



Quality Evaluation of Cookies Produced from Wheat, Sorghum and Defatted Coconut Flour Blends

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Authors' contributions

This work was carried out in collaboration among all authors. Author MOA carried out all laboratories analysis and performed the statistical analysis. Author BAA wrote the first draft of the manuscript and edited the manuscript. Author ISO conceived and designed the study, Author JOO managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The use of wheat, sorghum and defatted coconut flour blends in the production of whole meal cookies was investigated with the aim of encouraging the use of sorghum and coconut flour in producing value-added products. Enriched cookies were produced from the blends of wheat flour (WF) and sorghum flour (SF) in varying proportions of 100:0, 90:5, 85:10, 80:15, 75:20, 70:25, 65:30, 60:35 with 5% of defatted coconut flour (CF) added to each sample and were labelled AMUS, BMUS, CMUS, DMUS, EMUS, FMUS, GMUS, HMUS respectively. Cookies with 100% wheat flour (AMUS) served as a reference sample. The proximate, physical, mineral and sensory properties of the cookies samples were examined using standard laboratory procedures. The proximate results of the cookies showed that protein, ash, fat, crude fibre, moisture and Carbohydrate ranged from (9.18–12.25%), (0.88–1.15%), (9.59–11.19%), (2.77–3.74%), (7.10–10.89%) and (64.20–66.71%) respectively. The physical characteristics of the cookies; weight

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(9.69–18.20 g), diameter (272.0–333.0 mm), thickness (7.72–11.40 mm), spread ratio (23.87–41.09) differed significantly ($p < 0.05$). However, the sensory results showed that the cookies varied in colour (6.85–7.80), taste (6.90–8.15), aroma (7.10–7.75), crispness (6.65–7.75) and overall acceptability (7.25–8.45). The reference sample had the highest sensory scores for all the attributes except for aroma and crispness, while cookies with 15% sorghum flour (SF) and 5% defatted coconut flour (CF) incorporation had highest score for crispness and 30% sorghum had highest score for aroma respectively. Based on the parameters evaluated 15% sorghum flour and 5% defatted coconut flour incorporation could be utilized for cookies production owing to its baking potential abilities. However, the high protein, ash and fibre contents of the cookies made with sorghum and defatted coconut flour substitution is very important as this could make a great contribution to the nutrient intake by consumers.

Keywords: Cookies; wheat; defatted coconut flour (CF); sorghum flour (SF); sensory properties; spread ratio; physical characteristics.

1. INTRODUCTION

Cookies are nutritive snacks known in the United Kingdom as a type of biscuits but more generally referred to as “cookies” in the United State of America where is regarded as confection-food with low moisture content [1], produced from single or composite unpalatable dough that is transformed into delicious and more appetizing products through the action of heat in an oven [2]. They are ready-to-eat, handy and cheap food product, containing digestive and dietary fibre of vital importance [3]. Dietary fibre has been shown to have important health benefits in the prevention for risk of chronic diseases such as cancer, diabetes mellitus and cardiovascular diseases [4].

Cookies constitute valuable amount of iron, calcium, protein, calorie, fibre and some of the B-vitamins to our diet and daily food requirement. They are classified based on the ingredient composition and processing techniques. However, the major ingredients are flour, fat, sugar, salt and water, these are mixed together with other minor ingredients (baking powder, skimmed milk, emulsifier and sodium meta-bisulphite) to form dough containing a gluten network [5]. Soft wheat flour is considered as a major ingredient used in the production of biscuit and other pastry products, but they can also be made with non-wheat flours such as maize, sorghum, plantain, acha grain, pearl millet, bambara-nuts etc.

Sorghum (*Sorghum bicolor*) is an important food crop grown on a subsistence level by farmers in the semi-arid tropics of Africa and Asia. It is the principal crop grown in northern Nigeria [6]. Sorghum like other cereals is predominantly starchy. The average starch content of the grain

ranged from 56 to 73%. It is relatively rich in iron and phosphorus but do not contain pro-vitamin A [7].

Coconut (*Cocos nucifera*) is popular in tropical regions, such as: South and Southeast Asia, Central America and Africa. Matured coconut endosperm is rich in lipid, protein and fiber [8]. Recently, the matured endosperm has been extracted for making coconut milk including concentrates and powder products and oil for food and cosmetic. However, there is a valuable amount of residual waste from processing of these aforementioned products. This residue contains significant amount of fiber, protein, carbohydrate and can be used for production of coconut flour [9]. Paucean et al. [10] reported the development of gluten-free cookies from the blends of rice and coconut flour, while others demonstrated that coconut flour can be substituted for wheat flour in bread [11] and noodles [12]. According to Sridevi and Sarojini [13], it was reported that coconut flour could substitute for 25% of wheat flour in cookies. These reports suggest that coconut flour could not only treat celiac disease, but also improve added value of coconut.

Nowadays, extensive studies on the preparation of cookies by fortification with some natively available and better nutritional value flours, for instance, whey protein, wheat germ, mushroom, cassava, and water chestnut flours have been conducted [14]. Producing less gluten cookies from wheat-sorghum-defatted coconut flour blend may enhance the nutritional and health status of consumers. Hence, the thrust of this study was to produce and assess the physical, chemical and sensory attributes of enriched cookies from the blends of wheat grain, sorghum and coconut.

2. MATERIALS AND METHODS

2.1 Materials

The materials used in the production of cookies which includes wheat flour, defatted coconut flour, sorghum flour, milk powder, milk flavour, egg, sugar, salt, margarine, baking powder, sodium bicarbonate were all gotten from Osiele market in Abeokuta, Ogun state. All reagents used for the analyses were of analytical grade.

2.1.1 Sample preparation

2.1.1.1 Production of sorghum flour

Sorghum flour was prepared by the method described by [15]. Sorghum grains were cleaned and sorted to remove stones and other contaminants, washed and dried. The dried grains were milled and sieved. The flour produced was packaged in a polyethylene bag for use in production of cookies.

2.1.1.2 Coconut flour preparation

Production of defatted coconut flour was done by the method described by [4]. Coconut was husked, shelled, pared, washed and then subjected to grating. Through the grating process, coconut milk was extracted and then spined. The coconut residue gotten was defatted. The residue was then subjected to drying in the hot air oven 60°C for 6 hours. The coconut flakes was milled and sieved. Finely textured coconut flour was obtained and packaged in airtight container until when needed for use.

2.1.1.3 Formulation of cookies

The cookies were produced based on the mixture outlined in Table 1 as formulated by [4]. While the control was made from 100% Wheat flour, the defatted coconut flour was made constant at 5% and the sorghum was added up to 35%. In total, 8 cookies formulation were made.

2.1.1.4 Cookies preparation

Sieved wheat-sorghum-defatted coconut flour, sugar, common salt, sodium- bicarbonate, milk powder, milk flavour, baking powder were mixed together in a bowl for three minutes (3 mins), fat was added and mixed until fluffy, water was added and mixed properly to make a dough. The dough was kneaded on a flat board sprinkled

with some flour to a uniform thickness using a wooden rolling pin. The dough were cut using a cookies cutter, placed on a greased baking tray and kept at ambient temperature for an hour to allow proper dough leavening. The samples were baked in an oven at 180°C for 15-20 mins, until a light brown colour was formed. Cookies was removed from the oven and cooled.

Table 1. Formulation of composite flour

Samples	Wheat flour (WF)	Sorghum flour (SF)	Defatted Coconut flour (CF)
AMUS	100	0	0
BMUS	90	5	5
CMUS	85	10	5
DMUS	80	15	5
EMUS	75	20	5
FMUS	70	25	5
GMUS	65	30	5
HMUS	60	35	5

2.2 Sample Analysis

2.2.1 Physical properties determination

2.2.1.1 Diameter

This was carried out according to the method described by [16]. Six cookies were placed edge to edge. The total diameter of the six cookies were measured in mm by using a ruler. The cookies were rotated at an angle of 90°C for duplicate reading. This was repeated once more and average diameter was reported in millimetres.

2.2.1.2 Thickness

This was carried out according to the method described by [17]. The total height was measured in millimetres with a ruler. The measurement was repeated thrice to get an average value and results was reported in millimetres.

2.2.1.3 Spread ratio

Spread ratio of the cookies samples was determined according to the method of [18]. Two rows of four well-formed cookies were made and the height measured. They were arranged horizontally edge to edge and the sum of their diameters measured. The spread ratio was calculated as diameter divided by height, using the formula below;

$$SF = D \times CF \times 10 / T$$

Where, CF is a correction factor at constant atmospheric pressure, D is the diameter and T is the thickness. It has a value of 1.0 in this case [17].

2.2.2 Proximate analysis determination

Proximate compositions (moisture, crude protein, crude fibre, ash, crude fat and carbohydrate) of the enriched cookies samples were analysed in duplicates using the methods adopted by [17] and discussed briefly:

2.2.2.1 Moisture content

Finely ground (2 g) of sample was weighed into a petri dish of known weight. It was dried in a hot air oven at 105°C for 4 hours; after the time has elapsed the sample was brought out and placed inside a desiccator for cooling. The moisture content was calculated as:

$$\text{Moisture \%} = [(W_1 - W_2) \times 100] \div W$$

W = Weight of sample

W₁ = weight of sample + weight of Petri dish.

W₂ = Weight of dried sample + weight of Petri dish.

2.2.2.2 Ash

5 g of sample was weighed and transferred in pre-weighed porcelain crucible. The weighed sample was burned till smoke ceases. The crucible was then transferred to muffle furnace maintained at 550°C and incinerated until light grey ash was obtained. The crucible was then cooled in desiccator and weighed. The results were reported on dry weight basis.

$$\text{Ash \%} = [(W_1 - W_2) \times 100] \div W$$

W = Weight of sample

W₁ = weight of sample + weight of crucible.

W₂ = Weight of ash + weight of petri dish (after ashing)

2.2.2.3 Crude fat

The dried samples were ground in a blender and 5 g of sample was weighed accurately and transferred to the thimble and defatted with petroleum ether in soxhlet apparatus for 6-8 hours at 80°C. The residue was procured and ether was removed by evaporation. The loss in

weight of thimble was estimated as loss of lipids from sample and expressed as percent lipids in sample.

$$\text{Fat \%} = [\text{loss in weight of sample} \times 100] \div \text{weight of sample}$$

2.2.2.4 Protein

2 g of sample was weighed and put into the digestion tube. Twenty millilitres of concentrated sulphuric acid (98%) and 2 tablets of digestion mixture as catalyst was added into the digestion tube. The digestion was carried out for 3-4 h (till the digested contents attained transparent colour). The digested material was then allowed to cool at room temperature and diluted to a final volume of 50 ml. The ammonia trapped in H₂SO₄ was liberated by adding 40% NaOH solution through distillation and collected in a flask containing 4% boric acid solution, possessing methyl indicator and titrated against standard 0.1 N H₂SO₄ solution.

Calculation:

$$\% \text{ Total Nitrogen} = \frac{14.01 \times (\text{sample titre} - \text{blank titre}) \times N}{10 \times \text{sample weight}}$$

N = Normality of acid

i.e protein (crude) = % Nitrogen X Conversion factor

Conversion factor = 6.25

2.2.2.5 Crude fibre

It was carried out by taking 3 g of each fat free flour sample and digested first with 1.25% H₂SO₄, washed with distilled water and filtered, then again digested with 1.25% NaOH solution, washed with distilled water and filtered. Then ignited the sample residue by placing the digested samples in a muffle furnace maintained for 3-5 hours at temperature of 550-650°C till grey or white ash was obtained. The percentage of crude fibre was calculated after igniting the samples according to the expression given below.

$$\text{Crude fibre} = \text{weight loss on ignition} / \text{weight of flour sample} \times 100$$

2.2.2.6 Carbohydrate

Carbohydrate content was calculated by difference method of [18] on dry using the following formula:

Total carbohydrate = 100 – (fat + fibre + ash + protein).

2.2.3 Mineral content determination

The procedure described by AOAC official Methods of Analysis AOAC [18] was adapted to determine the following minerals: Iron (Fe), calcium (Ca) and potassium (K).

2.2.3.1 Iron (Fe) and calcium (Ca)

They were determined by Flame Atomic Absorption spectrophotometer, as described by [17]. 0.5ml of each sample was digested in 20 ml each of acid solution of HNO₃, H₂SO₄. The corresponding solutions were heated until white fumes appeared. The clear solution was diluted up to 50 ml with distilled water and filtered with Whatman filter paper one. The standard working solution of each element was prepared to make the standard calibration curve and the readings were taken and recorded.

2.2.3.2 Potassium

Potassium in the samples were determined by the vanadomolybdate (yellow) spectrometry described by [19].

2.2.4 Colour analysis

The colour analysis was determined according to the method described by [20]. It was analysed by a colorimeter CR-400 Chroma Meter (Konica-Minolta, Japan) using a D₆₅ illuminant, and the results were expressed as coordinates of the CIE Lab system. Calibration of the apparatus was carried out before use, through a reading on a white tile pattern. Determinations were made on both surfaces of cookies (up and down sides) and recorded.

2.2.5 Sensory evaluation

This was carried out using 9-point Hedonic scale as described by [21]. The samples were evaluated by twenty (20) semi-trained panellists selected from the Department of Food Science and Technology, Federal University of Agriculture Abeokuta. A 9-point Hedonic scale was used for aroma, taste, crispness, colour, hardness and overall acceptability with 1 representing the least score (dislike extremely) and 9 the highest score (like extremely).

2.3 Statistical Analyses

All analyses were conducted in duplicates. Data obtained were subjected to one-way analysis of

variance (ANOVA) using the Statistical Package for Social Sciences (SPSS) version 20.0 and Duncan New Multiple Range Test was used to separate the means with significance level at $p < 0.05$.

3. RESULTS AND DISCUSSION

3.1 Physical Properties of Cookies Produced from Wheat, Sorghum and Defatted Coconut Flour Blends

There were significant differences in the weight among the cookie samples ($P < 0.05$) and the reference sample (AMUS). The weight of the cookies varied from 9.69g to 18.20g, the highest weight was observed in the sample with 85% wheat and 10:5% composite blends of sorghum and coconut (CMUS). Addition of SF and CF caused a significant ($p < 0.05$) increase in the weight of cookies. The findings were in contrary to the observation of some researchers who reported significant reduction in the weight of cookies produced from soya bean supplemented with wheat flour [22]. The differences among the weight of the cookies obtained in this study may be due to the different processing techniques the sorghum and defatted coconut flour was subjected to and the levels of substitution of sorghum and defatted coconut with wheat flour [23]. The diameter ranged from 332 to 272 mm. Sample AMUS (100% wheat) had the lowest value while sample HMUS (60% wheat, 35% sorghum flour and 5% coconut flour) had the highest value. The diameter of the cookies samples were also observed to increase gradually with increase in the level of substitution. Therefore, cookies prepared from composite flour of wheat, sorghum and coconut flour could compare favorably in diameter with the control (100% wheat flour). This observation is similar to the report of [24] for biscuits made from a blend of bambara groundnut, ground bean seed and moringa seed flour. The diameter of the cookies prepared from the composite flour containing wheat, sorghum and coconut flour varied significantly ($P < 0.05$) among the samples. The thickness of the enriched cookies had no significant differences ($p < 0.05$) between the reference samples and others. The thickness ranged from 11.40mm to 7.72mm; reference sample (AMUS) had the highest thickness value (11.40mm) while sample with (EMUS) 20% sorghum and 5% coconut flour substitution had the least (7.72).

Spread ratio is used to determine the quality of flour used in producing cookies and the ability of

the cookies to rise. The higher the spread ratio of cookie the more desirable [22]. The spread ratio of the cookies ranged between 23.87 and 41.09, cookie sample (FMUS) had the highest spread ratio value (41.09), while the reference sample (T0) had the least (23.87). The addition of sorghum flour (SF) and coconut flour (CF) caused a significant ($p < 0.05$) increase in the spread ratio of the cookies with increasing level of substitution of wheat flour to 70% with SF and CF. A similar finding was observed by [25], who reported that the spread ratio of cookie samples increased with increasing substitution level with quality protein maize.

3.2 Proximate Composition of Cookies Produced from Wheat, Sorghum and Defatted Coconut Flour Blends

The moisture content of the wheat-sorghum-coconut cookies varied from 7.10% in EMUS - 10.89% in FMUS. These findings were lower than the results reported for sorghum-wheat composite flour biscuits [26] and also agreed with the reports of [27], who reported that low moisture content of flour prevents food spoilage and growth of pathogenic organisms. The low moisture content of the biscuit will require a unique packaging material to prevent reabsorption of moisture. According to Giwa and Abiodun [26], baked foods: cake, cookies and bread with high moisture content encourages bacterial, yeast and mould growth that could lead to spoilage. However, cookies should therefore have low moisture for safe storage and inhibition of microbial growth that could affect their quality.

The fat content ranged from 9.59% - 11.19%; sample with 20% level of substitution of sorghum

and 5% coconut flour in the blends had the highest value (11.19%) while sample GMUS had the least value (9.59%). Addition of sorghum and coconut flour caused significant ($p < 0.05$) increase in the crude fat content of the cookies. Fat could play a role in determining the shelf-life of foods. The low quantity of fat present in the cookies samples could enable to prolong the shelf life of the product as the rate of rancidity which could lead to the production of off flavours and odours will be reduced drastically.

The ash content of the cookies samples increased from 0.93-1.15% with increase in the sample ratio. Ash content in food substances indicates the presence of mineral matter in the food. Ash is a non-organic compound containing the mineral content of food which aids metabolism of other compound such as protein fat and carbohydrate [28].

The crude fibre ranged from 2.77-3.74% in cookies samples. The fiber contents of all the cookies were within the Recommended Daily Allowance which should not exceed 5 g dietary fiber per 100 g dry matter [29].

The protein content of the cookies ranged from 9.18 to 11.78%; cookies sample (BMUS) had the highest protein content (11.78%) while sample (GMUS) had the lowest (9.18%). The findings conform with the report of [30] for the increasing trend of protein content (8.54–17.72%) in cookies produced from wheat-defatted cashew nut flour blends, but lower than the protein content (10.62–28.12%) of cookies made from wheat-brewers spent grain [31]. Giwa and Abiodun [26] also reported an increased trend in the protein content (7.06–11.84%) of cookies made from sorghum-wheat flour blend.

Table 2. Physical properties of cookies produced from wheat, sorghum and defatted coconut flour blends

Samples	Weight (g)	Diameter (mm)	Thickness (mm)	Spread ratio
AMUS	10.74±2.85 ^a	272.0±2.83 ^a	11.40±0.41 ^a	23.87±0.61 ^a
BMUS	10.60±1.77 ^a	292.0±5.66 ^b	10.43±1.14 ^a	28.20±3.64 ^{ab}
CMUS	18.20±1.41 ^c	321.0±1.41 ^d	10.90±0.48 ^a	29.48±1.43 ^{ab}
DMUS	12.53±4.07 ^{ab}	325.0±1.41 ^{de}	9.54±0.64 ^a	34.15±2.43 ^{ab}
EMUS	9.69±1.33 ^a	293.0±1.41 ^b	7.72±1.03 ^a	38.28±4.94 ^{ab}
FMUS	15.90±0.95 ^{bc}	333.0±4.24 ^e	8.52±2.60 ^a	41.09±13.0 ^b
GMUS	11.68±0.86 ^{ab}	311.0±4.24 ^c	9.86±0.40 ^a	31.56±0.84 ^{ab}
HMUS	10.87±0.18 ^a	332.0±2.82 ^e	9.11±2.64 ^a	37.99±10.7 ^{ab}

Mean values with different superscripts within the same column are significantly different ($P < .05$): AMUS- 100% Wheat flour, BMUS- 90/5/5 Wheat flour/Sorghum flour/Defatted coconut flour, CMUS- 85/10/5 Wheat flour/Sorghum flour/Defatted coconut flour, DMUS- 80/15/5 Wheat flour/Sorghum flour/Defatted coconut flour, EMUS- 75/20/5 Wheat flour/Sorghum flour/Defatted coconut flour, FMUS- 70/25/5 Wheat flour/Sorghum flour/Defatted coconut flour, GMUS- 65/30/5 Wheat flour/Sorghum flour/Defatted coconut flour, HMUS- 60/35/5 Wheat flour/Sorghum flour/Defatted coconut flour

Table 3. Proximate composition of cookies produced from wheat, sorghum and defatted coconut flour blends

Samples	Moisture	Crude Fat	Total Ash	Crude Fibre	Crude Protein	Carbohydrate
AMUS	9.41±0.04 ^d	11.04±0.09 ^{ed}	0.93±0.02 ^{ab}	3.27±0.08 ^c	10.22±0.15 ^b	65.14±0.38 ^b
BMUS	9.29±0.01 ^{cd}	10.67±0.30 ^c	1.15±0.01 ^d	2.92±0.08 ^{ab}	11.78±0.16 ^e	64.20±0.21 ^a
CMUS	9.67±0.04 ^e	10.13±0.09 ^b	0.97±0.02 ^b	2.99±0.04 ^{ab}	10.33±0.13 ^{bc}	65.93±0.20 ^c
DMUS	9.88±0.08 ^f	9.83±0.13 ^{ab}	1.08±0.03 ^c	3.02±0.13 ^b	11.14±0.25 ^d	65.07±0.40 ^b
EMUS	7.10±0.14 ^a	11.19±0.04 ^e	1.11±0.01 ^{cd}	3.74±0.14 ^d	12.25±0.12 ^f	64.62±0.17 ^{ab}
FMUS	9.11±0.71 ^b	10.78±0.05 ^{cd}	1.08±0.06 ^c	3.29±0.04 ^c	10.64±0.11 ^c	65.11±0.08 ^b
GMUS	10.89±0.04 ^g	9.59±0.38 ^a	0.88±0.02 ^a	2.77±0.06 ^a	9.18±0.09 ^a	66.71±0.59 ^d
HMUS	9.16±0.07 ^{bc}	11.00±0.06 ^{cd}	0.97±0.01 ^b	3.40±0.11 ^c	11.27±0.16 ^d	64.20±0.27 ^a

Mean values with different superscripts within the same column are significantly different ($P < 0.05$);

AMUS- 100% Wheat flour, BMUS- 90/5/5 Wheat flour/Sorghum flour/Defatted coconut flour, CMUS- 85/10/5 Wheat flour/Sorghum flour/Defatted coconut flour, DMUS- 80/15/5 Wheat flour/Sorghum flour/Defatted coconut flour, EMUS- 75/20/5 Wheat flour/Sorghum flour/Defatted coconut flour, FMUS- 70/25/5 Wheat flour/Sorghum flour/Defatted coconut flour, GMUS- 65/30/5 Wheat flour/Sorghum flour/Defatted coconut flour, HMUS- 60/35/5 Wheat flour/Sorghum flour/Defatted coconut flour

The carbohydrate content of cookies ranged from 63.36 to 69.20%. Significant differences ($p < 0.05$) exist in the carbohydrate content of the cookies produced from wheat, sorghum and coconut flour blends. The carbohydrate content of the sample is favourably compared with the [32]. This also implies that the cookies could serve as a source of energy needed for body metabolism.

3.3 Mineral Composition of Cookies Produced from Wheat, Sorghum and Defatted Coconut flour Blends

The addition of sorghum and defatted coconut blends to wheat flour is a good source of minerals as presented in Table 4. The calcium, potassium and iron are the predominant mineral

elements present in the wheat-based composite cookies.

Calcium content ranged from 101.70 mg/100g in FMUS to 259.10 mg/100g in GMUS. Meanwhile, there are Significant differences ($p < 0.05$) were observed in the calcium composition of the cookies. The result obtained for calcium is high and this could be due to low level of oxalic acid and phytic acids being the major chelators of calcium, hence releasing calcium for biological activities [33].

Potassium was the most abundant mineral in the cookies followed by calcium and then iron. The potassium content of the samples ranged from 188.30 mg/100g in the reference sample to 363.50 mg/100 g in HMUS. The potassium

Table 4. Mineral composition of cookies produced from wheat, sorghum and defatted coconut flour blends

Samples	Calcium (mg/100g)	Potassium (mg/100g)	Iron (mg/100g)
AMUS	103.2±2.63 ^a	188.3±2.67 ^a	6.12±0.01 ^e
BMUS	212.6±5.26 ^e	310.4±3.22 ^e	4.81±0.01 ^c
CMUS	174.3±9.75 ^c	245.2±4.40 ^d	6.42±0.05 ^f
DMUS	118.3±2.93 ^b	207.1±4.12 ^b	3.90±0.01 ^b
EMUS	232.3±3.09 ^f	345.3±5.67 ^g	4.93±0.01 ^d
FMUS	101.7±0.97 ^a	195.6±7.56 ^a	3.73±0.02 ^a
GMUS	259.1±1.41 ^g	333.5±4.60 ^h	6.50±0.05 ^e
HMUS	246.5±1.32 ^h	305±2.50 ^f	5.65±0.01 ^b

Mean values with different superscripts within the same column are significantly different ($p < 0.05$)

AMUS- 100% Wheat flour, BMUS- 90/5/5 Wheat flour/Sorghum flour/Defatted coconut flour, CMUS- 85/10/5 Wheat flour/Sorghum flour/Defatted coconut flour, DMUS- 80/15/5 Wheat flour/Sorghum flour/Defatted coconut flour, EMUS- 75/20/5 Wheat flour/Sorghum flour/Defatted coconut flour, FMUS- 70/25/5 Wheat flour/Sorghum flour/Defatted coconut flour, GMUS- 65/30/5 Wheat flour/Sorghum flour/Defatted coconut flour, HMUS- 60/35/5 Wheat flour/Sorghum flour/Defatted coconut flour

content of the cookies increased with increase in level of sorghum-coconut flour addition, which means that the sorghum-coconut blends have higher content of potassium than wheat. This finding conforms to the report that the most abundant mineral element in biscuit is potassium[34].

The iron (Fe) content of this study ranged from 3.73mg/100g in FMUS – 6.58 mg/100 g in HMUS and it is lower than the recommended daily allowance (RDA) - 10 mg of iron per day [35]. Iron is a major component of haemoglobin that carries oxygen to all parts of the body. Iron also has a critical role within cells assisting in oxygen utilization, enzymatic systems, especially for neural development, and overall cell function [24].

3.4 Colour Attribute of Cookies Produced from Wheat, Sorghum and Defatted Coconut Flour Blends

The colour attribute of the enriched cookie is presented in Table 6. There is significant differences ($p < 0.05$) in lightness (L^*), redness (a^*) and yellowness (b^*) of cookies produced from wheat, sorghum and defatted coconut flour blend. The cookies sample DMUS had the highest value for lightness 68.66 while DMUS had the least L^* value 62.47. A notable trend was observed, as the blending ratio increased the lightness value decreased. Sample HMUS recorded higher a^* (4.80) while sample DMUS (1.89) recorded the least degree of redness. The b^* value of the biscuit ranged from 32.75 in BMUS to 28.71 in DMUS. Baking process have

influenced the colour of the samples. Results obtained from this study is in agreement with [36] who said that the effect of heat on the carbohydrate during extrusion as a result of high temperature in the extruder may have cause reaction between the amino acids and reducing sugars in the complementary foods which may have accounted for the variation in the colour of the formulated diets. Colour is an important quality parameter that influence market performance. Consumer perceptions about some products are based on colour and many foods are associated with a specific colour. Colour is by far one of the main quality criteria for consumers' acceptance of food flour[37].

3.5 The Sensory Score of Cookies Produced from Wheat, Sorghum and Defatted Coconut Flour Blends

The results of the sensory assessment of cookies produced from wheat-sorghum-defatted coconut flour blends are presented in Table 5. The mean scores of colour, taste, flavour, aroma, crispness and overall acceptability for the cookies were significantly different ($p < 0.05$) from one another. The reference sample had the highest scores for all the attributes observed, except for aroma and crispiness.

The mean score for the cookies colour ranged between 6.85 and 7.80. The reference cookies sample (AMUS) had the highest value (7.80) while sample (CMUS) had the lowest value (6.85). Generally, the scores for cookies colour increased as the substitution level sorghum and defatted coconut flour increased. This could

Table 5. Colour attribute of cookies produced from wheat, sorghum and defatted coconut flour blends

Samples	L^*	a^*	b^*
AMUS	62.47±1.00 ^a	3.92±0.11 ^d	31.22±0.91 ^{bc}
BMUS	65.90±1.60 ^c	3.71±0.16 ^c	32.75±1.48 ^d
CMUS	67.94±0.05 ^d	2.32±0.02 ^b	30.15±0.02 ^{ab}
DMUS	68.66±0.90 ^d	1.89±0.07 ^a	28.71±0.37 ^a
EMUS	63.65±0.03 ^{ab}	3.70±0.10 ^c	30.43±0.03 ^b
FMUS	65.04±0.04 ^{bc}	4.56±0.04 ^e	32.40±0.01 ^{cd}
GMUS	63.56±0.35 ^{ab}	4.68±0.04 ^{ef}	30.77±0.14 ^b
HMUS	63.17±0.42 ^{ab}	4.80±0.01 ^f	30.62±0.18 ^b

Mean values with different superscripts within the same column are significantly different ($P < 0.05$); AMUS- 100% Wheat flour, BMUS- 90/5/5 Wheat flour/Sorghum flour/Defatted coconut flour, CMUS- 85/10/5 Wheat flour/Sorghum flour/Defatted coconut flour, DMUS- 80/15/5 Wheat flour/Sorghum flour/Defatted coconut flour, EMUS- 75/20/5 Wheat flour/Sorghum flour/Defatted coconut flour, FMUS- 70/25/5 Wheat flour/Sorghum flour/Defatted coconut flour, GMUS- 65/30/5 Wheat flour/Sorghum flour/Defatted coconut flour, HMUS- 60/35/5 Wheat flour/Sorghum flour/Defatted coconut flour.

L^* : Lightness, a^* : Redness, b^* : Yellowness

Table 6. The sensory score of cookies produced from wheat, sorghum and defatted coconut flour blends

Samples	Colour	Taste	Crispness	Crunchiness	Aroma	Overall Acceptability
AMUS	7.80±0.89 ^b	8.15±0.99 ^b	7.55±1.19 ^{bc}	8.10±0.91 ^b	7.70±0.98 ^a	8.45±0.69 ^c
BMUS	7.45±0.10 ^{ab}	7.60±1.10 ^{ab}	7.20±1.15 ^{abc}	7.75±1.07 ^b	7.70±1.38 ^a	8.05±0.83 ^{bc}
CMUS	6.85±1.53 ^a	6.90±1.37 ^a	6.65±1.63 ^a	6.70±1.56 ^a	7.10±1.17 ^a	7.25±1.21 ^a
DMUS	7.50±1.10 ^{ab}	7.90±1.12 ^b	7.75±1.07 ^c	7.65±1.14 ^b	7.55±1.19 ^a	8.10±0.79 ^{bc}
EMUS	7.35±1.14 ^{ab}	7.35±1.46 ^{ab}	6.90±1.07 ^{ab}	6.80±1.00 ^a	7.20±1.15 ^a	7.70±0.92 ^{ab}
FMUS	7.65±1.04 ^{ab}	7.45±1.28 ^{ab}	7.55±1.19 ^{bc}	8.05±0.10 ^b	7.70±0.80 ^a	8.05±0.76 ^{bc}
GMUS	7.60±0.99 ^{ab}	7.45±1.10 ^{ab}	7.70±0.80 ^{bc}	7.80±0.89 ^b	7.75±1.10 ^a	8.00±1.03 ^{bc}
HMUS	7.50±1.19 ^{ab}	7.85±0.93 ^b	7.70±0.98 ^{bc}	8.10±0.85 ^b	7.60±0.82 ^a	8.10±0.97 ^{bc}

Mean values with different superscripts within the same column are significantly different ($P < 0.05$);

AMUS- 100% Wheat flour, BMUS- 90/5/5 Wheat flour/Sorghum flour/Defatted coconut flour, CMUS- 85/10/5 Wheat flour/Sorghum flour/Defatted coconut flour, DMUS- 80/15/5 Wheat flour/Sorghum flour/Defatted coconut flour, EMUS- 75/20/5 Wheat flour/Sorghum flour/Defatted coconut flour, FMUS- 70/25/5 Wheat flour/Sorghum flour/Defatted coconut flour, GMUS- 65/30/5 Wheat flour/Sorghum flour/Defatted coconut flour, HMUS- 60/35/5 Wheat flour/Sorghum flour/Defatted coconut flour

beattributed to the dark brown coloration of the cookies samples with incorporation of sorghum and defatted coconut flour as compared with that of the reference sample as well as the coarser texture of the former compared with the latter. The intense brown colour of the composite cookies could be due the presence of high amount of carbohydrate in the flour blends, thus resulting in caramelized product [38].

Based on taste, the scores for the cookies ranged from 6.90 to 8.15; cookies sample (CMUS) had the lowest value while the reference sample (AMUS). The astringent taste observed among the cookies samples could be attributed to the development of bitter substances, owing to the presence of tannin in sorghum.

The mean scores for the cookies aroma ranged between 7.10 and 7.75. Cookies sample (CMUS) had the lowest value while sample (HMUS) had the highest value. Generally, the scores for cookies aroma increased as the substitution level increased and no significant difference ($p > 0.05$) exist among the cookies samples.

The scores for the crispness of cookies ranged from 6.65 to 7.70; cookie sample (CMUS) had the lowest value while sample (HMUS) and also (GMUS) had the highest value. This could be as the result high level of substitution of sorghum and coconut flour in the samples.

The mean scores (7.25–8.45) for the overall acceptability of the cookies were above the average (4.5), indicating high acceptability of the cookies samples. The reference sample (AMUS) had the highest value (8.45), while cookies

sample (CMUS) had the least value (7.25). It is therefore clear according to the result that substitution of 30% sorghum and 5% defatted coconut flour blends substitution level could produce good cookies that are sensorial comparable with reference sample and acceptable.

4. CONCLUSION

The inclusion of the blends of sorghum and defatted coconut flour to wheat flour in the production of cookies enhanced the fibre, protein and mineral contents of the cookies. The results also showed that substitution with sorghum and defatted coconut flour did not alter the physical characteristics and consumer acceptability of the cookies samples. The use of sorghum and defatted coconut flour in cookies production has the advantage of improving the protein, crude fibre, calcium and mineral content of the cookies and this could be nutritionally advantageous in Nigeria where 100% wheat cookies is one of the commonest snacks amongst all classes of people. This should be encouraged for the production of cookies and this will tend to reduce the cost spent on wheat and enhance the utilization of sorghum and defatted coconut flour.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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