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Assessment on mineral composition: Rice-based composite flour and its baked products in Calabar, Nigeria

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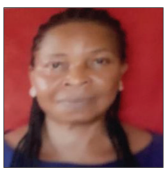

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ABSTRACT

Objectives: Staple food to mobilize micronutrients as well as agricultural effects to improve food availability, affordability, and accessibility, in the utilization of food to address nutrient deficiencies and other nutritional challenges. This study will explore strategies and mechanisms for assessing the mineral composition of rice-based composite flour produced from blends of rice, soybean, coconut, water-yam, and sweet potato flours.

Material and Methods: Different blends of the composite flours will be prepared as A, B, C, etc. The mineral composition of the rice-based composite flour and its cookies was determined by the spectrophotometric method (applicable to Na, Fe, Ca, K, and Mg).

Results: The mineral contents of the composite flour samples analyzed in the present study ranged between 30.47 ± 1.41 and 82.00 ± 0.57, 0.24 ± 0.02 and 1.27 ± 0.07, 17.37 ± 0.46 and 87.97 ± 0.24, 104.27 ± 0.54 and 701.63 ± 1.32, and 12.17 ± 78.00 and 78.00 ± 0.67 mg/100 g for sodium (Sa), iron (Fe), calcium (Ca), potassium (K), and magnesium (Mg), respectively, while the mineral contents of the rice-based composite cookie samples analyzed ranged between 170.67 ± 8.45 and 383.33 ± 4.10, 1.07 ± 0.01 and 2.75 ± 0.02, 45.77 ± 0.78 and 64.73 ± 2.17, 113.97 ± 1.46 and 144.23 ± 0.52, and 27.77 ± 0.35 and 74.73 ± 1.73 mg/100 g for Na, Fe, Ca, K, and Mg, respectively. There was a significant difference ($P < 0.05$) in the mineral composition of the samples.

Conclusion: The finding of this study is a wake-up alert for policymakers to improve and increase availability, accessibility in the utilization of food to address nutrient deficiencies and other nutritional challenges in the country.

Keywords: Composite flour, Micronutrients, Nutritional assessment, Baking flour

INTRODUCTION

In recent times, consumption of confectionaries and/or baked products has been seen to continuously increase in many countries of the world.[1] Wheat flour is generally known to be the ideal flour suitable for baking but the high level of its utilization has resulted in an overdependence on wheat flour for baked goods, especially in non-wheat-producing countries like Nigeria. In these countries, the wheat flour needed for baking bread, rolls, and pastry goods is imported, and as the climatic conditions and soil nature do not favor commercial growing of wheat locally, the rising importation of wheat has had an increasingly adverse effect on their balance of trade.[2] The growing market for confectioneries,[3] substitution of wheat with local raw materials is increasing, and thus, several developing countries have encouraged the initiation of programs to evaluate the feasibility of alternative locally available flours as a substitute for wheat flour.[2] The concept of composite technology initiated by the Food and Agriculture Organization (FAO) in 1964 reported that the application of composite flour in various food products would be economically advantageous by causing the imports of wheat to be reduced or even eliminated and that demand for bread and pastry products could easily be met by the use of domestically grown products instead of wheat.[3] The bakery products produced using composite flour show good quality, with some characteristics similar to wheat flour-based products, although their texture and properties are different from those made from wheat flour, they were observed to have an increased nutritional value and better appearance.[4]

Cookies are confectionary products dried to a low moisture content,[5] compared to biscuits. Cookies tend to be larger with a softer chewier texture,[6] and they are consumed extensively all over the world as a snack food on a large scale in developing countries where protein and caloric malnutrition are prevalent.[7] The different health problems related to food consumption such as celiac diseases (lifelong intolerance to wheat gluten, characterized by inflammation of the proximal small intestine), diabetes, and coronary heart diseases have caused increased advocacy on the consumption of functional foods by world nutrition bodies including the recent World Health Organization recommendations which stand to reduce the overall consumption of sugars and foods that promote high glucose responses.[8]

A current trend in nutrition is the consumption of low carbohydrate diets, including slowly digested food products as well as increased intake of functional foods.[9] Food professionals and industries are faced with the challenges of producing foods containing functional ingredients to meet the nutritional requirements of individuals with health challenges. Cookies can serve as the vehicle for delivering important nutrients if made readily available to the population.[10] There is a need to develop cookies containing functional ingredients with high nutritional quality such as in the use of composite flours.[11] Among ready-to-eat snacks, cookies also possess several attractive features, including a wider consumer base, relatively long shelf life, greater convenience, and good eating quality.[12] The growing interest in these types of bakery products is due to their better nutritional properties and the possibility of their use in feeding programs and catastrophic situations such as famine or earthquakes.[13] In many countries, cookies are prepared with fortified or composite flour to increase their nutritive value, and for example, some high-protein cookies have been made using composite flours that include blends of soybean[14] with field pea and defatted peanut, replacing wheat flour by up to 30 g/100 g.[15] Chickpea cookies were observed to have a higher crispiness value compared to mung bean cookies,[15] indicating that this might have resulted from the water-binding effort in mung bean flour which increased with the heat denaturation of protein content, Udensi *et al.* [16] also reported that a proportion of 90:10 of plain wheat flour and sweet potato flour produced good results without any adverse effect on the physical and sensory characteristics of cookies. Composite flour shows good potential for use as a functional agent in bakery products, and at the same time, the development and consumption of such functional foods not only improves the nutritional status of the general population but also helps those suffering from degenerative diseases associated with today's changing lifestyles and environment. This study aims at assessing the mineral composition of rice-based composite flour produced from blends of rice, water-yam, sweet potatoes, coconut, and soybean flour, and its baked products, respectively.

MATERIALS AND METHODS

Collection of samples

The materials used were; high-quality rice (*Oryza sativa*) flour, water-yam (*Dioscorea alata*) flour, soybean (*Glycine max*) flour, sweet potato (*Ipomoea batatas*) flour, coconut (*Cocos nucifera*) flour, and wheat (*Triticum aestivum*) flour, granulated sugar, baking fat, salt, baking powder, and water. All raw materials were purchased from Watt Market in Calabar, Cross River State, Nigeria, as well as additives such as sugar, baking fat, and flavor.

Preparation of samples

The raw materials were processed into flour as shown below;

Processing technology for rice flour

Rice flour was prepared according to the method described by Ndife *et al.*[17] The rice grains were sorted and washed 5 times with water, sun dried, for 12 h at 50°C. It was then be milled and sieved with a 0.05 mm screen and then packaged in a plastic container for further use.

Processing technology for water-yam flour

The yam tubers were processed into flour according to the method described by Etudaiye *et al.*[18] This involved peeling, washing, slicing into cubes, and drying in a hot air oven at 65°C for 48 h. The dried yam chips were milled into flour using an attrition mill, packaged in polyethylene bags, and stored until needed.

Processing technology for soybean flour

Soybean flour was prepared according to the method described by Okafor and Usman.[19] The soybean (1 kg) was thoroughly cleaned to remove dirt and other extraneous materials such as stones and sticks. It was then washed and oven-dried. The soybeans were roasted, decorticated, winnowed, and milled into fine flour using a hammer mill (model EU 5000 D) and sieved through 250 μm aperture sieves. The flour was then packed and sealed in polyethylene bags until analyzed.

Processing technology for sweet potato flour

Sweet potato processing into flour was done according to the method (Wardlaw, 2004).[20] It involved washing the fresh roots with water, peeling, soaking in water (24 h to leach out sugars) decanting of water, sun drying of chips, milling using a hammer mill, and sieving (with muslin cloth) to obtain fine flour and then packaging in polyethylene bags.

Processing technology for coconut flour

The flour was processed according to the method described by Inyang and Ekop, 2015.[21] After dehulling and splitting, the coconut water will be drained out. The kernel (meat) was collected and milk was removed by crushing with a hard crusher and dried by an oven dryer for 6 h at 60°C. The dried coconut was then grounded into flour and the coconut flour was packaged in high-density polyethylene and stored.

Study setting

The study was conducted in two different laboratories. This project involved experimental and statistical analysis of the mineral properties of rice-based composite flour and its products. Preparation of composite flour samples and baking experiments was done in the food research laboratory of the Department of Human Nutrition and Dietetics while analysis of the rice-based composite flour and its product was done in the food research laboratory of the Department of Food Science and Technology, both in the University of Calabar, Calabar. Furthermore, mineral properties were monitored using a spectrometer, conical beakers (250 mL), watch glass, filter paper, hot plate or steam bath, centrifuge, etc., other activities carried out to achieve the study objectives are explained in the following subsections.

Baking experiment

Six different formulations developed from the flour blends as shown in [Table 1] and ingredients, as shown in [Table 2], were used for this experiment. The cookies were prepared using the method described by Eneche, 1999, with slight modifications. The flour (500 g), sugar (150 g), baking fat (190 g), and salt (5 g) were mixed manually for 5 min to get a creamy dough. The baking powder (2.5 g) and vanilla (5 g) were then added. A measured amount of water (125 mL) was then added gradually using continuous mixing until a good texture, slightly trim dough is obtained. The dough was thereafter kneaded on a clean flat surface for 4 min and rolled manually into sheets and cut into shapes using the stamp cutting method. The cut dough pieces were transferred into fluid fat greased pans and baked in an oven (Carma, Model 1945XL, Terim Group, Italy) at 180°C for 20 min, cooled, and packaged for further analysis.

Statistical analysis

Data are presented as mean ± SEM. Data were analyzed using a one-way analysis of variance, significant data were then followed with a *post hoc* test (least square deviation). $P < 0.05$ was accepted as statistically significant.

RESULTS

Mineral composition for flour samples

The results of the mineral composition structured in different experimental samples of flour are shown below. The minerals analyzed include sodium (Na), iron (Fe), calcium (Ca), potassium (K), and magnesium (Mg).

The Na contents of the rice-based composite flours and the control ranged from 30.47 mg/100 g to 82.00 mg/100 g with sample E having the least value while the highest value was recorded by sample B. The Na content of sample B (RF40SF15CF5WYF40) was 82.00 mg/100 g and this was significantly higher ($P < 0.05$) than the control (66.40 mg/100 g), sample C (35.80 mg/100 g), sample D (42.30 mg/100 g), sample E (30.47 mg/100 g), and sample F (66.40 mg/100 g) composite flours. The Na content of

Table 1: Mix ratio of composite flour formulations in the experiment.

Sample (%)	Wheat flour (%)	Rice flour (%)	Soybean flour (%)	Coconut flour (%)	Water-yam flour (%)	Sweet potato flour (%)
A	100	-	-	-	-	-
B		40	15	5	40-20	-
C		40	15	5	10	40
D		40	15	5	30	20
E		40	15	5		30
F		40	15	5		10

Table 2: Ingredients used in dough formulation.

Materials	Composition (g)
Flour	500
Water	125
Sugar	150
Baking fat	190
Vanilla	5
Baking powder	2.5
Salt (NaCl)	5

Nutritional profiling used for food formulation

the sample F (RF40SF15CF5WYF30SPF10) rice-based composite flour and that obtained for the control (100% wheat flour) was 66.40 mg/100 g and this value was significantly higher than that of sample D (42.30 mg/100 g), sample C (35.80 mg/100 g), and sample E (30.47 mg/100 g) composite flours but significantly lower than sample B (82.00 mg/100 g) composite flour. The Na content of sample D (RF40SF15CF5WYF20SPF20) was 42.30 mg/100 g which was significantly higher than samples E (30.47 mg/100 g) and C (35.80 ± 1.47 mg/100 g) composite flours but significantly ($P < 0.05$) lower than the control (66.40 mg/100 g) and the composite flours of sample B (82.00 mg/100 g) and sample F (66.40 mg/100 g). The sample C (RF40SF15CF15SPF40) rice-based composite flour was at 35.80 mg/100 g and this value was significantly higher than that of the sample E composite flour (30.47 ± 1.41 mg/100 g) but significantly ($P < 0.05$) lower than values obtained for the control (66.40 mg/100 g) and sample B (82.00 mg/100 g), sample F (66.40 mg/100 g), and sample C (42.30 mg/100 g) composite flours. The sample E (RF40SF15CF5WYF10SPF30) rice-based composite flour had a Na content of 30.47 mg/100 g which recorded the least value and was significantly lower than the control (66.40 mg/100 g) and sample B (82.00 mg/100 g), F (66.40 mg/100 g), D (42.30 mg/100 g), and C (35.80 mg/100 g) composite flours.

The Fe content of the rice-based composite flours and the control ranged from 0.24 mg/100 g to 1.27 mg/100 g with sample F having the least value while the highest value was recorded by the control (100% wheat flour). The Fe content of sample C (RF40SF15CF15SPF40) was 0.37 mg/100 g which was significantly ($P < 0.05$) higher than samples B (0.34 mg/100 g), D (0.30 mg/100 g), E (0.27 mg/100 g), and F (0.24 mg/100 g) composite flours but it was significantly ($P < 0.05$) lower than the control (1.27 mg/100 g). The rice-based composite flour of sample B (RF40SF15CF5WYF40) had an Fe content of 0.34 mg/100 g which was significantly lower ($P < 0.05$) than that of the control (1.27 mg/100 g) but had a significantly higher ($P < 0.05$) value than that of samples D (0.30 mg/100 g), E (0.27 mg/100 g), and F (0.24 mg/100 g) composite flours. The Fe content of samples E (RF40SF15CF5WYF10SPF30) and D (RF40SF15CF5WYF20SPF20) was 0.27 mg/100 g and 0.30 mg/100 g, respectively, and these values were significantly lower ($P < 0.05$) than the control (1.27 mg/100 g) and samples C (0.37 mg/100 g) and B (0.34 mg/100 g) composite flours but significantly higher than the sample F (0.24 mg/100 g) composite flour. The Fe content of sample F (RF40SF15CF5WYF30SPF10) was 0.24 mg/100 g and this value was significantly ($P < 0.05$) lower than values obtained for the control (1.27 mg/100 g) and the other samples, respectively.

The Ca content of the rice-based composite flours and the control ranged from 17.37 mg/100 g to 87.97 mg/100 g with sample E having the least value while the highest value was recorded by the control (100% wheat flour). The sample B (RF40SF15CF5WYF40) rice-based composite flour had a value of 31.80 mg/100 g which was significantly higher ($P < 0.05$) than sample C (24.53 mg/100 g), sample D (28.20 mg/100 g), sample E (17.37 mg/100 g), and sample F (22.57 mg/100 g) composite flours but significantly lower ($P < 0.05$) than the control (87.97 mg/100 g). The Ca content of sample D (RF40SF15CF5WYF20SPF20) recorded a value of 28.20mg/100 g which was significantly higher than sample C (24.53 mg/100 g), sample E (17.37 mg/100 g), and sample F (22.57 mg/100 g) composite flours but significantly lower ($P < 0.05$) than the control (87.97 mg/100 g) and sample B (31.80 mg/100 g) composite flour. The composite flour of sample C (RF40SF15CF15SPF40) had a value of 24.53 mg/100 g which was significantly higher ($P < 0.05$) than the composite flours of sample E (17.37 mg/100 g) and sample F (22.57 mg/100 g) but significantly lower ($P < 0.05$) than the control (87.97 mg/100 g) and the samples B (31.80 mg/100 g) and D (28.20 mg/100 g) composite flours. The Ca content of sample F (RF40SF15CF5WYF30SPF10) had a value of 22.57mg/100 g which was significantly higher ($P < 0.05$) than sample E (17.37 mg/100 g) but significantly lower ($P < 0.05$) than the control (87.97 mg/100 g) and samples B (31.80 mg/100 g), C (24.53 mg/100 g), and D (28.20 mg/100 g) composite flours.

The K contents of the rice-based composite flours and the control ranged from 104.27 mg/100 g to 701.63 mg/100 g with the control (100% wheat flour) having the least value while sample C recorded the highest value. The K content of sample C (RF40SF15CF15SPF40) rice-based composite flour was 701.63 mg/100 g which was significantly higher ($P < 0.05$) than the control (104.27 mg/100 g), samples B (686.30 mg/100 g), D (558.60 mg/100 g), E (624.67 mg/100 g), and F (651.23 mg/100 g) composite flours. The K content of sample B (RF40SF15CF5WYF40) recorded a value of 686.30 mg/100 g which was significantly higher ($P < 0.05$) than the control (104.27 mg/100 g) and samples D (558.60 mg/100 g), E (624.67 mg/100 g), and

F (651.23mg/100g) composite flours but significantly lower than the sample C (701.63 mg/100 g) composite flour. The rice-based composite flour of sample F (RF40SF15CF5WYF30SPF10) had a value of 651.23 mg/100 g which was significantly higher (P < 0.05) than the control (104.27 mg/100 g) and the composite flours of samples D (558.60 mg/100 g) and E (624.67 mg/100 g) but significantly lower (P < 0.05) than samples C (701.63 mg/100 g) and B (689.30 mg/100 g) composite flours. The sample E (RF40SF15CF5WYF10SPF30) rice-based composite flour had a value of 624.67 mg/100 g which was significantly higher (P < 0.05) than the control (104.27 mg/100 g) and sample D (558.60 mg/100g) composite flour but significantly lower (P < 0.05) than the composite flours of samples C (701.63 mg/100 g), B (686.30 mg/100 g), E (624.67 mg/100 g), and F (651.23 mg/100 g). The K content of sample D (RF40SF15CF5WYF20SPF20) had a value of 558.60 mg/100 g which was significantly lower (P < 0.05) than sample B (686.30 mg/100 g), sample C (701.63 mg/100 g), sample E (624.67 mg/100 g), and sample F (651.23 mg/100 g) composite flours but significantly higher (P < 0.05) than the control (104.27 mg/100 g). However, all the composite samples were higher than the control.

The Mg content of the rice-based composite flour and the control had values ranging from 12.17 mg/100 g to 78.00 mg/100 g with the control (100% wheat flour) having the least value while sample B recorded the highest value. The Mg content of sample B (RF40SF15CF5WYF40) was 78.00 mg/100 g and this value was significantly higher (P < 0.05) than the Mg content of the control (12.17 mg/100 g) and samples C (43.47 mg/100 g), D (46.83 mg/100 g), E (43.57 mg/100 g), and F (43.07 mg/100 g) composite flours. The Mg content of sample D (RF40SF15CF5WYF20SPF20) had a value of 46.83 mg/100 g which was significantly lower (P < 0.05) than the value obtained from sample B (78.00 mg/100 g) composite flour but significantly higher (P < 0.05) than the control (12.17 mg/100 g) and the composite flours of samples C (43.47 mg/100 g), E (43.57 mg/100 g), and F (43.07 mg/100 g). The rice-based composite flour of samples C RF40SF15CF15SPF40) and E (RF40SF15CF5WYF10SPF30) was 43.47 mg/100 g and 43.57 mg/100 g, respectively, and they were observed to show no significant differences. These values were significantly lower (P < 0.05) than sample B (78.00 mg/100 g) and sample D (46.83 mg/100 g) composite flours but significantly higher (P < 0.05) than control (12.17 mg/100 g) and the sample F (43.07 mg/100 g) composite flour. The Mg content of sample F (RF40SF15CF5WYF30SPF10) was 43.07 mg/100 g and this value was significantly lower (P < 0.05) than the Mg content of sample B (78.00 mg/100 g), sample D (46.83 mg/100 g), sample C (43.47 mg/100 g), and sample E (43.57 mg/100 g) composite flours but significantly higher (P < 0.05) than that of the control (12.17 mg/100 g) sample. All the composite flour samples were, however, again higher than the control.

A comparison of mineral composition between the different experimental samples of cookies is shown in [Table 3].

The Na contents of the rice-based composite cookies and the control ranged from 170.67 mg/100 g to 383.33 mg/100 g with sample E having the least value while the highest value was recorded by sample C. The Na content of sample C (RF40SF15CF15SPF40) having the highest value was 383.33 mg/100 g and this was significantly higher (P < 0.05) than the control (100% wheat cookies) which had a value of 321.00 mg/100 g. The Na value of sample C (383.33 mg/100 g) was observed to be significantly higher (P < 0.05) than samples B (268.33 mg/100 g), D (290.33 mg/100 g), E (170.67 mg/100 g), and F (265.33 mg/100 g) composite cookies also. The sample D (RF40SF15CF5WYF20SPF20) composite cookies had a value of 290.33 mg/100 g which was significantly higher (P < 0.05) than samples B (268.33 mg/100 g), E (170.67 mg/100 g), and F (265.33 mg/100 g) composite cookies but significantly lower (P < 0.05) than the control (321.00 mg/100 g) and the sample C (383.33 mg/100 g) composite cookies. The Na contents of sample B (RF40SF15CF5WYF40) and sample F (RF40SF15CF5WYF30SPF10) composite cookies recorded a value of 268.33 mg/100 g and 265.33 mg/100 g, respectively. These values were observed to be significantly higher (P < 0.05)

Table 3: Comparison of mineral composition between the different experimental samples of cookies.

	Na (mg/100 g)	Fe (mg/100 g)	Ca (mg/100 g)	K (mg/100 g)	Mg (mg/100 g)
Sample A	321.00±1.73	1.07±0.01	64.73±2.17	116.20±3.02	74.73±1.73
Sample B	268.3±1.76*	32.75±0.02*	45.77±0.78*	126.37±0.87*	27.77±0.35*
Sample C	383.3±4.10*,a	31.14±0.01a	52.30±0.21*,a	144.23±0.52*,a	32.90±0.46*,a
Sample D	290.33±*,a,b	1.17±*,a	55.33±*,a	132.63±*,a,b	35.17±0.23
Sample E	170.67±8.45*,a,b,c	1.21±0.01*,a	63.13±0.15a,b,c	113.97±1.46a,b,c	34.80±0.17*,a
Sample F	265.33±2.33*,b,c,d	1.28±0.06*,a,b,c	51.17±0.23*,a,c,d	114.07±0.52a,b,c,d	31.33±0.33*,a,c,d

Values are expressed as mean SEM, n=5, *significant different from sample A at P<0.05. [a]Significant difference from sample B at P<0.05, [b]significant difference from sample C at P<0.05, [c]significant difference from sample D at P<0.05, [d]significant difference from sample E at P<0.05. Na: Sodium, Fe: Iron, Ca: Calcium, K: Potassium, Mg: Magnesium than the value obtained for sample E (170.67 mg/100 g) but significantly lower ($P < 0.05$) than the values obtained for the control (321.00 mg/100 g) and the composite cookies of samples B (383.33 mg/100 g) and D (290.33mg/100g). The sample E (RF40SF15CF5WYF10SPF30) composite cookies had a Na content of 170.67 mg/100 g which was recorded as the least value and was significantly lower ($P < 0.05$) than the values obtained for the control (321.00 mg/100 g) and the composite cookies of samples C (383.33 mg/100 g), D (290.33 mg/100 g), B (268.33 mg/100 g), and F (265.33 mg/100 g), respectively.

The Fe content of the rice-based composite cookies and the control had values ranging from 1.07 mg/100 g to 2.75 mg/100 g with the control (100% wheat flour) having the least value while sample B recorded the highest value. The Fe content of sample B (RF40SF15CF5WYF40) was 2.75mg/100 g and this value was significantly higher ($P < 0.05$) than the Mg content of the control (1.07 mg/100 g) and samples C (1.14 mg/100 g), D (1.17 mg/100 g), E (1.21 mg/100 g), and F (1.28 mg/100 g) composite cookies. The Fe content of sample F (RF40SF15CF5WYF30SPF10) had a value of 1.28 mg/100 g which was significantly lower ($P < 0.05$) than the value obtained for sample B (2.75 mg/100 g) composite cookies but significantly higher than the control (1.07 mg/100 g) and the values obtained for samples C (1.14 mg/100 g), D (1.17 mg/100 g), E (1.21 mg/100 g), and F (1.28 mg/100 g) composite cookies. The rice-based composite cookies of samples D (RF40SF15CF5WYF20SPF20) and E (RF40SF15CF5WYF10SPF30) were 1.17 mg/100 g and 1.21 mg/100 g, respectively, and they were observed to show no significant differences. These values were significantly lower ($P < 0.05$) than sample B (2.75 mg/100 g) and sample F (1.28 mg/100 g) composite cookies but significantly higher ($P < 0.05$) than control (1.07 mg/100 g) and the sample C (1.14 mg/100 g) composite cookies. The Fe content of sample C (RF40SF15CF15SPF40) was 1.14 mg/100 g and this value was significantly lower ($P < 0.05$) than the Fe content of sample B (2.75 mg/100 g), sample F (1.28 mg/100 g), sample D (1.17 mg/100 g), and sample E (1.21 mg/100 g) composite cookies but significantly higher ($P < 0.05$) than that of the control (1.07 mg/100 g) sample. All the composite cookie samples were higher than the control.

The Ca content of the rice-based composite cookies and the control ranged from 45.77 mg/100 g to 64.73 mg/100 g with sample B having the least value while the highest value was recorded by the control (100% wheat cookies). The sample E (RF40SF15CF5WYF10SPF30) composite cookies recorded a Ca content of 63.13 mg/100 g which was significantly lower ($P < 0.05$) than the control (64.73 mg/100 g) but significantly higher ($P < 0.05$) than composite cookies of samples B (45.77 mg/100 g), C (52.30 mg/100 g), D (55.33 mg/100 g), and F (51.17 mg/100 g). The samples C (RF40SF15CF15SPF40) and D (RF40SF15CF5WYF20SPF20) composite cookies had a value of 52.30 mg/100 g and 55.33 mg/100 g which was significantly lower ($P < 0.05$) than the control (64.73 mg/100 g) and sample E (63.13 mg/100 g) composite cookies but significantly higher ($P < 0.05$) than the composite cookies of sample B (45.77 mg/100 g) and sample F (51.17 mg/100 g). The Ca content of sample F (RF40SF15CF5WYF30SPF10) recorded a value of 51.17 mg/100 g which was significantly lower ($P < 0.05$) than the control (64.73 mg/100 g) and samples E (63.13 mg/100 g), C (52.30 mg/100 g), and D (55.33 mg/100 g) composite cookies but significantly higher ($P < 0.05$) than sample B (45. 77 mg/100 g) composite cookies. The composite cookies of sample B (RF40SF15CF5WYF40) had a value of 45.77 mg/100 g which was significantly lower ($P < 0.05$) than the control (64.73 mg/100 g) and samples E (63.13 mg/100 g), C (52.30 mg/100 g), D (55.33 mg/100 g), and F (51.17 mg/100 g) composite cookies, respectively.

The potassium contents of the rice-based composite cookies and the control ranged from 113.97 mg/100 g to 144.23 mg/100 g with sample E having the least value while the highest value was recorded by sample C. The potassium content of cookies made from sample C (RF40SF15CF15SPF40) composite flour blends had a value of 144.23 mg/100 g which was significantly higher ($P < 0.05$) than the control (100% wheat cookies) which was 116.20 mg/100 g. The potassium contents of sample C composite cookies were significantly higher ($P < 0.05$) than sample B (126.37 mg/100 g), sample D (132.63 mg/100 g), sample E (113.97 mg/100 g), and sample F (114.07 mg/100 g) composite cookies. The composite cookies of sample D (RF40SF15CF5WYF20SPF20) had a value of 132.63 mg/100 g which was shown to be significantly higher ($P < 0.05$) than the control (116.20 mg/100 g) and sample B (126.37 mg/100 g), sample E (113.97 mg/100 g), and sample F (114.07 mg/100 g) composite cookies. The sample B (RF40SF15CF5WYF40) composite cookies had a potassium content of 126.37 mg/1000 g which was significantly higher ($P < 0.05$) than the control (116.20 mg/100 g) and the composite cookies of sample E (113.97 mg/100 g) and sample F (114.07 mg/100 g) but significantly lower ($P < 0.05$) than sample C (144.2 mg/100 g) and sample D (132.63 mg/100 g) composite cookies. The potassium contents of the sample E (RF40SF15CF5WYF10SPF30) and sample F (RF40SF15CF5WYF30SPF10) composite cookies were 113.97 mg/100 g and 114.07 mg/100 g, respectively. These values were shown to be significantly lower ($P < 0.05$) than the control (116.20 mg/100 g) and the composite cookies of sample C (144.2 mg/100 g), sample D (132.63 mg/100 g), and sample B (126.37 mg/100 g), respectively.

The Mg content of the rice-based composite cookies and the control ranged from 27.77 mg/100 g to 74.73 mg/100 g with sample B having the least value while the highest value was recorded by the control (100% wheat cookies). The samples C (RF40SF15CF15SPF40), D (RF40SF15CF5WYF20SPF20), and E (RF40SF15CF5WYF10SPF30) composite cookies recorded values of 32.90 mg/100 g, 35.17 mg/100 g, and 34.80 mg/100 g, respectively, which were significantly lower ($P < 0.05$) than the control (74.73 mg/100 g) but significantly higher ($P < 0.05$) than sample B (27.77 mg/100 g) and sample F (31.33 mg/100 g) composite cookies. The Mg content of sample F (RF40SF15CF5WYF30SPF10) recorded a value of 31.33 mg/100 g which was significantly lower ($P < 0.05$) than the control (64.73 mg/100 g) and the composite cookies of samples C (32.90 mg/100 g), D (35.17 mg/100 g), and E (34.80 mg/100 g) but significantly higher ($P < 0.05$) than sample B (27.77 mg/100 g) composite cookies. The composite cookies of sample B (RF40SF15CF5WYF40) had a value of 27.77 mg/100 g which was significantly lower ($P < 0.05$) than the control (64.73 mg/100 g) and the samples C (32.90 mg/100 g), D (35.17 mg/100 g), E (34.80 mg/100 g), and F (31.33 mg/100 g) composite cookies, respectively.

DISCUSSION

Today, scientists are engaged to improve the maximum nutritional value of rice-based composite flour which will benefit human beings. Rice could be seen as a staple food in our society today. In recent times, protein-energy malnutrition in elderly people becomes a social issue. Malnutrition in elderly people increases and the risk of falling into age-related chronic diseases becomes worrisome. Therefore, substitution in our dieting habits could prevent elderly people from such age-related diseases. Composite flour would be a good foodstuff for the preparation of a diet suitable for humans. The mineral composition in some of this wheat flour contained specific organelles termed protein bodies and amyloplast in the cells of the endosperm and aleurone layer. The effect of blending ratios of rice, soybean, coconut, sweet potatoes, and water-yam flours on the mineral contents of rice-based composite flour is shown in [Tables 4 and 5]; the result from this study shows that the rice-based composite flour would contribute substantially to the recommended dietary requirement for minerals.[22] The mineral contents of the composite flour samples analyzed in the present study such as Na, Fe, Ca, K, and Mg relatively compared based on the variation observed could be due to the compositional difference in terms of mineral content between the crops used in the blends. In addition, 100% wheat flour (sample A) served as the control for flour and there was a significant difference ($P < 0.05$) that existed between the composite flour samples and the control for the minerals analyzed.

In terms of Na content, data sample B had the highest Na value of 82.00 mg/100 g, respectively, and sample E had the least value of 30.47 mg/100 g. The trend showed that there was an increment in Na as the amount of water-yam blend increased. Na intake needs to be monitored as it can become a major dietary problem where high blood pressure problems are concerned. The low level of Na observed in this study will make the product suitable for use in Na-restricted diets.[23]

The data from Fe content showed that sample A (the control and 100% wheat flour) and sample F had the highest and lowest Fe value of 1.27 mg/100 g and 0.24 mg/100 g, respectively. Fe is a mineral that has many different roles in the body but it is particularly important for making hemoglobin, a protein contained in the red blood cells that transport oxygen around the body. Fe also plays an essential role in maintaining a healthy immune system (your body's natural defense system) and with the increasing prevalence of Fe-deficiency anemia, the appreciable amount of Fe in this study can be used to supplement minerals in the diet.

The Ca content of the composite flour samples and the control investigated in the present study was significantly affected ($P < 0.05$) by the blending ratio. Ca is an important mineral for the development of strong teeth and bones. An adequate intake of Ca is one of several factors which are important for acquiring bone mass and attaining peak bone mass. Diets containing insufficient amounts of Ca may lead to low bone mineral density, which may have implications for bone health, notably the risk of osteoporosis, later in life. Ca is a mineral required by the body for a variety of physiological functions and the maintenance of bone tissues throughout life.[24]

Table 4: Comparison of mineral composition between the different experimental samples of flour.

Samples	Na (mg/100 g)	Fe (mg/100 g)	Ca (mg/100 g)	K (mg/100)	Mg (mg/100 g)
Sample A	66.40±0.95	1.27±0.07	87.97±0.24	104.27±0.54	12.17±0.20
Sample B	82.00±0.57*	0.34±0.01*	31.80±0.06*	686.30±3.14	78.00±0.67*
Sample C	35.80±1.47*,a	0.37±0.01*	24.53±1.71*	701.63±1.32*,a	43.47±1.04*,a
Sample D	42.30±1.03*,a,b	0.30±0.01*	28.20±0.78*,a,b	558.60±1.59*,a,b	46.83±1.14*,a,b
Sample E	30.47±1.41*,a,b,c	0.27±0.03*,b	17.37±0.46*,a,b,c	624.67±2.30*,a,b,c	43.57±1.37*,a,c
Sample F	66.40±1.23a,b,c,d	0.24±0.02*,a,b	22.57±0.79*,a,b,c,d	651.23±0.55*,a,c,d	43.07±0.80*,a,c

Values are expressed as mean SEM, n=5. *Significant difference from sample A at P<0.05. aSignificant difference from sample B at P<0.05, bsignificant difference from sample C at P<0.05, csignificant difference from sample D at P<0.05, dsignificant difference from sample E at P<0.05. Na: Sodium, Fe: Iron, Ca: Calcium, K: Potassium, Mg: Magnesium

Table 5: Comparison of mineral composition between different experimental samples of flour and cookies.

	Na (mg/100 g)	Fe (mg/100 g)	Ca (mg/100 g)	K (mg/100 g)	Mg (mg/100 g)
Sample A					
Flour	66.40±0.95	1.27±0.07	87.97±0.24	104.27±0.54	12.17±0.20
Cookies	321.00±1.73*	1.07±0.01*	64.73±2.17*	116.20±3.02*	74.73±1.73*
Sample B					
Flour	82.00±0.57	0.34±0.01	31.80±0.06	686.30±3.14	78.00±0.67
Cookies	268.33±1.76*	2.75±0.02*	45.77±0.78*	126.37±0.87*	27.77±0.35*
Sample C					
Flour	35.80±1.47	0.37±0.01	24.53±1.71	701.63±1.32	43.47±1.04
Cookies	383.33±4.10*	1.14±0.01*	52.30±0.21*	144.23±0.52*	32.90±0.46*
Sample D					
Flour	42.30±1.03	0.30±0.01	28.20±0.78	558.60±1.59	46.83±1.14
Cookies	290.33±1.20*	1.17±0.01*	55.33±0.78*	132.63±0.65*	35.17±0.23*
Sample E					
Flour	30.47±1.41	0.27±0.03	17.37±0.46	624.67±2.30	43.57±1.37
Cookies	170.67±8.45	1.21±0.01	63.13±0.15*	113.97±1.46*	34.80±0.17*
Sample F					
Flour	66.40±1.23	0.24±0.02	22.57±0.55	651.23±0.79	43.07±0.80
Cookies	265.33±2.33	1.28±0.06	51.17±0.23*	114.07±0.52*	31.33±0.33*

Values are expresses as mean SEM, n=5. *Significant different from flour at P<0.05. Na: Sodium, Fe: Iron, Ca: Calcium, K: Potassium, Mg: Magnesium

In terms of K content, the composite flour samples and the control had the highest value while the control (100% wheat cookies) which was significantly different from other cookies in terms of Fe contents at $P < 0.05$ had the least value of K content. The trend showed that there was an increment in the amount of K with an increase in the water-yam blend. Potassium is an essential nutrient needed for the maintenance of total body fluid volume, acid and electrolyte balance, and normal cell function.[24] Reduced K consumption has been associated with hypertension and cardiovascular diseases, and appropriate levels could be equally protective against these conditions.[25] The relatively high K content of the samples and the control is an indication that the flour products will help in ensuring adequate intakes of K in household diets.

The Mg values of the composite flour samples and the control had the highest value while the control 100 W had the least Mg content, indicating that Mg is important as it assists in maintaining electrolyte balance and Ca, Na, and K homeostasis, all of which are essential for stabilizing excitable membranes.[25] The appreciable amounts of Mg in this study can help to improve the intake of this mineral needed in sufficient amounts for numerous physiological processes.

Minerals are chemical constituents used by the body in many ways. Although they yield no energy, they have important roles to play in many activities in the body. The effect of the blending ratio of rice, wheat, soybean, coconut, sweet potatoes, water-yam, and coconut flours on the mineral contents of cookies is shown in [Table 3]. In addition, 100% wheat cookies (sample A) were served as the control for cookies and there was variation observed among the various samples of composite cookies and the control which could be due to the compositional difference in terms of mineral content between the crops used in the blends. Higher mineral content in the present study found in different cookies may be attributed to a higher concentration of minerals in the raw materials used for supplementation of composite flours.[26]

The Ca content of the composite cookie samples investigated in the present study was significantly affected ($P < 0.05$) by the blending ratio. The trend showed that there was an increment in the amount of Ca as the amount of sweet potato blend increased. Ca is by far the most important mineral that the body requires and its deficiency is more prevalent than many other minerals, it helps in the formation of strong bones and teeth. The Ca content of the composite cookie samples and control (100% wheat cookies) was similar and so, their products would still give good amounts of Ca to both children and elderly people for strong bone and body development.[26]

Mg is a cofactor in more than 300 enzyme systems that regulate diverse biochemical reactions in the body, including protein synthesis, muscle and nerve function, blood glucose control, and blood pressure regulation. Mg keeps bones strong and the heart rhythm steady.[27] The composite cookie samples had a high content of Mg as the flour blends are rich sources of Mg.[28]

The K content of the composite cookie samples investigated in the present study was significantly affected ($P < 0.05$) by the blending ratio. The results also revealed that increased K content was observed when there was a high concentration of sweet potato flour in the composite cookies. Potassium is present in all body tissues and is required for normal cell function and the relatively high K content of the composite cookie samples and the control is an indication that the cookie products will help regulate many physiological processes in the body including maintaining intracellular fluid volume and transmembrane electrochemical gradients.[29]

In terms of Fe content, the composite cookie samples, and the control (100% wheat cookies), the Fe content of the samples and control obtained in this study were lower than the Fe content of 183.10 mg/100 g of wheat soy flour reported by the Institute of Medicine.[30] The Fe content of the cookie samples investigated in the present study was significantly affected ($P < 0.05$) by the blending ratio. The trend showed that there was an increment in the amount of Fe as the amount of water-yam flour increased in the blend used for baking cookies.

In terms of Na content, the Na content of the composite cookie samples investigated in the present study was significantly affected ($P < 0.05$) by the blending ratio. The composite cookies and the control were significantly different from each other in terms of Na contents at $P < 0.05$. In humans, Na is an essential mineral that regulates blood volume, blood pressure, osmotic equilibrium, and pH but still, the Na content in the present study was relatively high and consumption should be in moderation as excess Na intake can become a major dietary problem where high blood pressure problems are concerned.[22,30] These high Na values can be a result of the increased Na content of the crops in the rice-based composite flour used for baking as well as the baking ingredients, respectively.

There was a significant difference ($P < 0.05$) that existed between the composite flour samples and the control for the minerals analyzed. The result of the current research agreed with a research finding by Allen *et al*.[31] who concluded that the zinc content of wheat ratios increased with the supplementation of soy flour[19] and another research done by Jan *et al*. reported that oilseeds flour contained an appreciable quantity of minerals which increased the mineral contents of composite flours. A similar result has also been reported by Jan *et al*.,[32] as soy fortified chapattis contained higher Fe, zinc, and Ca than whole wheat flour chapattis, Rawat *et al*.[33] also concluded that the higher mineral contents in the experimental samples compared to 100% wheat were attributed to the increasing proportions of beniseed integrated into wheat flour.[34] The result from this study shows that substituting 100% wheat flour for a rice-based composite flour made from blends of flour derived from locally grown crops such as legumes, cereals, and tubers can cause an increment in the mineral content of the composite flour and cookies obtained from it, as this would also contribute substantially to the recommended dietary requirement for minerals in household diets for rural and urban communities alike. However, some challenges that we may encounter may come as a result of infrastructural problems such as lack of reliable power supply from the Power Holding Company of Nigeria and public water supply, especially for small and medium scale would be operators who will like to venture into non-wheat flour milling business.

The unwillingness of multinational companies operating in Nigeria to incorporate non-wheat flour for composite flour production, as will reduce the quantity of wheat they import and the profit their parent companies make from the sale of wheat.

CONCLUSION

The finding of this study is a wake-up alert for policymakers to improve and increase availability, accessibility in the utilization of food to address nutrient deficiencies, and other nutritional challenges in the country. Therefore, creating a new source of food is a gateway to building on food-based dietary guidelines in the country to secure a diversified and balanced nutritional diet for the growth and development of human health. Also, this will increase the utilization of these locally grown crops, to alleviate food insecurity and high cost of wheat importation into the country.

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Declaration of patient consent

Patient’s consent not required as there are no patients in this study.

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Conflicts of interest

There are no conflicts of interest.

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