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Physicochemical and Nutritional Properties of Baby-Led Cookies Produced from Rice, Banana and Cashew-nut Flour Blends

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Aim: Cookies from rice, banana and cashew-nut flour blends were prepared as alternative to gluten-free baby-led food for children.
Place and Duration of Study: The study was carried out in the Chemistry Laboratory, Department of Science Laboratory Technology, University of Medical Sciences, Ondo, Nigeria and Food Processing Laboratory, Department of Food Technology, Auchi Polytechnic, Auchi, Nigeria between August, 2022 and January, 2023.
Methodology: Baby-led weaning cookies were formulated from flour blends as 100% raw rice (RRC), 50% rice and 50% wheat (RWC) and 40% rice, 20% cashew and 40% unripe banana

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(RCB) and their physical properties, sensory attributes, proximate properties, mineral compositions, vitamin profiles and anti-nutrients were determined and compared with 100% commercial cookie (CMC) with the view to substituting wheat flour with suitable flour blends with enhanced nutritional quality.

Results: The peak diameter (10.40±0.20 mm), thickness (6.37±0.06 mm) and weight (17.65±0.04 g) were obtained in RCB. Spread ratio was highest (2.66±0.11) and lowest (1.42±0.01) in CMC and RWC respectively while spread factor decreased from 100% in CMC to 77.19% (RRC), 53.46% (RWC) and 62.47% (RWC). The grittiness, texture, aroma, taste and general acceptability of RCB were significantly similar to those of CMC ($P < 0.05$). Na, K, Mg and Zn contents increased in RCB. Proximate compositions (%) of the cookies formulated varied significantly from CMC. Peak crude protein (14.49±0.59), crude fibre (4.03±0.02) and fat (32.22±0.00) in RCB, ash (3.28±0.02) and carbohydrate by difference (58.15±0.13) in CMC and moisture (18.19±0.11) in RRC. The peak values of fat-soluble vitamins (A, D, E, K) and water-soluble vitamins (B_1, B_2, B_3, B_6, B_9, B_{12}, C) were most abundant in RCB. The proportions (mg/g) of phytate, oxalate, tannins and phenols in the cookies formulated were comparatively lower than the lethal dose, implying that the cookies would be safe for consumption.

Conclusion: RCB cookie had excellent nutritional quality, which, as a novel baby-led weaning cookie, could serve as a suitable alternative to commercial cookies.

Keywords: Baby-led weaning; cookies; spread factor; anti-nutrients; lethal dose.

1. INTRODUCTION

Baby-led weaning (BLW), as an alternative to traditional approach of complementary foods, is a method that allows the babies feed themselves with finger foods after 6 months of their infant's life, until the age of 12 months [1,2]. In addition to the nutritional gains, BLW provides children's increase in grasping precision, intense sensory and motor coordination, independent meal participation and making eating pleasurable [3-6].

Cookies, ready-to-serve snacks and available in different sizes and shapes, are rich in protein, fat, carbohydrate, minerals and energy [7,8], which can be used as finger foods in BLW. The challenges posed by whole-wheat products such as celiac disease and high cost of importation have resulted in quest for composite flours in bakery and pasta products in the recent decade [9-12].

With the arise of the gluten related disorders, some of which have been known for a long time – such as celiac disease and dermatitis herpetiformis – and others only recently identified – as gluten sensitivity – it has become very important to expand the gluten-free food market.

The use of green banana and its derived sub-products could be an interesting alternative for wheat or gluten replacement in food. Possible applications for culled bananas could be flour production or banana pulp production [13] with other flours as a blend. A composite flour has been described as a mixture of vegetable flours from tubers and/or legumes and/or cereal, with or without wheat flour, which is more preferable in the production of cookies more than bread [14].

Rice (*Oryza sativa* L.), a fundamental staple food crop grown worldwide, is a good source of carbohydrates, proteins, vitamins and trace elements [15,16]. It provides more calories in the human than any other cereal in the world [17]. Rice in itself is a functional food due to its low fat content, high content of B-complex vitamins and high content of minerals such as Zn, Fe, K, Mn, Cu. The proteins metabolize into amino acids that help muscles to be resilient, capable of stretching and bending [18,19].

Banana (*Musa sp*.) is one of the most cultivated tropical fruit globally [20] and the rate of consumption varies between the ripe banana and unripe (or green) banana. Green banana has been identified as having potential to add nutritional and physiological values to human health [21]. This is adduced to abundance of dietary fibres, vitamins A, C and B6, essential minerals such as K, P, Mg, Zn, bioactive compounds such as phenolic compounds, and resistant starch found in green banana [22,23]. Thus, green banana is classified as a functional food [24]. Cookies prepared from composite green banana and wheat flours have shown appreciable dietary fiber, ash content and calories when compared with wheat flour [25].

Cashew (*Anacardium occidentale* L) is a multipurpose crop, which is now widely cultivated mainly for its nuts to be used as food, medicine, and source of income in many countries of the world mainly in Asia, Africa and South America [26]. The two consumable parts of cashew are the apple, usually called the cashew nutshell liquid (CNSL), and the kernel, usually called cashew nut, which can be directly consumed as snakes, roasted or processed as milk [27]. Cashew and its products are curative to many human health problems, which include lowering the cholesterol level in blood, controlling diabetes and coronary heart disease risk [28]. Cashew nuts are rich in magnesium which is vital for healthy bone development and prevention of high blood pressure [26].

This study was aimed at formulating and developing baby-led weaning cookies from rice, unripe (green) banana and cashew-nut flour blends as an alternative to complementary weaning foods, which has not been reported or documented in literatures. The sensory attributes, proximate compositions, mineral compositions, vitamin profiles and anti-nutrient contents of the cookies produced were evaluated to ascertain their nutritional quality as baby-led weaning meal.

2. MATERIALS AND METHODS

2.1 Sources of Materials

Cashew nuts, banana and rice were commercially purchased from Uchi market, located in Etsako-West Local Government Area, Edo State, Nigeria. The crops were used for research purpose only according to international chemical methods. All reagents used were of analytical grade and were used as purchased.

2.2 Preparation and Formulation of Flour Blends

The rice grains were sorted manually, cleaned, dried at 60^{o}C in an air-dry oven (Plus II Samyo. Gallenkamp Plc, Loughborouch, Lacestershite, Uk) and milled aseptically with a laboratory blender (Kenwood electronics, Model KM 9011 UK) and packaged in a transparent polyethylene film. The Cashew-nut flour was processed as follows: the nuts were shelled, cleaned, roasted, dried at 60^{o}C in an air-dry oven (Plus II Samyo. Gallenkamp, Uk) and milled aseptically with a laboratory blender (Kenwood electronics, Model KM 9011 UK) and packaged in a transparent polyethylene film [29]. A standard chemical method was adopted to prepare banana flour with slight modification [30]. The unripe banana fruits were peeled, mashed, weighed, the weighed samples was added to the other flour samples and baked (Table 1).

Table 1. Formulation of cookies

Sample Code	Formulation
CMC	100% commercial cookies
RRC	100% raw rice
RWC	50% rice and 50% wheat
*RCB	40% rice, 20% cashew and 40% unripe banana

Obtained as the best mixture using multiple RSM design 7.0

2.3 Cookies Preparation

The recipe for the cookies included 250 g flour, 63 g fat, 63 g sugar, 1 g of salt, 25 mL whole egg, 5 g powdered milk, 1.5 g nutmeg, 1 g baking powder, and 20-60 mL water. The flour, sugar and fat were mixed using a table-top mixer (Triomph, KE 1150) until the mixture was fluffy. Other ingredients, eggs, milk, baking powder, ground nutmeg, and salt were added to obtain a dough, which was kneaded, rolled out, cut into shapes and baked in an air-dry over at 180 ^{o}C for 20 min to a golden-brown colour. The cookies obtained (Fig. 1) were packaged in a non-sticky film.

2.4 Physical Properties of Cookies

Four cookies samples were placed edge to edge and the thickness (mm) determined using a digital Vernier caliper. A digital Vernier caliper was used to determine the diameter of the cookies by placing four cookies samples edge to edge. The weight of the cookies was determined with the aid of an analytical weighing balance. Mathematical deduction was used to evaluate the spread ratio and spread factor of the cookies [31]. All the determinations were carried out in triplicate and the data obtained were recorded as average thickness, diameter and spread ratio [14].

2.5 Sensory Acceptance of Cookies

The reconstituted formulated cookies samples and the control cookies samples were coded and presented to 10 untrained panelists. The panelists were assigned individually to a well illuminated laboratory booth and the baked cookies were served at 40 ^{o}C. Sample acceptance (color, texture, taste, aroma, general acceptability) was rated on scoring scale of 1 to 9, where 1 = dislike extremely and 9 = like extremely. Panelists made their responses on score sheets designed in line with the test procedures [32].

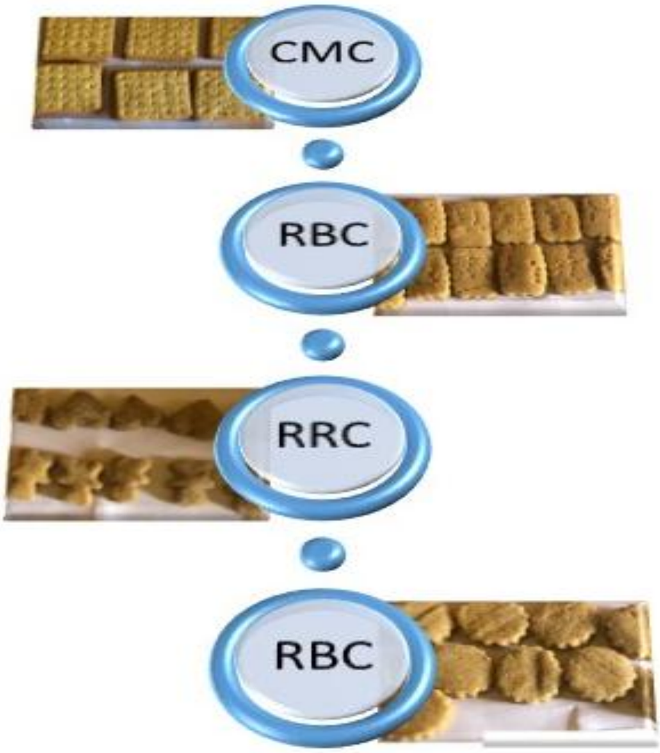

Fig. 1. Pictures of cookies

2.6 Proximate Analysis

The crude protein, crude fibre, ash, moisture and fat contents of the cookies were determined using the standard methods of Association of Official Analytical Chemists (AOAC, 2010). Carbohydrate was obtained by difference 100% – (moisture + protein + fat + ash + fibre)%.

2.7 Mineral Analysis

The minerals of the cookies were determined using dry ash methods as described in AOAC (2012). Each flour (1.0 g) was weighed into a crucible, transferred to a muffle furnace and ashed at 550 ^{o}C for 6 h. The ash was dissolved in 10 mL of 0.1 M HCl solution and the crucible was rinsed three times with 0.1 M HCl and made up to 100ml with deionized water. The clear aliquot of digest was analyzed for sodium, potassium, calcium, magnesium, iron and zinc, using Atomic Absorption Spectrophotometer (AAS Model SP9, Pye Unicam Ltd, Cambridge, UK).

2.8 Vitamins Determination

The vitamin contents of the cookies were determined by adopting standard methods with slight modifications. Vitamins B_1 (thiamine), B_2 (riboflavin), B_3 (Niacin) and C (ascorbic acid) of the cookies were determined using the method described by [33]. Vitamins B_6 (pyridoxine), B_9 (folic acid), B_{12} (cobalamin) and K (phytonadione) were determined using the method described by [34]. A standard chemical method [35] was used to determine vitamins A (retinol), D (calciferol) and E (tocopherol).

2.9 Anti-Nutrient Analysis

2.9.1 Determination of tannin (folin-denis spectrophotometric method)

A measured weight of each sample (1.0 g) was dispersed in 10 mL distilled water, agitated and allowed to stand for 30 min at room temperature. The dispersion was centrifuged and the extract obtained. The extract (2.5 mL) was dispersed into a 50 mL volumetric flask, followed by the addition of 1.0 mL Folin-Denis reagent and 2.5 mL saturated Na_2CO_3 solution, and the mixture made up to 50 mL. Similarly, 50 mL blank solution was made (2.5 mL of standard tannic acid; 1.0 mL Folin-Denis reagent; 2.5 mL saturated Na_2CO_3 solution. The mixtures were incubated for 90 min at room temperature. The absorbance of each mixture was measured at

250 nm in a UV Spectrophotometer (UV-1900, Shimadzu) [36].

$$\text{Tannin (mg/g)} = \frac{A_t \times C \times V_F}{A_s \times V_A \times w}$$

where, A_t = absorbance of the test sample; A_s = absorbance of standard solution; C = concentration of standard solution; w = weight of sample used; V_F = total volume of extract; and V_A = volume of extract analyzed.

2.9.2 Determination of oxalate

The determination of oxalate content involved three (3) processes: digestion, precipitation and titration [36]. *Digestion:* A known weight (2 g) of the sample dispersed in 190 mL of distilled water in a 250 mL volumetric flask was digested at 100 °C for 1 hour.by adding 10 mL of 6 M HCl. The resulting solution was cooled, made up to 250 mL and filtered. *Precipitation:* Duplicate portions of the filtrate were measured into breakers, followed by four drops of methyl red indicator and NH_4OH solution dropwise until the test solution changed from pink to faint yellow colour. Each portion was then heated to 90 °C, cooled and filtered to remove the precipitate containing ferrous ion. The filtrate was again heated to 90 °C and 10 mL of 5% $CaCl_2$ solution was added while being stirred constantly and left overnight at 25 °C. The solution was centrifuged at 2000 rpm for 5 min, the supernatant decanted, the precipitate completely dissolved in 20 mL of 25% (v/v) H_2SO_4 solution and the filtrate made up to 300 mL. *Permanganate Titration:* 125 mL aliquots of the filtrate was heated until near boiling and was titrated against 0.02 M standardized $KMnO_4$ solution to a faint pink color, which persisted for 30 seconds.

$$\text{Oxalate Content (mg/g)} = \frac{T \times (V_{me}) \times D_f}{M_s \times M_f}$$

where, T = titre of $KMnO_4$ (mL); V_{me} = volume-mass equivalent; D_f = Dilution factor= V_t/A (V_t is the total volume of filtrate (300 mL) and A is the aliquot used i.e. 125 mL); M_e = molar equivalent of $KMnO_4$ in oxalate; and M_f = weight of the sample.

2.9.3 Determination of phenols

Sample (2.0 g) was defatted with 100 mL of diethylether using a soxhlet apparatus for 2 h. The fat-free sample was boiled with 50 mL of ether for 15 min and 5 mL of the extract was pipette into a 50 mL volumetric flask, followed by addition of 10 mL distilled water, 2 mL of NH_4OH solution and 5 mL concentrated amyl alcohol. The mixture was made up to mark and left to react for 30 min for colour development. The absorbance of the solution was read UV Spectrophotometer (UV-1900, Shimadzu) at 505 *n*m wavelengths [33].

2.9.4 Phytate determination

Two processes of extraction and precipitation were involved in the determination of phytate content of the flour blends, which were carried out by adopting the method described by [37]. Sample (2 g) was soaked with 100 mL of 2% conc. HCl in a 250 mL conical flask for 3 h and then filtered. The filtrate (50 mL) was diluted with 107 mL distilled water and 10 mL of 0.3% ammoniumthiocyanate solution was added as indicator before titrating with standard iron chloride solution which contained 0.00195 g iron/mL to the end point, signified by brownish-yellow colour that persisted for 5 min.

$$\text{Phytate Content (mg/g)} = \frac{T \times 0.00195 \times 1.9}{w}$$

where, T = titre value (mL); and w = sample weight.

2.10 Statistical Analysis

IBM Statistical Package for Social Science (SPSS 26.0) software was used for statistical analysis of the data obtained for mean comparison, using Duncan's least significant test and one-way analysis of variance (ANOVA) at 5% significance level.

3. RESULTS AND DISCUSSION

3.1 Physical Properties of Cookies

The physical properties of the cookies produced from the flour blends in comparison with commercial cookies are shown in Table 2. The diameters (mm) of the cookies produced are higher than the commercial, except for RWC. However, in terms of thickness (mm) and weight (g), the cookies produced are thicker and weightier than the commercial cookies. These differences may be adduced to the incorporation of wheat in RWC and cashew-nut in RCB. The peak diameter (10.40±0.20 mm), thickness (6.37±0.06 mm) and weight (17.65±0.04 g) obtained in RCB can be adduced to the fibrous nature of cashew-nut flour in the blend, and possible due to gluten-free network in the cookie.

Table 2. Dimensions of cookies from rice, cashew-nut and banana flour blends

Parameter	Sample			
	CMC	RRC	RWC	RCB
Diameter (mm)	8.23^{b}±0.06	10.37^{c}±0.06	7.17^{a}±0.06	10.40^{c}±0.20
Thickness (mm)	3.10^{a}±0.10	5.07^{b}±0.06	5.07^{b}±012	6.37^{c}±0.06
Weight (g)	7.45^{a}±0.03	12.12^{b}±0.59	16.77^{c}±0.01	17.65^{d}±0.04
Spread Ratio	2.66^{d}±0.11	2.05^{c}±0.01	1.42^{a}±0.01	1.66^{b}±0.03
***Spread Factor (%)**	100.00±0.00	77.19±4.09	53.46±2.60	62.47±2.06

$^{*}Spread\ factor = \frac{Spread\ ratio\ of\ sample}{Spread\ ratio\ of\ control} \times 100$ *(Source: Manohar and Rao, 1997); CMC = Commercial cookies; RRC = 100% raw rice; RWC = 50% rice, 50%wheat; RCB = 40% rice, 20% cashew and 40% unripe banana. Results are the means of triplicate determination ± standard deviation values in the same row with the same superscripts letters (a > b > c > d) are not significantly different (P < 0.05)*

This is supported by the value of crude fibre of the sample (Table 4). An opposite trend is observed in terms of spread ratio, which is lowest (1.42±0.01) in RWC and highest (2.66±0.11) in CMC. The spread factor ranges from 100% in the control cookie to 77.19% in RRC, 53.46% in RWC and 62.47% in RWC. The presence of gluten network in cookies has been adduced to variations in viscosity, flow of mass, diameter and thickness [38,39].

3.2 Sensory Attributes of Cookies

The grittiness, texture, aroma, taste and general acceptability of RCB are significantly similar to those of CMC (P < 0.05). CMC possesses slightly brighter colour attribute than RWC and RCB (Table 3). Among all the cookies formulated, RCB exhibits the brightest colour, highest grittiness, texture, aroma, taste and general acceptability. The bright colour of RCB may not be unconnected to the impact of high chlorophyll in the natural form of unripe banana used to replace wheat in the formulation. The substitution of banana in the formulation enhances all the attributes of the cookies formulated, which is in agreement to [38], who found that banana in baked products improved aroma and flavour.

3.3 Proximate Compositions of Cookies

Table 4 shows the results of the proximate compositions. The moisture content of the cookies increases from 5.04±0.54% in CMC to 14.09±0.59, 16.84±0.47 and 18.19±0.11% in RWC, RCB and RRC respectively, indicating higher shelf-life in the control than the cookies formulated [40]. The ash contents are relatively low, ranging from the least (1.74±0.19%) in RWC to the peak (3.28±0.02%) in CMC. However, RCB has the highest ash content among all the cookies formulated, justifying the possibility of being richer in total minerals, and falling within the range of 0 to 12% documented for processed food, and < 5% for fresh foods [41]. All the cookies formulated have higher fat content than the control with the highest value (32.22±0.00%) obtained in RCB. This observation may arise from the addition of fat in the formulation whereas CMC is made from defatted flour. However, a range of 21.17 – 24.85% fat content has been reported for maize-tigernut flour blends in biscuits [11]. The crude fibre has its peak value (4.03±0.02%) in RCB, which becomes least (1.32±0.01%) in CMC. This observation can be adduced to the abundance of resistant starch in banana, which is resistant to digestion by the small intestine. However, for easy digestion, low crude fibre has been recommended in infant food formulations [42].

Crude protein is appreciably high in RCB (14.49±0.59%) due to incorporation of cashew-nut flour in the formulation. This is an indication that the samples can contribute immensely to the daily human protein requirement [43]. Carbohydrate by difference, varying from 29.59±1.05 to 58.15±0.13% is significantly different in both the control and the formulated (P < 0.05) with the former higher than the latter. The low carbohydrate by difference of RCB may have been impaired by the abundance of its fat content. The low carbohydrate by difference of RCB may have been impaired by the abundance of its fat content. Low carbohydrate, high fat (LCHF) foods have been identified as standard ketogenic diets in which the body generate energy by burning fats instead of carbohydrates [44].

Table 3. Sensory attributes of cookies

Attribute	Sample			
	CMC	RRC	RWC	RCB
Colour	4.80^{a}±0.42	3.70^{c}±0.82	4.40^{b}±0.84	4.40^{b}±0.52
Grittiness	4.20^{a}±0.79	3.40^{b}±0.70	3.90^{ab}±0.57	4.10^{a}±0.74
Texture	4.40^{a}±0.84	3.20^{ab}±1.32	3.40^{ab}±1.26	4.30^{a}±0.67
Aroma	4.50^{a}±0.71	3.50^{b}±1.27	4.20^{ab}±0.92	4.50^{a}±0.71
Taste	4.40^{a}±0.84	3.10^{c}±1.29	3.40^{bc}±1.17	4.10^{ab}±0.99
General Acceptability	4.40^{a}±0.84	3.10^{c}±1.19	3.80^{bc}±0.92	4.40^{a}±0.70

Results are the means of triplicate determination ± standard deviation values in the same row with the same superscripts letters (a > b > c > d) are not significantly different (P < 0.05)

Table 4. Proximate compositions of cookies

Sample	Proximate Composition (%)					
	Moisture Content	Ash Content	Fat Content	Crude Fibre	Crude Protein	Carbohydrate By Difference
CMC	5.04^{d}±0.54	3.28^{a}±0.02	22.31^{d}±0.58	1.32^{d}±0.01	9.90^{d}±0.07	58.15^{a}±0.13
RRC	18.19^{a}±0.11	2.13^{c}±0.05	31.33^{b}±0.04	1.81^{c}±0.04	10.69^{c}±0.03	36.00^{c}±0.11
RWC	14.09^{c}±0.59	1.74^{d}±0.19	28.78^{c}±0.19	2.76^{b}±0.03	13.69^{b}±0.42	38.95^{b}±0.18
RCB	16.84^{b}±0.47	2.83^{b}±0.02	32.22^{a}±0.00	4.03^{a}±0.02	14.49^{a}±0.59	29.59^{d}±1.05

Results are the means of triplicate determination ± standard deviation values in the same column with the same superscripts letters (a > b > c > d) are not significantly different (P < 0.05)

3.4 Mineral Compositions of Cookies

From Fig. 2, while K, Ca and Fe are most available in CMC, Na and Mg are in RCB. However, noticeable increase in Na, K, Mg and Zn contents is observed when wheat flour is replaced with banana and cashew-nut flours in the formulations. Osmoregulation ratio of Na/K increases with increase in Na concentration. This indicates the possibility of RCB serving as a better osmoregulation supplement than CMC and other cookies formulated. Calcium concentration (mg/kg) is highest (20.41±0.01) in CMC, which can be made available for bone formation and skeleton development [45], if it exists as free calcium that is not involved in complex formation with oxalate. Magnesium content is the highest (15.80^{a}±0.01 mg/kg) in RCB and lowest (10.80±0.01) in RRC. Magnesium has electrical potentials that aid nerve transmission and neuromuscular conduction [46]. Zinc and iron are the least abundant out of all the reported mineral content with the ranges of 0.25±0.01–0.34±0.01 and 0.06±0.00–0.10±0.01 mg/kg respectively. For infants and children (<7 months), the adequate intake (AI) of zinc is 2.0 mg/day and iron is 0.27 mg/day [47,48]. It has been reported that complementary foods with high calories, nutrient density and adequate iron content as well as high nutrient bioavailability can be used to prevent iron deficiency in infants and children [47,49]. Zinc functions as a component of various enzymes in the maintenance of the structural integrity of proteins and in the regulation of gene expression [49].

3.5 Vitamins of Cookies

Fat-soluble and water-soluble vitamins of the cookies are shown in Table 5 with reference to the recommended daily allowance (RDA) as documented [50]. The fat-soluble vitamins A, D, E and K are vital for the smooth functioning of the body and the deficiencies have been implied in several health disorders. This shows that a child taking the meal thrice per day will have vitamins A, D, E and K sufficient enough to maintain smooth functioning of the body. The peak values of vitamins A (1.92±0.03 mg), D (0.17±0.01 µg), E 1.77±0.06 µg) and K (0.08±0.01 µg) are obtained in RCB, implying that the substitution of wheat flour with cashew-nut and banana flours grossly enhanced the vitality of the cookies formulated and RCB cookie is a richer source of fat-soluble vitamins than CMC. Similarly, the water-soluble vitamins B_1, B_2, B_3, B_6, B_9, B_{12} and C are most abundant in RCB. This enhanced values in RCB compared to the control cookie (CMC) and other cookies formulated are not unconnected to the incorporation of unripe (green) banana and cashew-nut flours to the formulation. This implies that in addition to the high protein content in the component materials for RCB, they are equally rich in water-soluble vitamins, which can be dissolved in water and easily absorbed into tissues for instant metabolic uses. For more emphasis, vitamin B_1 in a co-catalyst in sugar digestion and is necessary for the function of the heart, nerve and muscles in child growth [51] and the deficiency lead to beriberi and excess leads to a sleeping disorder [52]. Vitamin B_2 is also involved in tissue respiration, deficiency in B_3 leads to condition known as pellagra while B_6 and B_9 are folic acids which help in anemia. Vitamin B_{12} is essential for the production of Red blood cells [52] and vitamin C is needed to form collagen that gives strength to the connective tissue and required for wound healing [53]. All vitamins evaluated are within the range of RDA [53]

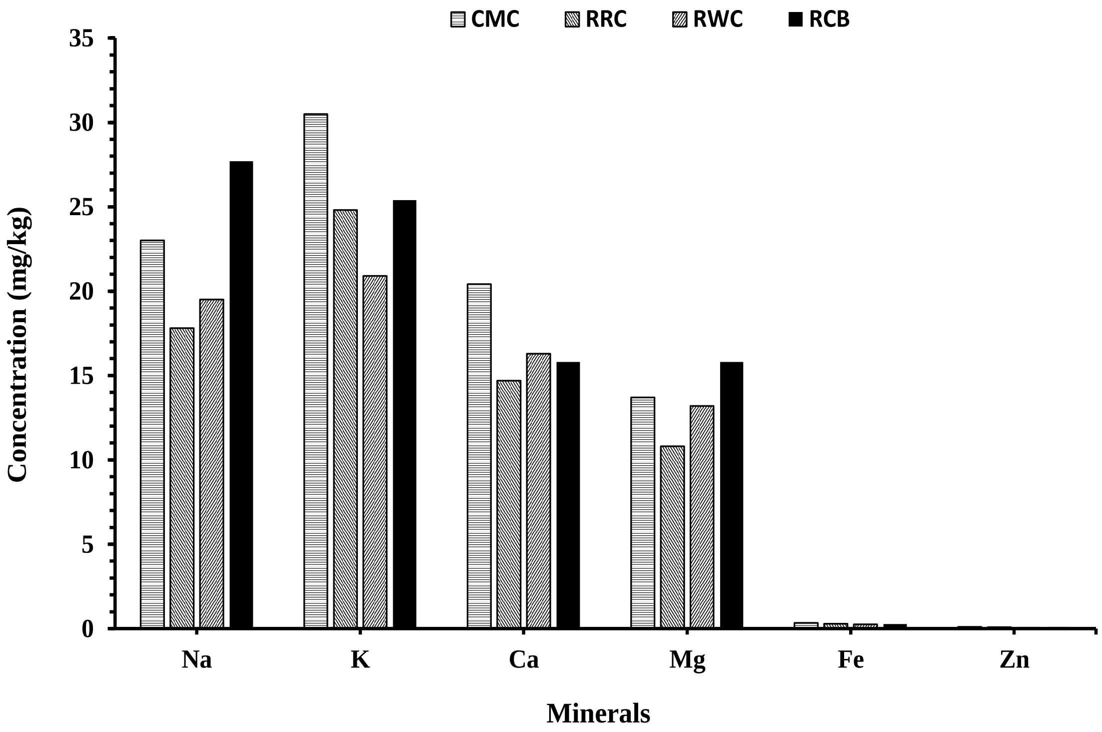

Fig. 2. Mineral composition of cookies

Table 5. Vitamins of cookies

Vitamin	RDA (mg)	Sample			
		CMC	RRC	RWC	RCB
A (mg)	8.00-10.00	1.55^{b}±0.09	1.22^{c}±0.01	1.61^{b}±0.01	1.92^{a}±0.03
B_1 (mg)	1.00-3.00	2.38^{b}±0.01	2.36^{c}±0.01	2.38^{b}±0.01	2.40^{a}±0.01
B_2 (mg)	1.00-1.20	1.74^{a}±0.01	1.11^{d}±0.01	1.17^{c}±0.01	1.19^{b}±0.01
B_3 (mg)	2.00-2.20	0.14^{c}±0.01	0.12^{d}±0.01	0.16^{b}±0.01	0.17^{a}±0.01
B_6 (mg)	1.00-3.00	0.13^{b}±0.01	0.10^{c}±0.01	0.17^{a}±0.01	0.18^{a}±0.01
B_9 (µg)	100.00-200.00	140.33^{c}±0.58	111.67^{d}±2.89	171.67^{b}±2.89	186.67^{a}±2.89
B_{12} (µg)	100.00-200.00	123.00^{d}±1.78	145.50^{c}±1.29	153.33^{b}±2.89	178.33^{a}±2.89
C (mg)	50.00-200.00	60.43^{c}±0.29	38.23^{d}±0.02	63.30^{b}±0.17	64.53^{a}±0.03
D (µg)	8.00-10.00	0.13^{bc}±0.01	0.11^{c}±0.01	0.14^{b}±0.01	0.17^{a}±0.01
E (µg)	0.70-1.40	1.22^{d}±0.03	0.82^{a}±0.06	1.53^{c}±0.06	1.77^{b}±0.06
K (µg)	0.80-0.10	0.03^{c}±0.00	0.02^{a}±0.01	0.05^{b}±0.02	0.08^{a}±0.01

Results are the means of triplicate determination ± standard deviation values in the same row with the same superscripts letters (a > b > c > d) are not significantly different (P < 0.05)

Table 6. Anti-Nutrients of cookies

Anti-Nutrient	Anti-Nutrient (mg/g)			
	Phytate	Oxalate	Tannins	Phenols
CMC	12.88[b]±0.01	6.66[a]±0.01	0.44[b]±0.01	10.95[b]±0.01
RRC	7.21[d]±0.01	1.35[d]±0.01	0.34[d]±0.01	8.59[d]±0.01
RWC	21.91[a]±0.01	3.07[b]±0.01	0.37[c]±0.01	9.18[c]±0.01
RCB	11.85[c]±0.01	2.52[c]±0.01	0.88[a]±0.01	22.18[a]±0.01

Results are the means of triplicate determination ± standard deviation values in the same column with the same superscripts letters (a > b > c > d) are not significantly different (P < 0.05)

3.6 Anti-Nutrients of Cookies

The analysis of anti-nutrients of the cookies shows the distribution of phytate, oxalate, tannins and phenols in the cookies (Table 6). Generally, their concentrations in all the cookies formulated are comparatively lower than the lethal dose documented: 90 mg/100g for tannins [8]; 25 mg/100g for phytate [51]; 200-500 mg/100g for oxalate [54]; and 7 mg/100g for phenols [52]. Therefore, their low values imply that all the cookies formulated safe for consumption. Phytate content is the highest in RWC (12.91±0.01 mg/g) and lowest in RRC (7.21±0.01 mg/g). Phyate is a chelate that reduces the bioavailability of metals, such as zinc, iron, magnesium and calcium through absorption into the blood stream [55-57]. Tannins is the least distributed anti-nutrient with values reducing from 0.88±0.01 mg/g (RCB) to 0.34±0.01 mg/g (RRC). Tannins exhibit anti-nutritional property by impairing the digestion of various nutrients and preventing the body from absorbing beneficial bioavailable substances [56]. The proportion of oxalate is highest in CMC (6.66±0.01 mg/g) and lowest in RRC (1.35±0.01 mg/g). Oxalate has been implicated to complete with mineral element such as calcium, magnesium and iron leading to the formation of insoluble oxalate salt thereby reducing the bioavailability of essential minerals for absorption into the blood stream [56-57]. Fermentation, cooking, soaking and puffing have been reported as traditional food preparation methods that can be employed to lower the effect of anti-nutrients on food quality [56].

4. CONCLUSION

The cookies formulated in this study are formulations of flour blends as100% raw rice (RRC), 50% rice and 50% wheat (RWC) and 40% rice, 20% cashew and 40% unripe banana (RCB). Their sensory attributes compete more favourably than the commercial cookie (CMC). Mineral distribution show bioavailability of essential minerals, such as Na, K, Mg and Zn in RCB more than CMC. The incorporation of cashew-nut and unripe banana flours in RCB enhances protein quality, bioavailability of both fat-soluble and water-soluble vitamins. All the cookies formulated exhibit lower proportions of tannins, phytate, oxalate and phenols; hence, they are safe for consumption. The formulation that contains 40% rice, 20% cashew and 40% unripe banana (RCB) has excellent nutritional quality among the cookies formulated.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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