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QUALITY EVALUATION OF BISCUIT PRODUCED FROM RICE *(Oryza sativa)*, DEFATTED SESAME *(Sesamum indicum)*, AND CARROTS *(Daucus carota)* FLOUR BLENDS

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ABSTRACT

Biscuits are a popular food product consumed by a wide range of consumers as breakfast items and snacks due to their pleasant, diverse flavours, relatively long shelf life, and low cost. The use of wheat flour, an imported, low-nutrient commodity, as the main ingredient in its production has raised concerns about its potential to cause gluten-related disorders and nutritional deficiencies, underscoring the need for a cost-effective, gluten-free, and nutrient-rich alternative for biscuit production. Hence, the study was aimed at producing biscuits from composite flour formulated from rice, defatted sesame seed, and carrots flour blend, with varying proportions of rice, defatted sesame seed, and carrots (100 % wheat, 100 % rice, 92:5:3, 87:10:3, 82:15:3, 89:5:6, 86:5:9, and 83:5:12, respectively). The functional, physical, proximate properties, mineral content, and sensory attributes of the biscuit blends were determined using standard analytical methods. The results of the functional properties varied significantly at p≤ 0.05. Oil absorption decreased from 50.50 to 38.70 with an increase in defatted sesame, while an increase in carrot content resulted in a decrease in bulk density from 0.46 to 0.41. Length and spread ratio increased while height, *weight ratio, and break strength increased, with the mean score of 2.45 to 2.65cm, 11.85-12.50, and 1939.85-2478.50g with the increase of defatted sesame in the sample. The moisture content decreased from 0.96-0.10 while ash content increased from 1.71 to 2.15 in the 82:15:3. However, crude protein and crude fiber increased 7.45-12.70 and 5.02-6.32% lipid exhibited an increase with an increase in defatted sesame content from 13.63-14.61 and 12.11-13.69. The mineral content increased with increasing defatted sesame. Calcium, potassium, and Phosphorus content increased from 3.05-4.12, 9.21-10.75, and 4.10-4.21mg, while the phosphorus level increased from 3.92-4.06mg|100 g. Sensory attributes increased across all attributes, with samples containing 82:15:3 exhibiting the highest protein and acceptability. The increased protein, fiber, and essential minerals in the blend could improve the nutrient intake of consumers and promote their well-being.*

Keywords: Biscuit, Carrots, Defatted sesame, Rice and Quality evaluation

INTRODUCTION

Biscuits are a popular food product consumed by a wide range of consumers as breakfast items and snacks due to their diverse flavours, long shelf life, and low cost (Javaria *et al.*, 2017). The major ingredients are typically wheat flour, sucrose, and fat, making biscuits a rather energy-dense cereal food (Sozer *et al*., 2014). Altering the ratios of non-wheat flours and adding various nutritional ingredients may improve the quality and shelf life of biscuits (Ahmed *et al*., 2012). All biscuits can be nutritious, contributing valuable amounts of iron, calcium, protein, calories, fibre, and some B vitamins to our diet and daily food requirements if made from composite flours. Composite flour has the added advantage of enhancing the nutritional value of biscuits and other bakery products, especially when cereals are blended with legumes or tubers (Tyagi *et al*., 2007). Rice (*Oryza sativa*) is the seed of the grass species. As a cereal grain, it is the most widely consumed staple food worldwide, especially in Nigeria. It is an agricultural commodity with the third-highest worldwide production, after maize, according to FAO (2010). Rice is the most important grain in terms of human nutrition and calorie intake, providing more than one-fifth of the calories consumed worldwide by humans. Its flour is a good substitute for wheat flour, which irritates the digestive systems of those who are gluten intolerant. Rice flour is also used as a thickening agent and for making rice bread (Hosking, 2017). The nutritional composition of white rice, as documented by Das *et al.* (2020), shows that rice contains 4.43 g of crude protein, 0.39 g of fat, 0.56 g of fibre, and 53.2 g of carbohydrate.

Sesame (*Sesamum indicum*) is an oilseed legume rich in protein and essential amino acids (Idowu *et al*., 2021). It is categorised as an underutilised oilseed, particularly for protein extraction and food formulation. Sesame is a rich source of most inorganic nutrients; it is also consumed for its medicinal properties. Sesame seeds are rich in protein compared to other seed proteins because of the higher essential amino acid content. Sesame protein is more nutritious compared to all the other oilseed proteins (Pathak *et al*., 2014; Idowu *et al*., 2021). Defatted sesame flour contains protein (55.70 %), ash (9.83 %), and crude fibre (1.64 %), total carbohydrate (29.40 %), and is high in sulfur-containing amino acids (El-adawy*et al*., 2021).

Carrots (*Daucus carota*) are among the most nutritious vegetables consumed worldwide, both raw and processed. Carrots are inexpensive and highly nutritious, as they contain appreciable amounts of vitamins B1, B2, B6, and B12, as well as being rich in carotene (Manjunatha *et al*., 2003) and fibre. In recent years, the consumption of carrots and related products has increased steadily due to recognition of the antioxidant and anticancer activities of beta-carotene, a precursor of vitamin A (Kotecha *et al*., 1998; Speizer *et al*., 1999). Carrots can be consumed raw, processed, or fortified in a variety of food products. Carrots are a staple of the human diet and can be eaten fresh, cooked into various dishes, or processed into puree, juice, or dehydrated. However, carrots are a seasonal product, and their quality can be significantly degraded by the loss of their bioactive compounds after harvest.

The high cost of wheat in Nigeria has significantly increased biscuit production costs, making it challenging for bakers to maintain profitability while providing affordable products to consumers. Furthermore, the complicated health concerns associated with wheat usage, such as gluten-related disorders and nutritional deficiencies, highlight the need for a cost-effective, gluten-free, and nutrient-rich alternative in biscuit production. The biscuit's nutritional content is relatively low and requires fortification. The study aimed to evaluate the quality of biscuits produced from a combination of rice, defatted sesame seed, and carrot flour.

MATERIALS AND METHODS

Source of Materials and Preparation

The materials used in the experiment are rice (*Oryza sativa*), defatted sesame (*Sesamum indicum*), and carrots (*Daucus carota*). The other ingredients included: margarine (Blue Band), sugar (Dangote), baking powder (Royal Baking Powder), salt (NASCO Ltd. salt), and water, which were purchased at Lafia Modern Market.

The method described by Okpala and Egwu (2015) was used to produce rice flour. The rice grains were sorted manually to remove extraneous materials. The rice was washed with potable water, sun-dried, and milled using a hammer mill, then passed through a 60 µm mesh sieve. Flour was stored in an airtight plastic container at room temperature (32–38 °C) until needed.

The method described by Chinma (2018) was used to produce defatted sesame seed flour. Sesame seeds were cleaned, sorted, washed, and dried at 60°C for 30 min. After cooling, the seeds were milled, oil was extracted, and the defatted sesame seed flour was air-dried for 1 h.

The carrots were peeled, sliced, and dried to an almost brittle consistency at 400 °C in a cabinet dryer (5 h to reduce the moisture content to 8%). The dried, brittle carrot was then milled into flour using a stainless steel milling machine. The flour was sieved through a 0.25µm sieve, packed into a cellophane bag, and stored for further analysis (Adegunwa *et al*., 2014).

Production of Flour Blends for Biscuits

The blends were thoroughly mixed in a Kenwood blender to achieve uniformity. The salt and baking powder were added and mixed. Another separate mixing bowl was used to combine the butter, sugar, and egg till the mixture became creamy. The creamy mixture was poured into the flour and mixed thoroughly. Water was added and mixed to obtain the dough. The dough was cut into sizes (3.0cm diameter, 0.1cm thickness) and baked at 180 °C for 15 minutes. The cookies were removed, cooled, and then packaged in airtight containers.

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Composite Flour Formulation

Table 1: Recipe of biscuit produced from Rice, defatted sesame, and carrot flour (%)

Materials	Samples							
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Wheat Flour (%)	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rice Flour (%)	0.00	100.00	92.00	87.00	82.00	89.00	86.00	83.00
Defatted Sesame Flour (%)	0.00	0.00	5.00	10.00	15.00	5.00	5.00	5.00
Carrot Flour (%)	0.00	0.00	3.00	3.00	3.00	6.00	9.00	12.00
Sugar (g)	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Baking fat (g)	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Baking powder (g)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Salt (g)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Water (ml)	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

Key:
R. S. C
A 100:0:0 Wheat Flour, B 100 :0: rice, C 92:5:3, D 87:10:3, E 82:15:3, F 89:5:6, G 86:5:9
H 83:5:12, R= Rice Flour, S = Sesame, C = Carrot Flour

Functional Properties

Water Absorption Capacity (WAC)

Water absorption capacity is an index of the amount of water retained within a food matrix under certain conditions. It usually refers to entrapped water, but includes bound water and hydrodynamic water, and depends upon the condition of determination. This was determined using the procedure described by Adebowale *et al*. (2012). Approximately 10mL of distilled water was added to 1.0g of each flour sample. The suspension was stirred using a magnetic stirrer for 3 minutes. The suspension was transferred into centrifuge tubes and centrifuged at 3,500 rpm for 30 min. The supernatant obtained was measured using a 10ml measuring cylinder. The density of the water was assumed to be 1g/mL. The water absorbed by the sample was calculated as the difference between the initial water used and the volume of the supernatant obtained after centrifugation. The result was expressed as a percentage of water absorbed by the blends on a percentage by weight basis.

Swelling capacity

The swelling capacity was determined by the method described by Okaka and Potter (1977). A graduated cylinder (100 mL) was filled with the sample to the 10 mL mark. Distilled water was added to achieve a total volume of 50 mL. The top of the graduated cylinder was tightly covered, and the contents were mixed by inverting the cylinder. The suspension was inverted again after 2 minutes and left to stand for an additional 8 minutes. The volume occupied by the sample was taken after the 8th minute.

Oil absorption capacity

The oil absorption capacity was also determined using the method described by Sosulski *et al.* (1976). One gram of sample mixed with 10 mL of soybean oil (Sp. Gravity: 0.9092) and allowed to stand at ambient temperature 30$\pm$2 0C) for 30 min, then centrifuged for 30 min at 300 rpm or 2000 ×g. Oil absorption was examined as the percentage of oil bound per gram of flour.

Bulk density

The volume of 100 g of the flour was measured in a measuring cylinder (250 mL) after tapping the cylinder on a wooden plank until no visible decrease in volume was noticed, and based on the weight and volume, the apparent (bulk) density was calculated (Jones *et al.,* 2000).

Physical Properties

Physical properties (weight, volume, spread ratio, break strength) were determined as described by Ayo *et al.* (2019). The weight and diameter of the baked biscuit were determined by weighing on a weighing balance and measuring with a calibrated ruler. The thickness was measured according to the AOAC (2012) method. Three rows of five well-formed biscuits were made, and their heights were measured. Also, the same were arranged horizontally edge-to-edge, and the sum diameter was measured. The spread ratio was calculated as the diameter divided by the height.

For break strength, a biscuit of known thickness (0.4cm) was placed between two parallel wooden bars (3.0cm apart). Weights were added to the biscuit until the biscuit snapped. The least weight that caused the breaking of the biscuit was regarded as the breaking strength of the biscuit.

Proximate Composition

The proximate composition (moisture, fat, fibre, protein, ash, and carbohydrate) of the blend biscuits was determined using the AOAC (2012) method as adopted by Paul *et al.* (2024).

Sensory Evaluation

Sensory quality attributes, including taste, flavour, texture, crust appearance, crumb colour, and overall acceptability of the biscuit samples, were evaluated by (20) panellists comprising students and staff members of the Department of Nutrition and Dietetics, Faculty of Agriculture, Shabu-Lafia campus, Nasarawa State University, Keffi, Nigeria. The panellists were instructed to score the coded samples based on a 9-point Hedonic scale, ranging from 9 (liked extremely) to 1 (disliked extremely) (Mishra *et al.,* 2015).

Data Analysis

All experiments were carried out in triplicate. The data obtained were subjected to one-way analysis of variance (ANOVA), and Duncan's Multiple Range Test was conducted to separate the means. These analyses were performed using the Statistical Package for the Social Sciences (SPSS version 16.0). The significance level was set at 5%.

RESULTS AND DISCUSSION

Functional Properties of Biscuits Produced from Rice, Defatted Sesame Seed, and Carrot Flour Blends

The results of functional properties are shown in Table 2. The functional properties varied significantly at ($p < 0.05$) for all parameters assessed. The oil absorption, water absorption, bulk density, foam capacity, and swelling capacity of the produced flour blend biscuits ranged from 38.70 – 50.50 cm3/100g, 185.50 -119.50 cm3/100g, 0.44 - 0.46 g/cm3, 30.50 - 70.50 cm3/100g and 145.80 -166.25 cm3/100g, respectively, with increase in the added defatted sesame (5-15 %). Also, the same assessed parameters ranged from 21.70 - 61.75 cm^3/100g, 193.50 - 24.50 cm3/100g, 0.41 - 0.42g/cm^3, 39.50 - 49.50 cm3/100g, 183.02 - 193.00 cm3/100g, respectively, with an increase (6-12 %) in added carrot flour. The 100% wheat-flour product had the lowest values for all assessed functional properties.

The observed decrease in oil absorption capacity could be beneficial for reducing the overall fat content of foods, which is crucial for managing cholesterol levels. Research by Mozaffarian (2016) suggests that high-fat diets rich in saturated fats can elevate LDL cholesterol, a risk factor for cardiovascular diseases. By lowering the oil absorption, the food blend becomes healthier, thereby reducing the risk of conditions such as atherosclerosis and coronary artery disease (Mozaffarian, 2016). The increase in high water absorption capacity could aid in digestion and enhance stool bulk, preventing constipation (Tiwari *et al.,* 2020). Foods with high water retention also have a lower caloric density, which contributes to weight management and the prevention of obesity (Tiwari *et al.,* 2020).

The low bulk density observed could be an added value. Lower bulk density is associated with lighter foods, which are easier to digest and can support individuals with low energy requirements or those following calorie-restricted diets. According to Singh *et al*. (2016), low bulk density also allows for nutrient-dense foods that are more efficient in meeting dietary needs without contributing to excessiveness.

The swelling capacity significantly increased from 245 g/mL to 193.00 g/mL in the 83:5:12 blend. Foods with high swelling capacity tend to promote satiety, helping to regulate appetite and reduce overeating (Kaur *et al.,* 2019). This is particularly important in weight management, as it can prevent excessive caloric intake and contribute to long-term weight control strategies (Kaur *et al.,* 2019).

Table 2: Functional Properties of Biscuits Produced from Rice, Defatted Sesame Seed, and Carrot Flour Blends

Sample R:S:C	Oil Absorption (%)	Water Absorption Capacity (%)	Bulk Density (g/cm^3)	Form Capacity (%)	Swelling Capacity (%)
*100%	66.90^{b}±0.42	56.50^{h}±0.71	0.79^{a}±0.00	20.50^{g}±0.71	78.75^{h}±0.35
100% rice	71.15^{a}±0.35	100.50^{g}±0.71	0.43^{c}±0.00	19.50^{h}±0.71	85.95^{h}g0.35
92:5:3	50.50^{d}±0.70	119.50^{f}±0.71	0.46^{b}±0.01	30.50^{f}±0.71	145.80^{f}±0.42
87:10:3	44.6^{e}±0.56	132.50^{e}±0.71	0.44^{b}±0.05	50.5^{b}±0.71	156.02^{e}±0.46
82:15:3	38.70^{g}±0.42	185.50^{d}±0.71	0.44^{b}±0.01	70.50^{a}±0.71	166.25^{d}±0.49
89:5:6	21.70^{h}±0.42	193.50^{c}±0.71	0.42^{c}±0.00	39.50^{e}±0.71	183.02^{c}±0.31
86:5:9	41.72^{f}±0.39	209^{b}±0.71	0.41^{d}±0.00	44.5^{d}±0.71	188.02^{b}±0.31
83:5:12	61.75^{c}±0.35	224.50^{a}±0.71	0.41^{d}±0.00	49.50^{c}±0.71	193.00^{a}±0.28

* 100 % wheat flour. R = Rice, S= Sesame, C=Carrot. Values are mean ± standard deviation of duplicate determinations. Mean values in the same column followed by different superscript letters are significantly (p< 0.05) different

Physical Properties of Biscuits Produced from Rice, Defatted Sesame Seed, and Carrot Flour Blend Biscuits

Table 3 represents the results of the physical properties of the samples, which showed that the spread ratio and break strength increased with the addition of sesame (5-15 %) and the values ranged from 10.90 - 11.70 and 1939.85 - 2121.60 g respectively and also 11.88 - 12.97 and 2314.11-2478.50 g with increase in added carrot (6.12 %), respectively. The 100 % wheat had the lowest spread ratio (6.15) and the highest break strength (2,522.45 g). The physical properties of biscuits, such as length, height, spread ratio, weight ratio, and break strength ratio, provide information on the food product's structural integrity and palatability. The increase in the spread ratio and break strength of the produced flour blend biscuits is significant (p<0.05) and acceptable. These properties can influence the food's texture, making it more appealing and easier to handle during preparation. According to Zhang *et al.* (2018), the improved spreadability and structural integrity of complementary foods contribute to consumer acceptability, which is crucial for promoting the consumption of nutrient-rich foods.

Table 3: Physical Properties of Biscuits Produced from Rice, Defatted Sesame Seed, and Carrot Flour Blend Biscuits.

Sample R:S:C	Length(cm^3)	Width(cm^3)	Height (cm^3	Weight Ratio(g)	Break Strength Ratio
*100%	$22.40^{g}\pm0.14$	$3.55^{a}\pm0.07$	$6.15^{h}\pm0.07$	$13.90^{a}\pm0.14$	$2522.45^{a}\pm4.03$
100% rice	$22.40^{g}\pm0.14$	$2.15^{g}\pm0.07$	$10.60^{g}\pm0.14$	$11.70^{g}\pm0.14$	$1825.25^{h}\pm3.89$
92:5:3	$22.10^{f}\pm0.14$	$2.45^{e}\pm0.07$	$10.90^{f}\pm0.14$	$11.85^{f}\pm0.07$	$1939.85^{g}\pm3.89$
87:10:3	$22.30^{e}\pm0.14$	$2.40^{f}\pm0.07$	$11.46^{e}\pm0.14$	$11.93^{e}\pm0.11$	$1998.98^{f}\pm4.00$
82:15:3	$22.50^{d}\pm0.14$	$2.45^{e}\pm0.07$	$11.70^{d}\pm0.14$	$12.10^{d}\pm0.14$	$2121.60^{e}\pm4.10$
89:5:6	$22.60^{c}\pm0.14$	$2.46^{d}\pm0.07$	$11.88^{c}\pm0.14$	$12.20^{c}\pm0.14$	$2314.11^{d}\pm0.82$
86:5:9	$22.65^{b}\pm0.14$	$2.55^{c}\pm0.07$	$12.80^{b}\pm0.14$	$12.35^{b}\pm0.14$	$2365.05^{c}\pm3.39$
83:5:12	$22.70^{a}\pm0.14$	$2.65^{b}\pm0.07$	$12.97^{a}\pm0.14$	$12.50^{ab}\pm0.14$	$2478.50^{b}\pm3.82$

* 100% wheat flour. R = Rice, S= Sesame, C=Carrot. Values are mean ± standard deviation of duplicate determinations. Mean values within the same column followed by different superscript letters are significantly ($p< 0.05$) different

Chemical Composition of Biscuits Produced from Rice, Defatted Sesame Seed, and Carrot Flour Blend Biscuits.

Proximate properties of biscuits produced from rice, defatted sesame seed, and carrot flour blends.

The proximate properties of the biscuits produced from rice, defatted sesame, and carrots are summarized in Table 4. The crude protein, crude lipid, ash, and crude fibre increased from 7.45 % to 9.64 %, 13.63 % to 14.61 %, 1.71 % to 2.15 %, and 5.02 % to 5.43 %, respectively, with increasing levels of added defatted sesame paste (5-15%). However, the protein, lipid, and ash content decreased from 7.31 % to 6.79 %, 2.21 % to 2.00 %, and 1.51 % to 1.45 %, respectively, with a sharp increase in the fiber content (from 5.89 % to 6.32%) accompanying the addition of carrot flour (from 6 % to 12 %). This research aligns with the findings of Paul *et al.* (2024), which revealed that the addition of defatted sesame increased the amounts of crude protein, crude fibre, ash, and mineral content in complementary food. Moreover, the defatted flour has relatively good foaming, water absorption, and emulsification properties; however, it has reduced oil absorption and bulk density due to its high protein content. The decrease in the moisture content is within the acceptable level for stored food. A low moisture content is advantageous for the shelf life and microbial stability of the product, as it reduces the risk of spoilage. According to Beyene *et al. (*2018), foods with lower moisture content are less susceptible to microbial growth, making them more suitable for long-term storage and reducing the risk of foodborne illnesses.

The increase in protein content could be due to the high protein content in the defatted sesame. Protein is a critical nutrient for growth, immune function, and tissue repair. The increased protein content in the enriched blends will support better nutritional outcomes, especially in children and pregnant women, who have higher protein requirements (Micha *et al.,* 2017). Protein-rich diets also play a key role in muscle development and the maintenance of lean body mass, making this food blend suitable for all age groups. The crude fiber content increased from 5.01 % to 6.32 % in the 83:5:12 blend. Dietary fiber is crucial for maintaining digestive health, as it supports regular bowel movements and helps prevent constipation (Anderson *et al.*, 2016). A higher fiber content also helps regulate blood sugar levels and lower cholesterol, contributing to the prevention of cardiovascular diseases and type 2 diabetes (Anderson *et al*., 2016).

The relative increase in lipid content is vital for providing essential fatty acids and facilitating the absorption of fat-soluble vitamins such as A, D, E, and K (Kris-Etherton *et al*., 2020). The relatively low carbohydrate content is still within the acceptable level. This may indicate a shift towards higher-protein and lipid formulations, which are beneficial for products targeting specific dietary needs, such as those with higher protein content (Khan *et al.,* 2016). Carbohydrates provide quick energy but should be balanced with proteins and fats for a well-rounded diet. The increase in energy content from 389.86 kcal to 486.43 kcal suggests that the formulations become more energy-dense as the R:S ratio changes. A higher energy density can be beneficial for individuals requiring increased caloric intake, such as athletes or those with higher metabolic demands (FAO, 2022). However, attention should be paid to the overall macronutrient balance to ensure that energy is derived from a variety of sources (Oloyede *et al*., 2021).

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Table 4: Proximate Properties of Biscuit Produced from Rice, Defatted Sesame Seed, and Carrot Flour Blend

Sample R:S:C	Moisture (%)	Crude protein (%)	Crude lipid (%)	Ash (%)	Crude fiber (%)	Carbohydrate (%)	Energy (kcal)
*100%	$14.01^{a}\pm0.01$	$10.61^{a}\pm0.01$	$1.91^{f}\pm0.01$	$1.41^{f}\pm0.01$	$10.51^{a}\pm0.01$	$82.59^{b}\pm0.02$	$389.86^{g}\pm0.08$
100%	$7.49^{b}\pm0.01$	$7.31^{e}\pm0.01$	$2.21^{e}\pm0.01$	$1.06^{g}\pm0.01$	$4.01^{g}\pm0.01$	$85.97^{a}\pm0.04$	$292.85^{h}\pm0.06$
92:5:3	$0.96^{c}\pm0.00$	$7.45^{d}\pm0.01$	$13.63^{b}\pm0.01$	$1.71^{c}\pm0.01$	$5.02^{f}\pm0.01$	$81.29^{c}\pm0.02$	$477.53^{d}\pm0.04$
87:10:3	$0.74^{d}\pm0.00$	$8.54^{c}\pm0.01$	$14.12^{ab}\pm0.01$	$1.92^{b}\pm0.01$	$5.22^{e}\pm0.01$	$79.10^{f}\pm0.01$	$477.03^{e}\pm0.04$
82:15:3	$0.59^{e}\pm0.00$	$9.64^{b}\pm0.01$	$14.61^{a}\pm0.01$	$2.15^{a}\pm0.01$	$5.43^{e}\pm0.01$	$78.47^{g}\pm0.04$	$483.76^{b}\pm0.08$
89:5:6	$0.52^{f}\pm0.00$	$7.3^{ed}\pm0.01$	2.22d±0.01	$1.51^{e}\pm0.01$	$5.89^{d}\pm0.01$	$82.14^{d}\pm0.02$	$475.94^{f}\pm0.06$
86:5:9	$0.35^{g}\pm0.00$	$7.00^{f}\pm0.01$	$2.10^{c}\pm0.01$	$1.62^{d}\pm0.01$	$6.11^{c}\pm0.01$	$80.09^{e}\pm0.01$	$481.04^{c}\pm0.05$
83:5:12	$0.10^{h}\pm0.00$	$6.79^{g}\pm0.01$	$2.00^{b}\pm0.01$	$1.72^{c}\pm0.01$	$6.32^{b}\pm0.01$	$78.13^{h}\pm0.03$	$486.43^{a}\pm0.04$

* 100% wheat flour. R = Rice, S= Sesame, C=Carrot. Values are mean ± standard deviation of duplicate determinations. Mean values in the same column followed by different superscript letters are significantly ($p< 0.05$). different

Table 5: Mineral Composition of Biscuits Produced from Rice, Defatted Sesame Seed, and Carrot Flour

*100% wheat flour. R = Rice, S= Sesame, C=Carrot. Values are mean ± standard deviation of duplicate determinations. Mean values in the same column followed by different superscript letters are significantly ($p< 0.05$) different.

The mineral content of the biscuits produced from Rice, defatted sesame, and carrots is summarized in Table 4. The calcium, potassium, and phosphorus content of the produced biscuits increased from 3.05 to 4.13, 9.21 to 11.79, and 4.10 to 4.21 mg/100 g, respectively, with increasing defatted sesame addition (5-15%). Additionally, the addition of carrot flour (6-12%) increased the calcium, potassium, and phosphorus levels from 3.28 to 4.12, 9.43 to 10.75, and 3.92 to 4.06 mg/100 g, respectively. The relative increase in the assessed minerals could be due to the substantial levels of these minerals in the added defatted sesame and carrot. Considering calcium intake from complementary foods in children, the amount is vital for improving bone development, muscle contraction, and the proper functioning of the cardiovascular system (Paul *et al.,* 2024). Potassium is crucial for maintaining normal fluid balance, nerve transmission, and muscle contractions (Grillo *et al.,* 2019). It also helps lower blood pressure, reducing the risk of hypertension and stroke (Grillo *et al.*, 2019). Phosphorus is a critical component of bones, teeth, and cellular energy production. It also plays a role in DNA synthesis and repair (Murray *et al*., 2018), making it an essential nutrient for growth and cell regeneration.

Sensory Quality of Biscuits Produced from Rice, Defatted Sesame Seed, and Carrot Flour Blend

Sample R:S:C	Calcium (mg/kg)	Potassium (mg/kg)	Phosphorus (mg/kg)
* 100%	1.93^{g}±0.01	0.36^{f}±0.01	1.72^{e}±0.01
100% rice	2.49^{f}±0.01	4.78^{e}±0.01	2.91^{d}±0.01
92:5:3	3.05^{e}±0.01	9.21^{d}±0.01	4.10^{b}±0.01
87:10:3	3.59^{c}±0.01	10.50^{b}±0.01	4.11^{b}±0.01
82:15:3	4.13^{a}±0.01	11.79^{a}±0.01	4.21^{a}±0.01
89:5:6	3.28^{d}±0.01	9.43^{d}±0.01	3.92^{c}±0.01
86:5:9	3.70^{b}±0.01	10.09^{b}±0.01	3.96^{c}±0.01
83:5:12	4.12^{a}±0.01	10.75^{b}±0.01	4.06^{c}±0.01

The sensory attributes of biscuits produced from rice, defatted sesame, and carrots are presented in Table 6. The average means score for the taste, aroma, appearance, mouth feel, and overall acceptability ranged from 7.73-8.65, 7.55-9.60, 7.30-8.40, 7.53-9.65, 7.35-8.90, and 8.07-8.90, respectively, with an increase in added defatted sesame (5-15 %) and carrot flour (6-12 %). Generally, all the products have very high average scores. Taste scores increased from 7.73 to 8.65 in the enriched blends. The improved taste is due to the addition of S and C, making the food more palatable and enhancing consumer satisfaction, which is crucial for ensuring adherence to a nutrient-rich diet (Meilgaard *et al.*, 2015). The taste and aroma improved significantly, with the highest scores of 9.60 and 8.40 in the 83:5:12 blend. These sensory attributes are essential for consumer appeal and can influence the perceived quality of the food (Meilgaard *et al.,* 2015).
The overall acceptability of the enriched blend was high at 8.90, indicating that the addition of S and C not only improved the nutritional quality but also the sensory attributes, making the blend more likely to be consumed and integrated into daily diets.

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Table 6: Sensory Quality of Biscuits Produced from Rice, Defatted Sesame Seed, and Carrot Flour

Sample R:S:C	Taste	Aroma	Appearance	Mouth feel	Overall acceptability
* 100%	8.20^{d}±0.89	7.70^{b}±0.80	7.80^{e}±1.32	7.50^{bc}±1.00	8.40^{c}±0.82
100% Rice	7.25^{f}±1.29	6.90^{c}±1.54	7.45^{f}±1.15	7.20^{d}±1.24	7.75^{d}±0.91
92:5:3	7.73^{e}±0.09	7.30^{bc}±1.19	7.53^{d}±1.24	7.35^{c}±1.12	8.07^{c}±0.87
87:10:3	7.80^{e}±1.17	7.65^{b}±1.66	7.62^{d}±2.04	7.75^{b}±1.33	8.65^{ab}±1.27
82:15:3	7.86^{e}±0.63	7.78^{b}±1.42	7.76^{d}±1.64	7.95^{b}±1.22	8.78^{ab}±1.40
89:5:6	8.35^{c}±1.16	7.85^{b}±1.79	7.89^{c}±1.54	8.20^{ab}±1.91	8.85^{b}±1.53
86:5:9	8.55^{b}±1.50	7.95^{b}±1.61	8.40^{b}±1.82	8.75^{a}±1.86	8.88^{a}±1.37
83:5:12	8.65^{a}±1.88	8.40^{a}±2.19	9.65^{a}±1.95	8.90^{a}±1.79	8.90^{a}±1.59

* 100% wheat flour. R = Rice, S= Sesame, C=Carrot. Values are mean ± standard deviation of duplicate determinations. Mean values within the same column followed by different superscript letters are significantly ($p< 0.05$) different

CONCLUSION

The study has shown that acceptable biscuits with relatively improved nutritional value can be produced from blends of rice, defatted sesame, and carrot flour. The most preferred and acceptable flour blend biscuit is one containing 83 % rice, 5 % defatted sesame, and 12 % carrot flour. The findings highlight the potential of these enriched complementary blends to enhance the nutritional status of diverse populations, particularly those at risk of malnutrition, including children, pregnant women, and the elderly. The increased protein, fiber, and essential minerals in the blends can contribute to better health outcomes by addressing common nutrient deficiencies and promoting overall well-being. The study has shown that acceptable biscuits with relatively improved nutritional value can be produced from blends of rice, defatted sesame, and carrot flour. The most preferred and acceptable flour blend biscuit is one containing 83 % rice, 5 % defatted sesame, and 12 % carrot flour. The findings highlight the potential of these enriched complementary blends to enhance the nutritional status of diverse populations, particularly those at risk of malnutrition, including children, pregnant women, and the elderly. The increased protein, fiber, and essential minerals in the blends can contribute to better health outcomes by addressing common nutrient deficiencies and promoting overall well-being.

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