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Research Article

Chemical and Mineral Composition of Biscuit Produced from Wheat and Bambara Groundnut Flour

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Abstract

NThe aim of this study was to determine the potential of bambara groundnut, an under utilised legume for use both as flour and protein isolate in biscuit production. Sixteen response surface methodology (RSM) runs were evaluated from combination of wheat flour (WF), bambara groundnut flour (BF) and bambara protein isolate (BPI). Based on the crude protein and functional properties these ratios were selected WF: BF (85.0:15.0%, 76.2:23.8% and 52.5:47.5%) and labeled as WBF1, WBF2, WBF3, respectively with WF: BPI (85.0:15.0%, 76.2:23.8% and 52.5:47.5%) as WBPI1, WBPI2 and WBPI3 for blends of wheat flour and bambara protein isolate respectively. The proximate and mineral composition of the composite flour blends and biscuits were determined. Data were analysed using one way analysis of variance (ANOVA) and significance at $P < 0.05$. The wheat-bambara groundnut flour, wheat-bambara groundnut protein isolate and biscuits contained (g/100g) moisture (9.43-9.63), (1.64-3.59), (6.70-7.60), (4.00-5.70), total ash (0.79-1.76), (2.83-3.37), (1.00-170), (2.50-2.80) and crude protein, wheat-bambara groundnut flour (14.41-21.67), wheat-bambara groundnut protein isolate (32.42-61.10) and biscuits (15.30-20.10) (26.20-46.20) g/100g were recorded respectively. The carbohydrate content for wheat-bambara flour (62.47-66.75) g/100g, wheat-bambara protein isolate flour (31.56-61.21) g/100g and biscuits (63.10-67.00), (40.50-5750) g/100g. The mineral composition (mg/100g): sodium ranged from (442.06 to 960.36) for wheat-bambara composite flour, biscuit (3.12-4.77) and calcium ranged from (94.33-494.88) for wheat-bambara composite flour, biscuit (2.08-3.82) respectively. Among the trace metals, copper ranged between for wheat-bambara composite flour (14.80-35.11), biscuit (0.04-0.06) and manganese ranged between for wheat-bambara composite flour (8.00-26.03), biscuit (0.21-0.31) were high in the composite flour and low in the biscuit samples. Lead was not detected in both the flour samples and the biscuit. The calculated mineral ratios Na/K of the composite flour was (0.24-0.41) and biscuits (0.58- 0.92) respectively. Ca/P ratio for wheat-bambara composite flour (1.07-2.42) and biscuit (2.00- 2.47). The Ca/P ratios in the composite flour and biscuits samples were greater than recommendation of > 1.0, this will help to increase the absorption of calcium on the small intestine.

It could be concluded that, the study remarkably developed flour and biscuit with high contents of crude protein, calcium, and phosphorus.

Keywords: Wheat-bambara Groundnut Flour; Wheat-bambara Groundnut Isolate; Proximate; Mineral

Introduction

Legume seeds are a good source of proteins (about 30% of total composition). The level of protein is closely bound with the kind of plant and cultivation conditions [1,2]. Grain legumes are the main dietary protein source for a large proportion of the population in many low-income food deficit countries (LIFDCs) of the world. Legumes such as bambara groundnut, lima beans, cowpea, soybeans etc. play important roles in the diets of many people in Africa and Asia and serve as major sources of protein, calories, vitamins and minerals. Thus, bambara groundnut could be used to complement cereal grains in order to provide a balanced amino acid profile. Bambara groundnut (*Vigna subterranean* L. Verdc) is a legume crop of African origin used locally as a vegetable or snack. Bambara nut is one of the most adaptable of all plants and it tolerates harsh conditions better than most crops. The seed is regarded as a balanced food because when compared to most food legumes, it is rich in iron and the protein contains high lysine and methionine [3].

Biscuits are confectionery dried to very low moisture content. According to Nwosu [4], biscuit is defined as a small thin crispy cake made from dough. Biscuits are an important baked product in human diet and are usually eaten with tea and are also used as weaning food for infants. The ingredients are simple; which contain soft wheat flour, sugar, fat, eggs [4-6]. Efforts have been made to enrich wheat with bambara groundnut to produce cake [7]. These ingredients are considered to be low in nutritive and biological values since soft wheat flour used for the production of biscuits is deficient in several nutrients including some vitamins, mineral elements as well as dietary fibre and protein [8]. Legumes are generally good sources of proteins and contain on an average from 18 to 25%. Legumes have an important role in the suitability of monotonous diets the world over and also many dietary uses. Legumes such as chickpea, bambara groundnut and soybean are normally added to the pasta, pastry products and bakery products [9,10].

Materials and Methods

Materials

Bambara groundnut seeds used in the study was purchased in large quantity at Owena market along Ilesa Akure road, Osun State, Nigeria. The seeds were authenticated at the Department of Crop Soil and Pest Management, Federal University of Technology, Akure. All reagents used were of analytical grade.

Methods

Processing of bambara groundnut

Prior to defatting and isolation of protein, bambara groundnut was processed by modifying the method of Mune., *et al.* [11]. First, the nuts were sorted manually to remove extraneous materials and diseased seeds. The selected nuts were then soaked for 6 h in cold water at room temperature, dehulled and dried in hot air oven at 50°C for 72h. The dried nuts were milled with attrition mill to obtain flour and sieved with 84 µm mess size. The flour were deffated by using soxhlet extraction and n-hexane solvent for 8 h according to [12]. The sample was removed from the thimble, air dried at 105°C, milled, sieved and packed in plastic container sealed with aluminum foil and stored at room temperature prior to analyses.

Preparation of protein isolate

This was prepared by the method described by Aremu., *et al.* [13]. One part of the defatted flour was dispersed in ten parts of distilled water (50°C), by stirring for 30 min. The pH of the dispersion was adjusted to pH 9.5 by drop wise addition of 0.1M NaOH. The extraction was continued by occasional stirring for 6 h. The dispersion was centrifuged at 400 rpm for 30 min to separate the solid, aqueous and oil/emulsion phases. The supernatant was adjusted to pH 4.5 using 0.1M HCl and was centrifuged and the precipitate neutralized, freeze dried and kept for analyses.

Formulation of composite flour

The flour used for biscuit production was obtained from blends of wheat flour, bambara groundnut flour and bambara groundnut protein isolate. The composite flour was obtained from response surface methodology (RSM) runs, which were evaluated from combination of wheat flour (WF), bambara groundnut flour (BF) and bambara protein isolate (BPI). Based on the crude protein and functional properties these ratios were selected WF: BF (85.0:15.0%, 76.2:23.8% and 52.5:47.5%) and labeled as WBF_1, WBF_2, WBF_3, respectively with WF: BPI (85.0:15.0%, 76.2:23.8% and 52.5:47.5%) as $WBPI_1$, $WBPI_2$ and $WBPI_3$ for blends of wheat flour and bambara protein isolate respectively. The 100% wheat flour biscuit was used as the control sample.

Production of biscuit

Bambara groundnut flour and protein isolate were weighed using a digital balance (JT302N, England) and blended together with wheat at different ratios using a Kenwood electronic blender, to obtain composite flour. Other ingredients such as sugar, water, baking powder, salt, egg, flavour and butter were also added. After mixing, they were allowed to proof, cut into different shapes, arranged on a tray and subsequently baked in an oven at 150°C for 30 min prior to drying in the same oven at 50°C for 15 min. This was done by modifying Nwosu [4] method. The samples were allowed to cool before packaging in a flexible material and kept till further use.

Analyses

Proximate Analysis: The proximate composition: moisture content, crude protein, crude fat, crude fiber and ash content were determined according to AOAC [14]. The carbohydrate content was calculated by difference.

The total energy values of the samples were calculated according to the method of Iombor., *et al*. [15] using the formula presented below:

Total energy (kcal/100g) = (% available carbohydrates × 4) + (% protein × 4) + (% fat × 9).

Determination of mineral composition

The method described by Association of Official Analytical Chemists AOAC, (2005) was used for mineral analysis. The samples were ashed at 550°C. The ashed samples were dissolved with 10 ml of 20% hydrochloric acid in a beaker and then filtered into a 100 ml standard flask. This was made up to the mark with deionized water. The minerals were determined from the resulting solution. Sodium (Na) and Potassium (K) were determined using the standard flame emission photometre (PFP7 Flame photometre JENWAY, model 410, South Africa). NaCl and KCl were used as the standards. Phosphorus was determined colorimetrically using the spectronic 20 (Gallenkamp, UK) with KH_2PO_3 as the standard. Calcium (Ca), magnesium (Mg) and iron (Fe) were determined using Atomic Absorption Spectrophotometre (AAS Model SP9). All values were expressed in mg/100g.

Statistical analysis

All analyses were carried out in triplicates and they were analysed using Analysis of Variance. Data obtained were subjected to statistical analysis (ANOVA) using Statistical Package for the Social Sciences, SPSS (version 16). Mean values were separated using Duncan's New Multiple Range (DNMR) test and significance difference was accepted at 5% confidence level.

Results and Discussion

Proximate composition of wheat-bambara groundnut composite flour and biscuit

The proximate composition of the composite flour (wheat-bambara groundnut flour, wheat-bambara protein isolate) and biscuit are presented in table 1-3 respectively. The crude protein content of the composite flour (WBF_1, WBF_2 and WBF_3) ranged between 14.4 and 21.67%, while that of wheat-bambara protein isolate ($WBPI_1$. $WBPI_2$ and $WBPI_3$) ranged between 32.4 to 61.10% and that of biscuit (WF, WBF_1, WBF_2, WBF_3, $WBPI_1$, $WBPI_2$ and $WBPI_3$) ranged between 10.37 to 46.20%, respectively. The 21.67% recorded for wheat-bambara groundnut flour (Table 1) shows the high protein content of the composite flour. The protein content was similar to the report on wheat-bambara groundnut flour (22.36%) by Abu-Salem and Abou-Arab (2011). The crude protein content of the wheat-bambara groundnut isolate protein in this study (32.42 - 61.10) was above the value reported for raw Ukulinga bean isolate (57.36%) Abiodun and Adepeju, (2011) and below (83.70%) reported by Adebowale., *et al*. (2011) for mucuna protein isolate. The protein content of the composite biscuits (18.1 - 46.20%) was higher than the report of wheat-bambara groundnut biscuit (25.00%) reported by Arise., *et al.* (2017). These high values may suggest that bambara groundnut flour and its protein isolate may be a good source of protein. The inner layers of the legume grain are largely comprised of cotyledon tissues, which contain a large proportion of the grain protein. Therefore, the observed increase in protein concentration upon isolating may be due to an increase in the components of the grain inner layers (Nti, 2009; Abiodun and Adepeju, 2011). The increase in crude fat content of the biscuit (4.69 - 7.80) may be due to the addition of margarine to the flour during the production.

Sample	Moisture content	Crude protein	Crude fat	Total ash	Crude fibre	Carbohydrate	Energy (Kcal)
WBF_1	9.43 ± 0.20^{e}	14.41 ± 0.10^{d}	6.92 ± 0.03^{a}	1.76 ± 0.01^{a}	0.73 ± 0.20^{c}	66.75 ± 0.20^{b}	378.80 ± 2.20^{bc}
WBF_2	9.63 ± 0.14^{c}	18.53 ± 0.04^{c}	6.59 ± 0.10^{c}	0.93 ± 0.91^{e}	0.65 ± 0.03^{e}	64.99 ± 0.04^{c}	382.06 ± 1.10^{d}
WBF_3	9.56 ± 0.13^{d}	21.67 ± 0.17^{ab}	5.16 ± 0.12^{d}	0.79 ± 0.23^{d}	0.35 ± 0.02^{d}	62.47 ± 0.06^{d}	379.38 ± 1.00^{bc}
Typical WF	12.04 ± 0.13^{a}	8.21 ± 0.06^{e}	1.50 ± 0.15^{e}	1.05 ± 0.81^{b}	1.81 ± 0.07^{a}	75.39 ± 0.10^{a}	347.90 ± 1.61^{e}
Typical BF	$10.31^{b} \pm 0.34$	21.80 ± 0.39^{ab}	$6.60^{b} \pm 0.23$	1.01 ± 0.91^{c}	0.97 ± 0.03^{b}	59.31 ± 0.21^{e}	383.84 ± 1.92^{a}

Table 1: Proximate composition of wheat-bambara groundnut composite flour (%).

Data indicate mean of triplicate readings ± standard deviation. Different superscripts along the same column indicate significant differences among samples ($P < 0.05$).

Key: WBF_1: Wheat flour 85.0% and bambara groundnut flour 15.0%.

WBF_2: Wheat flour 76.2% and bambara groundnut flour 23.8%.

WBF_3: Wheat flour 52.5% and bambara groundnut flour 47.5%.

WF: Wheat flour, BF: Bambara flour.

Sample	Moisture content	Crude protein	Crude fat	Total ash	Crude fibre	Carbohydrate	Energy(Kcal)
$WBPI_1$	1.64 ± 0.32^{d}	32.42 ± 0.23^{d}	1.34 ± 0.67^{a}	3.37 ± 0.31^{ab}	0.02 ± 0.14^{cd}	61.21 ± 0.11^{a}	386.58 ± 3.20^{ab}
$WBPI_2$	2.80 ± 0.14^{c}	43.81 ± 0.35^{c}	1.03 ± 0.82^{b}	3.29 ± 0.45^{c}	0.05 ± 0.22^{b}	49.02 ± 0.59^{b}	380.59 ± 1.10^{c}
$WBPI_3$	3.59 ± 0.05^{b}	61.10 ± 0.13^{b}	0.84 ± 0.91^{c}	2.83 ± 0.31^{d}	0.08 ± 0.45^{a}	31.56 ± 0.23^{c}	378.20 ± 2.30^{d}
Typical BPI	3.70 ± 0.39^{a}	82.27 ± 0.71^{a}	0.00 ± 0.21^{d}	3.37 ± 0.26^{ab}	0.02 ± 0.37^{cd}	10.64 ± 0.61^{d}	386.44 ± 1.36^{ab}

Table 2: Proximate composition of wheat-bambara groundnut protein isolate composite flour (%).

Data indicate mean of triplicate readings ± standard deviation. Different superscripts along the same column indicate significant differences among samples (P < 0.05).

Key: $WBPI_1$: Wheat flour 85.0% and bambara groundnut protein isolate 15.0%.

$WBPI_2$: Wheat flour 76.2% and bambara groundnut protein isolate 23.8%.

$WBPI_3$: Wheat flour 52.5% and bambara groundnut protein isolate 47.5%.

BPI: Bambara protein isolate.

Samples	Moisture content	Crude protein	Crude fat	Total ash	Crude fibre	Carbohydrate	Energy (Kcal/Kg)
WBF_1	7.60 ± 0.53^{b}	15.30 ± 0.33^{f}	7.80 ± 0.25^{a}	1.00 ± 0.28^{g}	1.30 ± 0.01^{g}	67.00 ± 0.72^{b}	399.20 ± 4.20^{a}
WBF_2	7.20 ± 0.07^{c}	18.60 ± 0.12^{e}	7.20 ± 0.41^{b}	1.40 ± 0.07^{f}	1.70 ± .054^{f}	63.90 ± 0.54^{cd}	394.80 ± 3.20^{b}
WBF_3	6.70 ± 0.34^{d}	20.10 ± 0.54^{d}	6.40 ± 0.07^{cd}	1.70 ± 0.21^{d}	2.00 ± 0.54^{d}	63.10 ± 0.02^{cd}	390.40 ± 1.20^{e}
$WBPI_1$	5.30 ± 0.45^{f}	26.20 ± 0.03^{c}	6.30 ± 0.74^{cd}	2.50 ± 0.05^{bc}	2.20 ± 0.07^{b}	57.50 ± 0.81^{e}	391.50 ± 1.20^{d}
$WBPI_2$	5.70 ± 0.12^{e}	31.30 ± 0.01^{b}	5.90 ± 40.05^{f}	2.60 ± 0.03^{bc}	2.50 ± 0.20^{a}	52.00 ± 40.04^{f}	386.30 ± 0.90^{f}
$WBPI_3$	4.00 ± 0.00^{g}	46.20 ± 0.03^{a}	4.69 ± 0.00^{g}	2.80 ± 0.00^{a}	1.90 ± 0.03^{e}	40.50 ± 0.03^{g}	393.21 ± 1.80^{c}
WF	8.69 ± 0.02^{a}	10.37 ± 0.07^{g}	6.22 ± 0.02^{e}	1.58 ± 0.03^{e}	2.11 ± 0.01^{c}	71.03 ± 0.41^{a}	381.60 ± 1.30^{g}

Table 3: Proximate composition of biscuit from composite flours (%).

Data indicate mean of triplicate readings ± standard deviation. Different superscripts along the same column indicate significant differences among samples (P < 0.05).

Key: WBF_1: Wheat flour 85% and bambara groundnut flour 15%, WBF_2: Wheat flour 76.25% and bambara groundnut flour 23.75%, WBF_3: Wheat flour 52.5% and bambara groundnut flour 47.5%, $WBPI_1$: Wheat flour 85% and bambara groundnut protein isolate 15%, $WBPI_2$: Wheat flour 76.25% and bambara groundnut protein isolate 23.75%, $WBPI_3$: Wheat flour 52.5% and bambara groundnut protein isolate 47.5%, WF: 100% Wheat flour.

The Energy values of the wheat-bambara groundnut composite flour ranged between WBF_1 378.80 - WBF2 382.06 kcal/100g, wheat-bambara groundnut protein isolate ranged between $WBPI_3$ 378.20 - $WBPI_1$ 386.56 kcal/100g and biscuit ranged between WF 381.60 - WBF_1 399.20 Kcal/100g). Statistically, the energy values of composite flours and the biscuits were significantly (P < 0.05) higher when compared to that of FAO/WHO, 1998 recommended energy value (344 Kcal /day). This implies that the composite flour and biscuit are capable of providing the necessary energy requirement for both children and adults.

Mineral elements of the composite flour and biscuit

The mineral element composition of the composite flours and biscuit are presented in table 4 and 5 respectively. The mineral elements tested for in the study included Ca, P, K, Na, Pb, Cu, Fe, Mn and Zn. For the composite flour and biscuit most of the mineral elements were above and below the recommended daily allowance respectively. The most predominant is calcium. The low concentrations of these mineral in the biscuit may be due to the removal of seed coat during processing. The high concentration of sodium in the composite flours especially that of the protein isolate compared to others might be due to the salt formed during the isolation of proteins (NaOH and NaCl) which ranged from 44.206 mg/ 100g to 963.036 mg/100g.

Sample	Na	K	Ca	Zn	Cu	Pb	Mn	Fe	P
WBF_1	44.206 ± 0.05^{f}	108.810 ± 0.38^{f}	9.433 ± 0.81^{f}	4.656 ± 0.58^{f}	3.412 ± 0.17^{b}	ND	0.800 ± 0.72^{f}	3.609 ± 0.62^{a}	4.100 ± 0.44^{f}
WBF_2	67.250 ± 0.13^{d}	284.275 ± 0.07^{a}	48.893 ± 0.28^{b}	5.664 ± 0.92^{e}	2.642 ± 0.23^{d}	ND	1.075 ± 0.29^{e}	2.874 ± 0.03^{b}	50.000 ± 0.75^{a}
WBF_3	86.325 ± 0.54^{b}	213.743 ± 0.54^{d}	49.488 ± 0.11^{a}	6.408 ± 0.15^{c}	1.863 ± 0.46^{e}	ND	1.436 ± 0.53^{d}	1.490 ± 0.45^{e}	43.700 ± 0.82^{b}
$WBPI_1$	52.437 ± 0.16^{e}	206.509 ± 0.85^{e}	11.671 ± 0.52^{e}	8.056 ± 0.27^{a}	3.511 ± 0.53^{a}	ND	1.883 ± 024^{c}	2.663 ± 0.57^{c}	6.850 ± 0.93^{de}
$WBPI_2$	71.408 ± 10.67^{c}	234.234 ± 0.36^{bc}	16.626 ± 0.47^{d}	7.076 ± 0.03^{b}	2.824 ± 0.03^{c}	ND	2.468 ± 0.47^{b}	2.450 ± 0.08^{d}	6.850 ± 0.55^{de}
$WBPI_3$	96.036 ± 0.72^{a}	234.267 ± 0.05^{bc}	20.600 ± 0.08^{c}	6.215 ± 0.67^{d}	1.480 ± 0.82^{f}	ND	2.603 ± 0.80^{a}	0.812 ± 0.75^{f}	10.550 ± 0.62^{c}
*RDA mg/day	240	3500	800	15	2		2	18	800

Table 4: Mineral elements of composite flour (mg/100g).

ND---not detected * source: USFDA (2013) Data indicate mean of triplicate readings ± standard deviation. Different superscripts along the same column indicate significant differences ($P < 0.05$) among samples ($P < 0.05$). key: WBF_1: Wheat flour 85.0% and bambara groundnut flour 15.0%, WBF_2: Wheat flour 76.2% and bambara groundnut flour 23.8%, WBF_3: Wheat flour 52.5% and bambara groundnut flour 47.5%, $WBPI_1$: Wheat flour 85.0% and bambara groundnut protein isolate 15.0%, $WBPI_2$: Wheat flour 76.2% and bambara groundnut protein isolate 23.8%, $WBPI_3$: Wheat flour 52.5% and bambara groundnut protein isolate 47.5%.

Sample	Na	K	Ca	Zn	Cu	Pb	Mn	Fe	P
WBF_1	4.32 ± 0.21^{c}	7.12 ± 0.08^{b}	4.45 ± 0.14^{a}	2.72 ± 0.00^{bc}	0.05 ± 0.02^{cd}	ND	0.31 ± 0.06^{ab}	1.13 ± 0.07^{cd}	2.14 ± 0.05^{b}
WBF_2	4.16 ± 0.11^{ef}	6.21 ± 0.07^{d}	3.82 ± 0.23^{b}	2.73 ± 0.09^{a}	0.05 ± 0.05^{cd}	ND	0.24 ± 0.02^{e}	1.06 ± 0.08^{e}	1.58 ± 0.00^{c}
WBF_3	4.13 ± 0.41^{ef}	6.69 ± 0.03^{c}	2.12 ± 0.18^{f}	2.71 ± 0.84^{de}	0.03 ± 0.07^{g}	ND	0.21 ± 0.06^{g}	1.11 ± 0.05^{cd}	1.10 ± 0.12^{fg}
$WBPI_1$	4.77 ± 0.00^{a}	5.20 ± 0.06^{g}	2.45 ± 0.71^{de}	2.71 ± 0.23^{de}	0.04 ± 0.08^{ef}	ND	0.27 ± 0.04^{c}	0.99 ± 0.05^{fg}	1.21 ± 0.00^{d}
$WBPI_2$	4.29 ± 0.01^{d}	7.43 ± 0.07^{a}	2.79 ± 0.03^{c}	2.72 ± 0.04^{bc}	0.06 ± 0.02^{ab}	ND	0.25 ± 0.05^{d}	1.21 ± 0.06^{a}	1.13 ± 0.08^{fg}
$WBPI_3$	4.46 ± 0.15^{b}	5.70 ± 0.46^{ef}	2.42 ± 0.83^{de}	2.65 ± 0.11^{f}	0.06 ± 0.07^{ab}	ND	0.22 ± 0.04^{f}	1.19 ± 0.02^{b}	1.17 ± 0.00^{e}
WF	3.12 ± 0.12^{g}	5.80 ± 0.09^{ef}	2.08 ± 0.43^{g}	2.04 ± 0.78^{g}	0.04 ± 0.01^{ef}	ND	0.31 ± 0.06^{ab}	0.97 ± 00.5^{fg}	2.20 ± 0.07^{a}
*RDA (mg/day)	240	3500	800	15	2		2	18	800

Table 5: Mineral composition of the formulated biscuit (mg/100g).

ND---not detected * source: USFDA (2013).

Data indicate mean of triplicate readings ± standard deviation. Different superscripts along the same column indicate significant differences among samples.

Key: WBF_1: Wheat flour 85.0% and bambara groundnut flour 15.0%, WBF_2: Wheat flour 76.2% and bambara groundnut flour 23.8%, WBF_3: Wheat flour 52.5% and bambara groundnut flour 47.5%, $WBPI_1$: Wheat flour 85.0% and bambara groundnut protein isolate 15.0%, $WBPI_2$: Wheat flour 76.2% and bambara groundnut protein isolate 23.8%, $WBPI_3$: Wheat flour 52.5% and bambara groundnut protein isolate 47.5%, WF: 100% Wheat flour.

Generally, the individual mineral content of all the samples differed significantly ($P < 0.05$). The values reported in this study were higher than those of previous studies (Amarteifio and Moholo, 1998 (23.03 - 452.72 mg/100g); Ijarotimi and Esho, 2009 (317.90 mg/100g)). Processing into flours and producing biscuit from the composite flours generally decreased the mineral content levels of all the samples. Abiodun and Adepeju, (2011) also reported a decrease in mineral content of dehulled bambara samples. The values of Na/K and Ca/P ratios are presented in table 6. The Na/K molar ratios in this report were within the FAO, (2003) recommended value of <1.00, hence, both the composite flour and the biscuit may be suitable for individuals with high blood pressure. The Ca/P ratios in the composite flour and biscuit samples were greater than FAO (2003) recommendation (>1.0).

Sample	Na/K Flour	Ca/P	Na/K Biscuit	Ca/P
WBF_1	0.41	2.29	0.61	2.08
WBF_2	0.24	1.07	0.67	2.42
WBF_3	0.40	1.13	0.62	2.00
$WBPI_1$	0.25	1.69	0.92	2.02
$WBPI_2$	0.30	2.42	0.58	2.47
$WBPI_3$	0.41	1.9	0.80	2.07
WF			0.54	0.95

Table 6: Mineral elements ratio of the composite flour and biscuit.

Na/K<1, and Ca/P >1.

Data indicate mean of triplicate readings along the same column.

Key: WBF_1: Wheat flour 85.0% and bambara groundnut flour 15.0%.

WBF_2: Wheat flour 76.2% and bambara groundnut flour 23.8%.

WBF_3: Wheat flour 52.5% and bambara groundnut flour 47.5%.

$WBPI_1$: Wheat flour 85.0% and bambara groundnut protein isolate 15.0%.

$WBPI_2$: Wheat flour 76.2% and bambara groundnut protein isolate 23.8%.

$WBPI_3$: Wheat flour 52.5% and bambara groundnut protein isolate 47.5%.

WF: Wheat flour 100%.

Foods are considered 'good' if Ca/P ratio is above one and poor if the ratio is less than 0.5, while Ca/P ratio above two helps to increase the absorption of calcium on the small intestine (Nieman., *et al.* 1992). Studies have reported that adequate intake of essential minerals could promote health, growth and cognitive development in children and adults (Bhan., *et al*. 2001; Ivanovic., *et al.* 2002). Deficiencies of some mineral elements therefore may lead to complications or onset of some diseases (Ogunyinka., *et al.* 2017). Bambara groundnut could therefore be a good source of minerals for both adults and children.

Conclusion

The addition of bambara groundnut flour and bambara groundnut protein isolate significantly improved the protein content, ash and crude fibre of biscuits better than biscuit from 100% wheat flour. In addition, the contents of calcium, phosphorus, and iron improved the biscuit produced. Bambara groundnut isolate can be used to substitute wheat flour up to 47.5% in the production of biscuit.

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