100g for composite flours reported by Emojorho *et al*. (2024b) [14]. The enhanced biscuits had increased potassium values.

"As the amount of groundnut flour in the biscuits increased, so did the values." At 149.94 mg/100g, the biscuit made entirely of wheat flour had the lowest potassium concentration. The biscuits made with 40% debittered groundnut flour had the highest potassium content (195.54 mg/100g), whereas the biscuits made with 100% wheat flour had the lowest potassium content (149.94 mg/100g). "Because groundnut flour had a higher potassium content than wheat flour, the addition effect caused the potassium contents to increase significantly ($p<0.05$) as the amount of groundnut flour in the biscuits increased." There was a significant difference ($P < 0.05$) in the potassium content of the biscuit samples.

According to Table 3, the biscuits' calcium amounts varied from 0.23 mg/100g to 12.76 mg/100g. The findings for rice, pigeon pea, and African yam bean composite flour were less than the 40.48 to 130.50 mg/100g reported by Anene *et al.* (2023) [4]. The enhanced biscuits had increased calcium levels. The amount of groundnut flour in the biscuits gradually increased as the values rose. At 0.23 mg/100g, the biscuit made entirely of wheat flour had the lowest calcium concentration. The biscuits' varying calcium amounts were significantly different ($p<0.05$). "Because groundnut flour had a higher calcium content than wheat flour, the addition effect caused the calcium contents to increase significantly ($p<0.05$) as the amount of groundnut flour in the biscuits increased." There were substantial ($P < 0.05$) differences in the interactions between biscuit samples' calcium content.

According to Table 3, the biscuits' iron levels varied from 1.87 mg/100g to 2.05 mg/100g. The results were less than the 2.33 to 10.36 mg/100g for rice, pigeon pea, and African yam bean composite flour reported by Anene *et al*. (2023b) [5]. The enhanced biscuits had a higher iron content. As the amount of groundnut flour in the biscuits grew, the values rose as well. At 1.87 mg/100g, the biscuit made entirely of wheat flour had the lowest iron concentration.

The iron content of the groundnut-based biscuits was higher than that of the samples made with wheat flour. Compared to biscuits made with wheat flour (1.87 mg/100g), those made with groundnut flour had greater iron concentrations (1.95–2.05 mg/100g). "The biscuits' iron contents varied significantly ($p<0.05$) from one another." Since groundnut flour had a higher iron content than wheat flour, the additive effect caused the iron content of all supplemented cookies to steadily rise as the amount of groundnut flour increased.

Conclusion

To increase the nutritional value of biscuits, groundnut flour could be used in place of wheat flour, according to the research. When compared to biscuits made with wheat flour, the biscuit's nutritional contents (fibre, protein, minerals, and fat) were improved by using groundnut flour. For biscuit production, the composite flour should be added to wheat flour to enhance the micronutrient makeup. Investigations should be conducted into the effectiveness of groundnut flour in baked goods like bread, cakes, and other items. It is necessary to assess the potential for nutraceutical benefits of baked goods that contain groundnut flour. Additionally, customers should be informed of the nutritional and health benefits of groundnut flour.

Disclaimer (Artificial intelligence)
Author(s) hereby declare that NO generative AI technologies have been used during the writing or editing of this manuscript.

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