IPS Journal of Nutrition and Food Science
IPS J Nutr Food Sci, 4(2): 384-389 (2025)
DOI: https://doi.org/10.54117/ijnfs.v4i2.87

Influence of Blending Ratios and Baking Temperature on the Nutritional and Sensory Properties of Biscuits Made from Wheat, Peanut and Banana Flour

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Abstract

Background: Biscuit is a small thin crisp cake made from unleavened dough.
Aim: The objective of the study is nutrient composition and sensory evaluation of biscuits made from wheat, peanut and banana fruit.
Materials and Methods: The study adopted an experimental study design. The study compared proximate composition (moisture, carbohydrate, fat, protein, crude fiber, and ash); micronutrients (zinc, iron, potassium, vitamin B1, B3 and C) and sensory attributes (taste, color, appearance, flavor, and texture) of biscuits made from different ratios of flour blends baked at 180ºC and 200ºC. Flours made from wheat, pigeon pea and moringa leaves were used to produce blends for biscuit production in the following ratios in percentage: 100:0:0 (Control), 60:30:10, and 70:25:5. Proximate, micronutrient, and sensory characteristics were determined using standard methods. Data were analyzed with means, standard deviations and analysis of variance.
Results: The proximate analysis of the six best accepted biscuit revealed that the samples had moisture highest in 60:30:10 baked at 180ºC. Biscuit made from 60:30:10 baked at 200ºC had the highest fat content. Biscuit produced from 70:25:5 baked at 180ºC and sample produced from 60:30:10 baked at 180ºC have the highest crude fiber content. The protein content of the biscuits was highest (38.89%) in sample made from 60:30:10 baked at 180ºC. The sample produced from 60:30:10 baked at 180ºC has the highest content of vitamin B3. Sample prepared from 60:30:10 baked at 180ºC exhibited the highest potassium content. The sensory evaluation revealed the Biscuit produced from 70:25:5 baked at 180ºC and 660:30:10 baked at 180ºC was generally accepted as it had ratings above average mark and can serve as a good snack.
Conclusion: Despite being a snack, biscuit can help the nutrient needs of adults and children.

Keywords: *Biscuits; Blending Ratios; Baking Temperature; Nutritional Composition; Sensory Evaluation.*

Article History
Received: 20 Mar 2025
Accepted: 02 Apr 2025
Published: 11 Apr 2025

How to cite this paper: Agbo, E. C., Nnadi, I. M., & Nnadi, U. P. (2025). Influence of Blending Ratios and Baking Temperature on the Nutritional and Sensory Properties of Biscuits Made from Wheat, Peanut and Banana Flour. *IPS Journal of Nutrition and Food Science*, *4*(2), 384–389. https://doi.org/10.54117/ijnfs.v4i2.87

1. Introduction

Biscuit is conventionally a wheat flour-based food product that has become a major component of human snacks in most parts of the world. They are ready-to-eat, convenient and inexpensive food product (1). Wheat *(Triticum aestivum)* flour constitutes the basic ingredient for biscuit production because of its gluten proteins. Gluten protein forms elastic dough during baking and gives high organoleptic quality to the finished products (2). Unfortunately wheat production is low in Nigeria due to the climatic condition which is unfavorable to the crop leading to the importation of wheat [3]. According to Okaka (4) wheat contains substantial amount of gliadin in which when kneaded with water gives gluten, the elastic material important in aerated baked goods.

Most of the carbohydrate fraction of wheat is starch (5). Variety of foods produced from wheat are poor sources of protein and therefore may require partial replacement to enhance the nutritional value (6). The nutritional value of legumes is related to their high protein content. Legumes contain relatively low quantities of the essential amino acid methionine. To compensate, some vegetarian cultures serve legumes along with grains, which are low in the essential amino acid lysine, which legumes contain. Thus a combination of legumes with cereals can provide all necessary amino acids for vegetarians (7).

Peanut (*Arachis hypogaea L.*) is technically considered as pea and belongs to the family (fabaceae) of bean/legume. Although a legume, it is generally included amongst the oilseeds due to

its high oil content. Peanuts are rich in protein, oil and fibers (8). Peanut is a rich source of edible oil, containing 36 to 54% oil and 25 to 32% protein (9). It has also revealed that peanuts are excellent source of proteins, fibers, polyphenols, resveratrol, phenolic acids, flavonoids and phytosterols. It is also a good source of Co-enzyme Q10 and contains all the 20 amino acids with highest amount of arginine (10).

Banana *(Musa Sp.)* is high starch content biomass and has gained ground in the development of products such as breads, biscuits and pastries. It has excellent medicinal properties, especially for several pathological conditions, including constipation and diarrhea, due to its ability to normalize colon functions and cases of gastrointestinal infection (11). Bananas are a type of fruit produced and consumed worldwide (12). With the arise of the gluten related disorders, some of which have been known for a long time – such as celiac disease and dermatitis herpetiformis – and others only recently identified – as gluten sensitivity – it has become very important to expand the gluten-free food market (13). The use of banana could be an interesting alternative for wheat or gluten replacement in food (12).

Most of the snacks consumed like biscuit are low in nutrient density. They are high in calories, sugar and fat, which can lead to various health problems. To promote healthier snacking habits, there is need to develop biscuit that are more nutritious by incorporating composite flours (14). Peanut and banana seems to have the potential for such, as banana provides lots of health benefits. It contains more fiber and protein than wheat. Peanut on the other hand is rich in protein and dietary fiber. Peanuts contain no gluten, making them a perfect choice for people who have celiac disease or any other kind of wheat allergy (15).

The protein content of wheat grains may vary between 10% - 18% of the total dry matter. The amount of starch contained in a wheat grain may vary between 60% and 75% of the total dry weight of the grain. The germ has the highest amount of lipids (11%), but significant amounts are also associated with the bran and the starch and proteins of the endosperm. Wheat proteins are classified according to their solubility in various solvents. Albumins are the smallest wheat proteins, followed in size by globulins. Gliadins and glutenins are complicated high-molecular weight proteins. Most of physiologically active proteins (enzymes) in wheat grains are found in the albumin and globulin groups. Gliadins and glutenins are storage proteins and cover about 75% of the total protein content. They have no enzyme activity, but they have a function in the formation of dough as they retain gas, producing spongy baked products (16).

Biscuit is a baked or cooked food that is typically small, flat and sweet. It usually contains flour, sugar and some types of oil or fat. It includes other ingredients such as raisins, oats, chocolate chips, nuts, etc. Biscuit, is a small quick bread usually made from flour, salt, butter or vegetable shortening and with baking powder as a leavening agent. The dough is kneaded briefly and rolled out, and the biscuits are cut with a round cutter. The dough may also be dropped by spoonful for an irregular shape (17). The major raw materials used for preparation of biscuits are flour, water, sugar, egg, milk and milk products. The average ingredients composition of biscuit is flour 44 %, sugar 23%, milk 3%, fat 11% and egg 4%. The minor ingredients are added in trace amount. The average chemical composition of biscuits is protein 5.58%, fat 28.05%, ash 0.47%, fiber 1.46% and carbohydrates 57.27%. The average energy content of biscuits is 578 kcal/100g (18).

2. Materials and Methods

Procurement of Raw Materials

The raw materials used in this project are wheat, barley, peanut, baking powder, granulated sugar, salt, unsalted butter, whole milk which were purchased from Ogige market in Nsukka, Enugu state, Nigeria.

Sample Preparation

The wheat, and peanut flour were processed in the following ways;

Processing of Wheat to Flour

The method of wheat flour processing was described by Sharmilee (19). The wheat was cleaned by hand sorting. It was then dried under the sun for 72hours. After which it was milled into flour. The flour was sieved.

Processing of Peanut into Peanut Flour

- Peanut was spread in a single layer on a baking sheet and roasted in a preheated oven for 5 minutes on 350°F (180°C) stirring occasionally. Roasting the peanuts helps to make peeling easy.
- Once the peanuts are roasted, they were removed from the oven and allow to cool for about 10-15 minutes. After which, it was peeled to remove its skin.
- The peeled peanut was then milled to powder.

Preparation of Mashed Banana

The banana is first sorted and cleaned, then peeled and sliced into smaller pieces and then mashed.

Biscuit

The modified recipe by FAO, (20) adopted after preliminary experimentation was used.

Table 1: Ratios for combination

	Control	Blending ratio 1	Blending ratio 2
Wheat	100	70	60
Peanut	-	25	30
Banana	-	5	10

Table 2: Distribution of ingredients used in different samples

Ingredients	Control	Blending Ratio 1	Blending Ratio 2
Wheat	250g	175g	150g
Peanut	-	63g	75g
Banana	-	13g	25g
Butter	65g	60g	55g
Baking Powder	7g	7g	7g
Sugar	20g	10g	5g
Eggs	50g	50g	50g
Whole milk	95mls	95mls	95mls
Salt	1g	1g	1g

Procedure for Biscuit Production

The butter was chilled in the freezer for 10-20 minutes before beginning the recipe.

1. The oven was preheated and the cookie sheet lined with nonstick parchment paper then set aside.
2. Wheat flour, peanut flour and banana was combined with the baking powder, sugar, and salt in a large bowl and mixed well.
3. The chilled butter was brought out, grated into the flour mixture and stirred.
4. Milk was added using a wooden spoon to mix evenly.
5. The biscuit dough was spread to a well-floured surface and gently worked on with hands.
6. Hands were used to flatten the dough to 1 inch thick and a 3/4 round biscuit cutter was lightly dusted with flour.
7. Close cuts were made by pressing biscuit cutter straight down into the dough and was dropped on top of already prepared baking sheets.
8. Biscuit was placed into the oven and baked at 180 ºC for 30 minutes and 200 ºC for 20 minutes until the tops began to turn lightly golden brown.

The biscuit to be used for proximate determination was preserved in a glass jar to prevent air from getting into it.

Sensory Evaluation

Biscuit samples for organoleptic evaluation was presented in clean closed plastic bag and served on the test day. The biscuit samples was subjected to sensory evaluation. The samples was blindly coded (A, B, C, D, E, F, G, H and I). About 25 Students from the Department of Nutrition and Dietetics evaluate the sensory characteristics of each coded samples for (Color, Flavor, Texture, Taste, and General acceptance) and a 9-point hedonic scale to ascertain the acceptability of each of the samples.

Analytical procedures

The proximate composition (moisture, carbohydrate, fat, protein, crude fiber, and ash) and micronutrients (zinc, iron, vitamin C and pro-vitamin A) were determined according to the Association of Analytic Communities method.

3. Results

Table 1 shows the proximate analysis of the samples. The moisture content of the sample ranges from 10.77% to 14.96%, sample BR1T2 has the lowest moisture content of 10.77% while sample BR2T1 has the highest moisture content of 14.96%. The ash content of the sample ranges from 1.88% to 3.64%, sample BR1T2 has the lowest ash content of 1.88% while sample CL 200 has the highest ash content of 3.64%. The fat content of the sample ranges from 2.07% to 4.40%, sample CL 180 has the lowest fat content of 2.07% while sample BR2T2 has the highest fat content of 4.40%. The crude fiber content of the sample ranges from 0.40% to 2.23%, sample CL 200 has the lowest crude fiber content of 0.40% while sample BR2T1 and BR1T1 has the highest crude fiber content of 2.23% each. The protein content of the sample ranges from 14.75% to 38.89%, sample CL 200 has the lowest protein content of 14.75% while sample BR2T1 has the highest protein content of 38.89%. The carbohydrate content of the sample ranges from 36.69% to 59.33%, sample BR2T2 has the lowest carbohydrate content of 36.69% while CL 180 has the highest carbohydrate content of 59.33%.

Table 1: Proximate Analysis of the Six Biscuit Samples

Sample	Moisture%	Ash%	Protein%	Fat%	Crude Fiber%	Carbohydrate%
CL 180	11.94 ± 0.16^{b}	2.49 ± 0.01^{b}	24.90 ± 0.11^{e}	2.07 ± 0.30^{a}	0.60 ± 0.01^{a}	59.33 ± 0.40^{d}
CL 200	10.98 ± 0.03^{a}	3.64 ± 0.23^{c}	14.75 ± 1.10^{a}	2.30 ± 0.30^{c}	0.40 ± 1.02^{a}	57.15 ± 0.32^{e}
BR1T1	13.26 ± 0.10^{c}	2.34 ± 0.11^{b}	26.30 ± 0.10^{d}	2.85 ± 0.56^{b}	2.10 ± 1.01^{b}	52.52 ± 0.42^{b}
BRIT2	10.77 ± 0.01^{d}	1.88 ± 0.13^{a}	24.71 ± 0.03^{b}	2.30 ± 0.28^{a}	2.10 ± 0.01^{b}	54.90 ± 0.15^{c}
BR2T1	14.96 ± 0.10^{e}	$3.3o\pm0.28^{c}$	38.89 ± 0.02^{f}	3.35 ± 0.50^{ab}	2.23 ± 0.20^{b}	37.81 ± 0.11^{a}
BR2T2	14.12 ± 0.33^{a}	2.17 ± 0.11^{a}	30.57 ± 0.11^{e}	4.40 ± 0.60^{a}	$2.17\pm o.03^{b}$	36.69 ± 0.25^{d}

Data represent mean ± standard deviation of four replications, values with "a" superscript are statistically significant ($p<0.05$) while values with "b" superscript are statistically insignificant ($p>0.05$)

Keys:

CL 180 -100% Wheat Flour (control) at 180ºC
CL 200 -100% Wheat Flour (control) at 200ºC
BR1T1 – 70% Wheat 25% Peanut 5% Banana (at 180ºC)
BR1T2 –70% Wheat 25% Peanut 5% Banana (at 200ºC)
BR2T1 – 60% Wheat 30% Peanut 10% Banana (at 180ºC)
BR2T2 –60% Wheat 30% Peanut 10% Banana (at 200ºC)

Table 2 shows the vitamin C, B1 and B3 analysis of the samples. The vitamin B1 content of the sample ranges from 2.19mg/100g to 3.66 mg/100g, sample BR1T2 has the lowest vitamin B1 content of 2.19 mg/100g while sample CL 180 has the highest vitamin B1 content of 3.66 mg/100g. The vitamin B3 content of the sample ranges from 3.16 mg/100g to 5.72 mg/100g, sample CL200 has the lowest vitamin B3 content of 3.16 mg/100g while sample BR2T1 has the highest vitamin B3 content of 5.72 mg/100g. The vitamin C content of the sample ranges from 1.28 mg/100g to 1.72 mg/100g, sample CL 200 has the lowest vitamin C content of 1.28 mg/100g while sample BR2T1 has the highest content of vitamin C content of 1.72 mg/100g.

Table 2: Vitamin analysis of the six biscuit samples

Sample	Vitamin B1 (mg/100g)	Vitamin B3 (mg/100g)	Vitamin C (mg/100g)
CL 180	3.66±0.08^{b}	3.19±0.04^{a}	1.60±0.49^{bc}
CL200	3.16±0.06^{b}	3.16±0.01^{a}	1.28±0.20^{a}
BR1T1	2.60±0.30^{a}	4.23±0.01^{a}	1.43±0.49^{c}
BR1T2	2.19±0.04^{a}	4.20±0.04^{a}	1.60±0.40^{a}
BR2T1	2.50±0.03^{a}	5.72±0.04^{a}	1.72±0.23^{b}
BR2T2	2.42±0.43^{a}	5.35±0.025^{b}	1.42±0.31^{a}

Data represent mean ± standard deviation of four replications, values with "a" superscript are statistically significant ($p<0.05$) while values with "b" superscript are statistically insignificant ($p>0.05$)

Keys:
CL 180 -100% Wheat Flour (control) at 180^{o}C
CL 200 -100% Wheat Flour (control) at 200^{o}C
BR1T1 – 70% Wheat 25% Peanut 5% Banana (at 180^{o}C)
BR1T2 –70% Wheat 25% Peanut 5% Banana (at 200^{O}C)
BR2T1 – 60% Wheat 30% Peanut 10% Banana (at 180^{o}C)
BR2T2 –60% Wheat 30% Peanut 10% Banana (at 200^{o}C)

Table 3 shows the iron, potassium and zinc analysis of the samples. The Iron content of the sample ranges from 0.64mg to 2.26mg, sample CL180 has the lowest Iron content of 0.64mg while sample BR2T2 has the highest Iron content of 2.26 mg. The Zinc content of the samples ranges from 0.29mg to 0.95mg, sample CL180 has the lowest zinc content of 0.95 mg while sample BR1T1 has the highest zinc content of 0.95 mg. The potassium content of the sample ranges from 219 mg to 487 mg, sample CL180 has the lowest potassium content of 219mg while sample BR2T1 has the highest potassium content of 487mg.

Table 4 shows the sensory evaluation of the samples. The color rating of the samples ranged from 5.35 to 7.80, sample BR2T2 has the lowest colour rating of 5.35 while sample BR1T1 has the highest clour rating of 7.80. The taste rating of the sample ranged from 5.00 to 7.50, sample BR2T2 has the lowest taste rating of 5.00 while sample BR1T2 has the highest taste rating of 7.80. The texture rating of the samples ranged from 5.40 to 7.40, sample CL180 has the lowest texture rating of 5.40 while sample BR1T1 and BR1T2 has the highest texture rating of 7.40 each. The flavour rating of the samples ranged from 5.05 to 7.50, sample BR2T2 has the lowest flavour rating of 5.05 while sample BR1T2 has the highest flavour rating of 7.50. The appearance rating ranged from 5.65 to 7.60, sample BR2T2 has the lowest appearance rating of 5.65 while sample BR1T1 has the highest appearance rating of 7.60. The general acceptability rating of the sample ranged from 4.75 to 7.00, sample BR2T2 has the lowest general acceptability rating of 4.75 while sample BR1T1 and BR1T2 has the highest general acceptability rating of 7.00 each.

Table 3: Mineral Analysis of the Six Biscuit Samples

Sample	Iron (mg)	Zinc (mg)	Potassium (mg)
CL 180	0.64±0.30^{a}	0.29±0.04^{a}	219.00±26.87^{a}
CL 200	0.59±0.25^{a}	0.38±0.08^{a}	463.00±11.31^{c}
BR1T1	1.98±0.02^{cd}	0.95±0.05^{c}	431.00±1.41^{b}
BR1T2	1.33±0.13^{b}	0.72±0.01^{b}	420.50±9.19^{c}
BR2T1	1.61±0.31^{bc}	0.75±0.05^{b}	487.00±1.41^{c}
BR2T2	2.26±0.23^{d}	0.65±0.01^{b}	461.50±2.12^{bc}

Data represent mean ± standard deviation of four replications, values with "a" superscript are statistically significant ($p<0.05$) while values with "b" superscript are statistically insignificant ($p>0.05$).

Keys:
CL 180 -100% Wheat Flour (control) at 180^{o}C
CL 200 -100% Wheat Flour (control) at 200^{o}C
BR1T1 – 70% Wheat 25% Peanut 5% Banana (at 180^{o}C)
BR1T2 –70% Wheat 25% Peanut 5% Banana (at 200^{O}C)
BR2T1 – 60% Wheat 30% Peanut 10% Banana (at 180^{o}C)
BR2T2 –60% Wheat 30% Peanut 10% Banana (at 200^{o}C

Table 4: Sensory Evaluation of the Six Biscuit Samples

Sample	Colour	Taste	Texture	Flavour	Appearance	General Acceptability
CL 180	6.70±1.86^{bc}	5.85±2.06^{ab}	5.40±1.98^{a}	5.60±1.69a	6.45±1.82^{ab}	5.35±2.06^{ab}
CL 200	7.15±1.14^{bc}	6.90±1.65^{bc}	6.60±1.10^{bc}	6.90±1.41^{bc}	6.90±1.21^{bc}	6.30±2.05^{bc}
BR1T1	7.80±1.00^{c}	7.20±1.77^{c}	7.40±1.50^{c}	6.75±1.94^{bc}	7.60±1.0^{c}	7.00±1.49^{c}
BRIT2	7.45±1.79^{bc}	7.50±1.46^{c}	7.40±1.63^{c}	7.50±1.23^{c}	7.35±1.79^{bc}	7.00±1.59^{c}
BR2T1	6.50±1.73^{b}	5.20±1.98^{a}	5.85±1.76^{ab}	5.95±1.98^{ab}	6.55±1.53^{abc}	5.55±2.01^{a}
BR2T2	5.35±2.13^{a}	5.00±2.43^{a}	5.45±2.16^{a}	5.05±1.79^{a}	5.65±1.95^{a}	4.75±2.07^{ab}

Data represent mean ± standard deviation of four replications, values with "a" superscript are statistically significant ($p<0.05$) while values with "b" superscript are statistically insignificant ($p>0.05$)

Keys:
CL 180 -100% Wheat Flour (control) at 180^{o}C
CL 200 -100% Wheat Flour (control) at 200^{o}C
BR1T1 – 70% Wheat 25% Peanut 5% Banana (at 180^{o}C)
BR1T2 –70% Wheat 25% Peanut 5% Banana (at 200^{O}C)
BR2T1 – 60% Wheat 30% Peanut 10% Banana (at 180^{o}C)
BR2T2 –60% Wheat 30% Peanut 10% Banana (at 200^{o}C).

4. Discussion

Biscuit produced from 70% Wheat flour, 25% Peanut and 5% Banana baked at 200^{o}C (BR1T2) exhibited the lowest moisture content and biscuit produced from 60% Wheat flour, 30% Peanut and 10% Banana baked at 180^{o}C (BR2T1) exhibit the highest moisture content at 14.96%. It is evident that baking temperature played a significant role in the moisture retention

of the biscuits. Higher baking temperatures tend to result in lower moisture content due to increased evaporation (21). The ash content of the biscuit was highest (3.64%) in the sample produced from 100% Wheat baked at 200°C (CL 200). The ash content primarily reflects the mineral content of the biscuits. The higher ash content in CL 200 can be attributed to the higher baking temperature, which might have caused more mineral residue. Biscuit made from 100% wheat baked at 180°C (CL 180) exhibited the lowest fat content at 2.07%, while biscuit made from 60% wheat flour, 30% Peanut and 10% Banana baked at 200°C (BR2T2) had the highest fat content at 4.40%. The higher fat content in BR2T2 could be due to the increased proportion of peanut flour, which is known for its higher fat content. This high fat content especially in BR2T2 increases the tendency of the cookies being affected by rancidity in room temperature and hence, off-flavour. This is why the cookies should be properly packaged to avoid reaction with oxygen which leads to rancidity. The fat content (2.07% - 4.40%) increased as the peanut substitution levels increased during the preparation of composite bread. The increases in fat content were due to the high-fat content of the peanut flour than wheat flour.

Biscuit produced from 70% Wheat flour, 25% Peanut and 5% Banana baked at 180°C(BR1T1) and sample produced from 60% Wheat flour, 30% Peanut and 10% Banana baked at 180°C (BR2T1) have the highest crude fiber content, suggesting that they might offer greater dietary fiber benefit compared to other samples. The blending ratio, specifically the inclusion of banana, appears to contribute to the higher crude fiber content. The high fiber is certainly due to the banana incorporated. The fiber prevents the absorption of excess cholesterol. It also prevents the intake of starchy food and therefore protect against obesity. In regard to mechanism of action, dietary fiber forms gels in the stomach and small intestine, slowing the rate of glucose absorption, and this inhibits a postprandial rise of blood glucose concentrations, and lipid rises which can improve insulin sensitivity by decreasing insulin secretion (22). Additionally, the baking temperature seems to have a slight impact, with lower temperatures resulting in higher crude fiber content.

The protein content of the biscuits is highest (38.89%) in sample made from 60% Wheat flour, 30% Peanut and 10% Banana baked at 180ºC (BR2T1) making it a favorable choice for those looking for a protein-rich biscuit. The blending ratio, particularly the higher proportion of peanut flour in the sample, BR2T1, significantly influenced the protein content. Peanut flour is known for its high protein content, contributing to the observed result (9). Biscuit made from 60% Wheat flour, 30% Peanut and 10% Banana baked at 200ºC (BR2T2) has the lowest carbohydrate content, making it suitable for individuals following low-carbohydrate diets. Conversely, the sample prepared from 100% Wheat baked at 180°C (CL 180) has the highest carbohydrate content, which might be preferred by individuals requiring higher energy levels. The blending ratio and baking temperature seemed to impact the carbohydrate content, with the inclusion of banana and the higher baking temperature resulting in lower carbohydrate content. The BR2T2 biscuits are appropriate snacks for diabetes patients. Lowering carbohydrates to 45% of total calories significantly reduced blood glucose among type 2 diabetes patients studied. Carbohydrate restriction to 45% could be recommended for optimal glycaemic control among type 2 diabetes patients (23). Low carbohydrate foods may lead to improvements in markers of glycaemic control such as insulin, C-peptide, and leptin. Low-quality carbohydrates may be associated with increased fullness and satiety (24).

The sample produced from 100% Wheat baked at 180ºC (CL 180) exhibited the highest vitamin B1 content at 3.66 mg/100g. The higher vitamin B1 content in CL 180 suggests that the control group with 100% wheat flour and lower baking temperature preserved more of this vitamin. The Vitamin B3 is lowest (3.16mg/100g) in the sample produced with 100 Wheat baked at 200°C (CL 200) while sample produced from 60% Wheat flour, 30% Peanut and 10% Banana baked at 180°C (BR2T1) has the highest content of 5.72mg/100g. This suggests that sample BR2T1 provides higher amount of vitamin B3 compared to other samples. The higher vitamin B3 content in BR2T1 suggests that the inclusion of peanut and banana flour, along with the lower baking temperature, contributed to the increased vitamin B3 levels. Sample produced from 100% Wheat baked at 200ºC (CL 200) exhibited the lowest vitamin C content at 1.28 mg/100g, while sample produced from 60% wheat flour, 30% Peanut and 10% Banana baked at 180ºC (BR2T1) had the highest vitamin C content at 1.72 mg/100g. The higher vitamin C content in BR2T1 suggests that the inclusion of banana flour and lower baking temperature helped retain more of this vitamin. Vitamin C is a water-soluble and temperature-sensitive vitamin, so it is easily degraded during cooking, and elevated temperatures and long cooking times have been found to cause particularly severe losses of vitamin C (25).

The zinc content of the biscuit is highest in the sample produced from 70% wheat flour, 25% peanut and 5% banana baked at 180°C (BR1T1). The higher zinc content in BR1T1 suggests that the inclusion of peanut flour contributed to the increased zinc levels. The potassium content of the biscuits ranged from 219mg to 487mg. Sample produced from 100% Wheat baked at 180ºC (CL 180) showed the lowest potassium content at 219mg, while sample prepared from wheat flour, 30% peanut and 10% banana baked at 180ºC (BR2T1) exhibited the highest potassium content at 487mg. The higher potassium content in BR2T1 suggests that the inclusion of banana flour contributed to the increased potassium levels. The samples analyzed show variations in iron content, with the biscuit produced from 100 Wheat baked at 180 (CL 180) having the lowest content of 0.64mg, while sample prepared from 60% Wheat flour, 30% Peanut and 10% Banana baked at 200ºC (BR2T2) is richer in iron content compared to other samples. The higher iron content in BR2T2 suggests that the inclusion of peanut and banana flour, along with the higher baking temperature, contributed to the increased iron levels. Iron is a mineral that is an essential component of hemoglobin, myoglobin, enzymes and cytochromes and is necessary for oxygen transport and cellular respiration (26).

The biscuit produced from 70% Wheat flour, 25% Peanut and 5% Banana baked at 180°C (BR1T1) has the highest color, texture, appearance and general acceptability with value of

7.80, 7.40, 7.60, 7.00 respectively, and biscuit produced from 60% Wheat flour, 30% Peanut 10% Banana baked at 180ºC (BR1T2) has the highest taste, texture, flavour, and general acceptability with values of 7.80, 7.40, 7.50, 7.00 respectively compared to other samples. This could be attributed to the fact that since there is a higher percentage of peanut and banana in the biscuit, it gives flavor and taste to the biscuit due its sugar content. The outcomes align with the study of the sensory properties of multi-grain cookies with varying proportions of flours by Yamsaengsung et al. (2012) who reported that cookies with a higher proportion of alternative flour, such as chickpea and quinoa flour, demonstrated improved sensory attributes compared to control samples made with only wheat flour (27). This corroborates with the current study's observations, where samples containing peanut and banana exhibited enhanced sensory characteristics in comparison to the wheat flour-based controls.

4. Conclusion

In this study, the findings indicated that supplementing peanut flour and banana with wheat flour significantly enhances protein, crude fiber, vitamin B3, iron and zinc contents and reduces carbohydrate content. Protein plays a vital role in solving protein-energy malnutrition in the country while low carbohydrate improves glycaemic control. The sensory evaluation revealed the biscuit produced from 70% Wheat flour, 25% Peanut and 5% Banana baked at 180ºC (BR1T1) and 60% Wheat flour, 30% Peanut and 10% Banana baked at 180ºC (BR1T2) are generally accepted as it had ratings above average mark and can serve as a good snack. Despite being a snack, biscuit can help meet the nutrient needs of adults and children.

Conflict of interest

The authors declare no conflict of interest.

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