

## **Studies on the quality characteristics of flour blends from sesame seeds, African yam bean and moringa leaf powder for “biscuit- like” manufacture**

### **Abstract**

This study was aimed at investigating the quality characteristics of flour blends produced from sesame seeds, African yam bean (AYB) and Moringa leaf powder (MLP) for “biscuit-like” production. Dehulled sesame seeds were roasted for 7-13 min at 185 – 200 °C, defatted and milled into flour and tagged as DSDS<sub>F</sub>. African yam bean was toasted at 125 °C for 40 min, dehulled, milled into flour, and tagged as TDAYB<sub>F</sub> while Moringa leaf was sundried, milled into flour and tagged as MLP. All these flour samples were then blended into 18 ratios and tagged as LMDTM<sub>1-18</sub>. The ratios of DSDS<sub>F</sub>:TDAYB<sub>F</sub>:MLP were 100: 0:0(LMDTM1), 0: 100: 0(LMDTM2), 95: 0: 5(LMDTM3), 95:5:0(LMDTM4), 90: 5:5(LMDTM5), 90:10:0(LMDTM6), 80:15:5 (LMDTM7), 80: 20:0(LMDTM8), 70:25: 5(LMDTM9), 70:30: 0(LMDTM10), 60: 35: 0(LMDTM11), 60: 40: 0(LMDTM12), 50: 45: 5(LMDTM13), 50: 50: 0(LMDTM14), 40: 55: 5(LMDTM15), 40: 60: 0(LMDTM16), 30: 65: 5(LMDTM17), and 30: 70: 0(LMDTM18). The flour blends were studied for physicochemical, functional and anti-nutrients properties. After blending, the formulated samples had proximate composition of 3.37 -9.21 % moisture, 18-27.5 % protein, 0.18-3.95 fat, 1.31 – 3.9 % ash, 3.2-8.88 % crude fiber and 52.75-65.45 % carbohydrate. Each proximate component varied significantly ( $p < 0.05$ ) between samples. While LMDTM13 had significantly ( $p < 0.05$ ) the highest moisture content, protein, and fat LMDTM6 had the highest ash content, LMDTM2 had the highest crude fiber and LMDTM1 had the highest carbohydrate. The control sample LMDTM1 had the highest bulk density (0.711), water absorption capacity (165.52 %), oil absorption capacity (94.5 %), protein solubility (13.4 %), foaming capacity (8.0 %), but lowest swelling power (3.5 %), emulsion capacity (46.2 %), phytate (16.29 mg/100g), tannin (4.64mg/100g)

and Trypsin inhibitor (1.20 mg/100g) compared to other samples. Blended flour mainly from plant sources of high-quality value can be blended when processed, giving the opportunity to increase its nutrition, consumption, and acceptability for biscuit-like production. In this study, sesame seeds were incorporated into African yam bean and moringa leaf powder to increase the quality and flavor replacing wheat flour in biscuit production.

**Keywords:** “biscuit-like”, blends, legumes, qualities, Studies,

## 1.0 INTRODUCTION

“Biscuits are mainly made from flour, sugar, and fat. Biscuits are manufactured in many shapes and sizes, and they can be covered with chocolates containing fat-based fillers or other pleasantly fragrant fillers. There is a very extensive assortment of biscuits due to many raw and auxiliary materials which are used, with different proportions of raw materials and technological processes applied” (HOODA and JOOD, 2005). “Based on the nutritional composition, biscuits may be produced from the hard dough, soft dough, or from batter. Biscuits are popular snack food consumed extensively all over the world. They are ideal for nutrient availability, palatability, compactness, and convenience and differ from other baked products like bread and cakes because of their low moisture content which makes them comparatively safer from microbial spoilage with a longer shelf-life” (Awolu *et al.*, 2015).

Nigeria being one of the tropical countries cannot grow wheat in commercial quantities due to the country’s climatic conditions. Only three percent of the country's total consumption of grain can be produced locally, therefore, the country can only survive by utilization of the availability of local wheat which can either partially or completely substitute wheat in the product without adversely affecting the quality of such products of totally producing biscuit like looking products from wheat. “Sesame (*Sesamu indicum L.*) commonly known as

'beniseed' in Nigeria is one of the most cultivated oil seeds of the world since its introduction compared to ground nut and other cash crops. Sesame is widely grown in some Northern and central parts of Nigeria. Based on FAO statistics for 2019, Nigeria is the fifth major exporter of sesame and produces about 83 metric tons of sesame annually" (Chemonics International, 2002). "Sesame seed (*Sesamum indicum* L.) is an oilseed with a chemical composition of about 50-52 % oil, 17-19 % protein and 16-18 % carbohydrate" (Tunde-Akintunde and Akintunde, 2004). "Its seed contains about 42-54 % quality oil, 22-25 % protein, 20-25 % carbohydrates and 4-6 % ash" (Tunde-Akintunde and Akintunde, 2004).

African yam bean (AYB) is botanically known as *Sphenostylis stenocarpa* and commonly referred to as "ijiriji" in Nsukka while in Abia state, it is called "Odudu" . The African yam bean (AYB) is a legume indigenous to Africa. It is one of the lesser-known legumes (Apata and Ologhobo, 1997) and is widely cultivated in the southern parts of Nigeria. "The color of the seed coat varies from white to various shades of cream, brown, and grey and some are mottled. It originated in Ethiopia, but both wild and cultivated varieties, now occur in tropical Africa as far north as Egypt and also throughout West Africa from Guinea to Southern Africa" (Busson, 2001. In Nigeria and indeed in many African countries, *Moringa oleifera* has been used in the formulation of ready-to-eat snack products.

In order to produce "biscuit-like" products, the goal of this study was to assess the quality attributes of flour blends made from sesame seeds, African yam bean, and moringa leaf powder.

## **2.0 MATERIALS AND METHODS**

## **Sample Collections and preparation**

Sample of sesame seeds, African yam bean, and moringa leaves were identified by market women and purchased from Kure market, Minna, Niger state. The samples were packaged in a polythene bag and taken to the analytical lab of National Cereal Research Institute Badeggi for identification, and authentication. Analysis was done at the Federal University of Technology, Minna. The chemicals were of analytical grade and purchased from sigma of BDH Company, UK. Borehole water was used to cover the sesame seeds in a container. The floatation method was used to separate the floating dirt, premature seeds, and other impurities. Sand and other extraneous matter were removed by sedimentation. The sesame seeds were soaked in Salt Solution (3 % NaCl) for 18 h and dehulled. The dehulled and dried sesame seeds were mixed electronically for 5 mins by sprinkling distilled water in a plastic container, uncovered, and fermented for 48 h at room temperature (25 °C) (Brummer and Lorenz, 2003). The dehulled, dried, and now fermented sesame seeds were then dried again in a hot-air oven (Binder 10-01536, Germany) at 50 °C for 3 h. The dehulled, fermented, and dried sesame seeds were roasted for 5-10 min at 180-210 °C with a roaster. The roasted sesame seeds were ground using a FOSS Tecador grinder (Cyclotec™ 1093, Hogana, Sweden). The roasted and ground sesame seeds were defatted. This was achieved by passing the seeds through solvent extraction (hexane). (NAERLS, 2011). Sesame seeds batter at the maximum conditions was dried at 50 °C for 3 h and then milled with Cyclotec- 1093 grinder and passed through 350 um sieve, to obtain fermented sesame seed flour. This was packaged under a vacuum and stored at 40 °C before analysis. The dehulled solid-state fermented and defatted sesame seed flour was identified as DSDS<sub>f</sub>. The fermentation process was performed in triplicate. Thirty kilograms of the African Yam Bean (AYB) seeds were sorted washed and oven dried for 2 days and thereafter, toasted on a traditional clay pot which was placed on a tripod stand fueled with firewood. The toasting was done in batches using 2 kg of African

Yam Bean (AYB) per batch, at 125 °C for 40 min. The clay pot was first heated for 5 min before introducing the African Yam Bean (AYB) seeds into the pot. These were allowed for 4 mins to make a pop sound before turning it with a wooden spoon in a clockwise direction for 40 mins to facilitate efficient dehulling. The toasted dehulled African Yam Bean (AYB) seeds were milled with an attrition mill (locally fabricated in Nigeria) and sieved into fine flour with a 1 mm mesh sieve. The dehulled and toasted African Yam Bean flour was identified as TDAYB<sub>f</sub>.

### **Analysis of samples**

#### **Proximate Analysis of blended flour samples**

#### **Moisture content analysis of samples**

The moisture content of each sample was determined by the hot air oven method described by the Association of Official Analytical Chemists (AOAC, 2012). Stainless steel oven dishes were cleaned and dried in the oven (Fulton, Model N YC-101) at 100 °C for 1 h to achieve a constant weight of the oven dishes. The oven dishes were cooled in desiccators and then weighed ( $W_1$ ). Two grams of the sample were placed in the oven dish ( $W_2$ ) and dried at 100 °C. The samples were removed from the oven and placed in desiccators to cool to room temperature (32 °C) before weighing. The oven dishes were put back into the oven to dry and weighed intermittently until a constant weighed was achieved ( $W_3$ ). The loss in weight from the original sample was calculated as the moisture content with the expression:

$$\% \text{ Moisture content} = \frac{W_2 - W_3}{W_2 - W_1} \times \frac{100}{1}$$

Where  $W_1$  = weight of empty moisture dish

$W_2$  = weight of empty moisture dish + flour sample

$W_3$  = weight of moisture dish + dried samples

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$W_1$  = Weight of the empty moisture dish

$W_2$  = Weight of the empty moisture dish + flour sample

$W_3$  = Weight of moisture dish + dried sample

### **Crude protein determination of samples**

The micro Kjeldahl method was used to determine the crude protein content of the flour samples (AOAC, 2012.). Each sample (0.15 g) was weighed into a boiling tube mixed with a catalyst (0.8 g) and 2.5 mL conc.  $H_2SO_4$  was added to the sample. The boiling tube was gently swirled to mix and then heated until the solution became clear and gave a blue-green color. The digest was washed into the distillation tube with 10 mL of 45 % NaOH solution and the distillates were collected in a conical flask containing 10 mL of 2 % boric acid with a few drops of bromocresol indicator. The distillate was titrated with 0.05N  $H_2SO_4$  until the color changed from lilac color to blue- green. The Nitrogen content was calculated with the expression

$$\% \text{ Nitrogen} = \frac{I_s - I_B \times N \times 1.4}{W}$$

Where,

$I_s$  = volume of 0.05N  $H_2SO_4$  titrated with distillate collected in 10 mL of 2 % boric acid with few drops of bromocresol indicator.

$I_B$  = volume of 0.05N  $H_2SO_4$  titrated with blank

W = weight of DSDS<sub>f</sub> or TDAYB<sub>f</sub> sample

N = normality of 0.05N H<sub>2</sub>SO<sub>4</sub>

Hence,

% Protein = % Nitrogen × conversion factor (5.95)

#### **Determination of Crude fat (Soxhlet extraction method)**

Triplicate samples (2 g) were pre-dried and placed into an extraction thimble, with porosity permitting a rapid flow of petroleum ether, and covered with cotton wool.

A pre-dried boiled flask was weighed and 25 mL of petroleum ether was added and the assembled unit was used to extract the fat by heating solvent in the boiling flask. After 4 h, the flask containing the extracted fat was dried in a hot air oven at 100 °C for 1 h, cooled in a desecrator, and weighed. The fat content (%) was calculated with the expression

$$\% \text{ fat} = \frac{\text{weight of fat in sample}}{\text{Original sample weight}} \times 100$$

#### **Ash content determination of samples**

Crucible was heated in a muffle furnace at 550 °C for 1 h, after which the crucible was cooled in desiccators and weighed. Then 5 g flour samples were weighed into the crucible and ashed in the muffle furnace at 550 °C for 6 h until no black carbon was present. The crucible was cooled and weighed after ashing. The ash content was calculated with the expression,

$$\% \text{ Ash} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

#### **Crude fiber determination of samples**

The method of AOAC (2012) was followed. Crucible and ashless filter paper were dried in the oven for 1 h at 105 °C and cooled in the desecrator. The weight of the filter paper was

taken (K). The sample (2 g) was weighed into a 500 ml conical flask, to which 200 mL boiled 0.25 NH<sub>2</sub>SO<sub>4</sub> was added, the flask was connected to a reflux condenser and boiled for 30 min. After boiling, the mixture was filtered through filter paper (Whatman No. 541); the residue was rinsed with clean distilled water. The residue was placed back into the conical flask mixed up with 200 mL and boiled with 0.313N NaOH reconnected to the condenser and boiled for another 30 min. Each sample mixture was treated likewise, filtered and the residues were rinsed again with boiled distilled water followed by ethanol until the filtrate was free from alkaline. Each sample residue and filter paper were placed in a crucible and dried in the oven at 105 °C, and the weight (S) was recorded, after which the crucible was placed in the muffle furnace at 550 °C and ashed completely (A).

$$\% \text{ Crude fibre} = \frac{(S-K)-Ax100}{W}$$

Where:

W = weight of defatted DSDS<sub>f</sub> sample TDAYB<sub>f</sub>

K= weight of filtered paper without Ash.

S = weight of crucible + filter paper x dried residue

A = weight of crucible x Ash.

### **Determination of carbohydrate content of samples**

The carbohydrate content of each sample was calculated by difference as described by AOAC (2012). The difference between 100 and the sum of the percentage of moisture, protein, fat, and ash of each sample was found and the result was expressed as a percentage carbohydrates as follows:

$$\text{Carbohydrate (\%)} = 100 - (\% \text{ moisture} + \% \text{ crude protein} + \% \text{ crude fat} + \% \text{ crude fibre} + \% \text{ ash})$$

## **Analysis of Functional Properties of Samples**

### **Foaming Capacity (FC)**

The foaming capacity of DSDS<sub>f</sub> and TDAYB<sub>f</sub> was determined by the method of Coffman and Garcia, (1977). Two grams of flour samples were dispersed in distilled water (100 mL) and homogenized properly for two minutes in a kitchen blender. The volumes were recorded before and after homogenization and the percent increase in the volume was calculated as FC of the flour by using the equation below

$$FS (\%) = 100(V_t/V_0)$$

Where,  $V_0$ =initial foam volume and  $V_t$ =foam volume after time (t)

### **Emulsifying activity and Emulsifying stability**

Emulsifying activity (EA) and Emulsifying stability (ES) of flour samples were analyzed by following the method of Neto *et al.*, (2001). Each flour sample (2 g) was dispersed in distilled water (100 mL) and the height of the solution in the cylinder was measured. After standing for 2 mins, the solution was homogenized with refined coconut oil 5 mL. The resulting emulsifying activity was calculated

$$EA (\%) = 100(H_2 - H_1/H_1)$$

EA= Emulsifying Activity

$H_1$  = is the initial height of the unemulsified solution while  $H_2$  is the height of the emulsion

This was followed by centrifugation at 100 X g for 5 mins. The emulsion stability was determined by the following equation.

$$ES (\%) = 100(H_1/H_2)$$

ES=Emulsifying Stability

Where  $H_2$  is the height of the emulsified layer before heating while  $H_t$  is the height of the emulsified layer after heating

### **Bulk density**

The bulk density (BD) of flour samples was measured following a standard method (Kaur and Singh, 2007). Flour samples (1.5 g) were weighed into a graduated cylinder (10 mL) and the cylinder was gently tapped until there was no further reduction in the sample level. Bulk density ( $\text{g/cm}^3$ ) was defined as the weight of the sample divided by the volume of the

sample.  $Bulk\ Density = \frac{\text{Weight of sample}}{\text{Volume of sample}}$

### **Water holding capacity measurement**

The water holding capacity (WHC) of the flour samples was measured in accordance with AACC, 2012. Legume flour (5.0 g) was suspended in 25.0 mL of distilled water in a 50 mL centrifuge tube and the tube was kept vertically for 10 min. The suspensions were subjected to centrifugation at 1000 g for 15 min at ambient temperature. After the centrifugation, the supernatant was carefully decanted, and the weight of the sediment was recorded. WHC was

calculated by dividing the weight of retained water by the dry weight of flour.

$$WHC = \frac{\text{Weight of retained water}}{\text{Volume of dry flour}}$$

### **Oil absorption capacity (OAC)**

The oil absorption capacity (OAC) of the flour samples was determined using the method of Nidhina and Muthukumar (2015) with some modifications. The flour sample (1.0 g) was mixed with 10.0 g canola oil in a 50 mL centrifuge tube and the tubes were kept vertically for a total period of 30 min, with vortexing for 10 sec at time intervals of 5 min. The flour-oil mixture was then centrifuged at 1000 g for 15 min at room temperature. After the centrifugation, the supernatant was carefully decanted and the weight of the pellet was recorded. OAC was calculated by dividing the weight of held oil over the dry weight of flour.

### **Swelling power**

Swelling power (SP) measurement of flour samples was performed according to Lin *et al.* (2011) with slight modifications. Two grams of sample were placed into a pre-weighed centrifuge tube and mixed with 50 mL of distilled water using a magnetic stirrer for 5 mins. The mixture was heated at 70 °C for 35 mins in a water bath and centrifuged at 1024 g for 20 mins after cooling to room temperature. The supernatant was removed and the tube with the sediments was re-weighed. The increase in sample weight was taken as its swelling power.

### **Determination of Anti-nutrients in flour samples**

**Phytic Acid in sample:** A rapid method as described by Wu *et al.* (2010) was adopted with a slight modification in terms of the extraction period. Exactly 0.06 g of each sample (DSDS<sub>f</sub> or TDAYB<sub>f</sub> or flour blends) was extracted with 10 mL of 0.2N HCl at room temperature for 3 h. The mixture was centrifuged at 2000 g for 10 mins. The supernatant (0.5 mL) was pipetted into a test tube and 1 ml of ammonium iron sulfate was added (which was prepared by dissolving 0.2 g of NH<sub>4</sub>Fe) Wu *et al.* (2010). (SO<sub>4</sub>)<sub>2</sub>. 12H<sub>2</sub>O was made into 100 mL of 2 mol/L HCl and the reagent was made to 1000 °C for 30 min. A 2 mL of (1 % v/v) of 2<sup>1</sup>, 2-bipyridine solution was added to the mixture after cooling to an ambient temperature and the

absorbance was immediately recorded at 519 nm against distilled water using a UV-vis spectrophotometer (Perkin Elmer, Shelton, USA). The results were expressed as  $\mu\text{g}$  phytic acid per g sample using a standard curve prepared by diluting a stock solution of phytic acid sodium salt hydrate.

**Tannin in flour samples:** The Folin-Denis spectrophotometric method was used. A measured weight of 1.0 g of sample (W) was dispersed in 10 mL of distilled water and agitated. This was left to stand for 30 min. It was later centrifuged and the extract was obtained (Wf). Then 2.5 mL of the supernatant (i.e extract) (Va) was dispersed into a 50 mL volumetric flask. Similarly, 2.5 mL of standard tannic acid solution was dispersed into a separate 50 mL flask. A 1.0 mL Folin-Denis reagent was measured in each flask, followed by 2.5 mL of saturated  $\text{Na}_2\text{CO}_2$  solution. The mixture was diluted to a mark in the flask (50 mL) and incubated for 90 min at room temperature. The absorbance was measured at 250 nm in a Genway model 6000 electronic spectrophotometer. Readings were taken with the reagent

$$\% \text{ Tannin} = \frac{A_n}{A_s} \times C \times 100 / w \times \text{Five}$$

Where:

$A_n$ =Absorbance of the test sample

$A_s$ =Absorbance of standard solution

C=Concentration of standard solution

W=weight of sample used

Wf=total volume of extract

**Trypsin inhibitor in legume flour:** A modified method described by AACC (2000) was followed. The sample (1.0 g) was mixed with 0.01 mol/L NaOH until pH was 8.4 and stirred for 3 h. Test tubes were filled with 1.4 mL of sample and diluted to 2.0 mL with de-ionized water. Trypsin solution containing 4 mg trypsin (Porcine Pancreas, Sigma) in 200 mL 0.001 mol/L HCl (2 mL) was added to the sample/trypsin standard solution and the tubes were

placed in a water bath at 37 °C to begin the reaction. Five mL of N  $\alpha$ - benzoyl –DL-arginine-*p*-nitroanilide hydrochloride (BAPA) solution (40 mg BAPA) in 100 mL 0.05 mol/L Tris buffer containing CaCl<sub>2</sub>, pH 8.2) was added and the reaction was stopped after 10 min incubation by adding 1 mL of acetic acid solution (30 mL of glacial acetic acid in 70 mL water). The mixtures were filtered and the absorbance of the filtrates was measured at 410 nm using a UV-1601 Spectrophotometer (Shimadzu, Kyoto, Japan) at room temperature. Trypsin inhibitor (TI) content of the sesame seed flour and African yam bean flour was calculated as:

$$\text{TI (mg/g Soybean)} = \frac{\text{absorbance standard} - \text{absorbance Sesame Sample}}{19} \times (\text{dilution factor})$$

all divided by 19. (Hamerstand, Black & Glover, 1981; Ariahu *et al.* (2012)

The reduction of trypsin inhibitor content was calculated by subtracting the TI content of the control determined from raw sesame and AYB flours against that of the samples.

### 3.0 RESULTS AND DISCUSSION

Plate 1 contained flours produced from dehulled solid-state fermented and defatted sesame seeds, toasted and dehulled African yam bean, and *Moringa oleifera* leaf. In Plate 1, sample LMDTM<sub>1</sub>, which contained 100% dehulled solid-state fermented and defatted sesame seed flour had darker brown color than LMDTM<sub>2</sub> which contained 100% toasted and dehulled AYB flour. The colors of blended flours became lighter brown as the replacement of samples with toasted and dehulled AYB flour increased and dehulled solid-state fermented and defatted sesame seeds flour decreased. Also, samples LMDTM<sub>4</sub>, LMDTM<sub>6</sub>, and up to samples LMDTM<sub>18</sub> had lighter colors and smoother particle sizes, fracturability, hardness, and cohesiveness except for those containing 5 % moringa added such as samples LMDTM<sub>5</sub>, LMDTM<sub>7</sub>, LMDTM<sub>9</sub>, LMDTM<sub>11</sub>, LMDTM<sub>13</sub>, LMDTM<sub>15</sub>, and LMDTM<sub>17</sub>. Both individual

flours (DSDS<sub>F</sub> and TDAYB<sub>F</sub>), as well as blended flours (LMDTM<sub>1-18</sub>), had pleasant and attractive aromas.



**Plates 1:** Pictorial presentation of blended flour

### Proximate Composition of Flour Blends

The proximate composition of blends of dehulled solid-state fermented sesame seeds flour, toasted and dehulled African yam bean flour, and Moringa leaf powder is shown in Table 1.

**Moisture contents:** The moisture contents of the flour blends were generally low and below 10 % (3.37 – 9.10 %). There were variations in the moisture content of the flour blends, with samples that contained 100 % dehulled solid-state fermented and defatted sesame seed + 0 % toasted and dehulled AYB flour + 0 % MLP (LMDTM<sub>1</sub>) having the lowest value of 3.37 % and sample with 100 % toasted dehulled African yam bean flour (LMDTM<sub>2</sub>) having the highest value of 9.80 %. The moisture contents of the control samples (LMDTM<sub>1</sub> and LMDTM<sub>2</sub>) appear to influence the moisture contents of the subsequent blends. As shown in Table 1, higher TDAYB<sub>F</sub> in the samples lead to higher moisture content compared with corresponding samples with lower TDAYB<sub>F</sub> of at least up to 50 % TDAYB<sub>F</sub> substitution (cf LMDTM<sub>3-4</sub> with LMDTM<sub>13-14</sub>). Beyond 50 % substitution of DSDS<sub>F</sub>, moisture contents appeared to be stabilized and similar (see LMDTM<sub>14-18</sub>). Dehulled solid-state fermented and defatted sesame seed flour (reduced from 95% to 30 %) and substituted with TDAYB<sub>F</sub> increased in moisture content as the supplementation with TDAYB<sub>F</sub> increased, thus, suggesting that TDAYB<sub>F</sub> had higher hydrophilic groups that readily bind water. The addition of 5 % MLP seemed to have marginally caused a reduction in moisture content compared with no addition (cf LMDTM<sub>3</sub> and LMDTM<sub>4</sub>; LMDTM<sub>5</sub> and LMDTM<sub>6</sub>; LMDTM<sub>7</sub> and LMDTM<sub>8</sub>, etc).

**Protein content:** The protein content of the flour samples was generally high (18.38 – 27.42 %). There were differences in the protein content of flour blends. The sample without sesame

**Table 1: Proximate composition of flour blends for "biscuit-like" manufacture**

Samples/Composition	Moisture (%)	Protein (%)	Crude fat (%)	Ash (%)	Crude fiber (%)	Carbohydrate (%)
LMTDM <sub>1</sub>	3.37±0.05	24.98±0.02	0.18±0.04	3.70±0.12	3.20±0.22	65.45
LMDTM <sub>2</sub>	9.80±0.10	18.38±0.03	3.79±0.06	2.04±0.02	8.88±0.00	59.11
LMDTM <sub>3</sub>	5.39±0.10	25.19±0.16	2.48±0.01	3.21±0.05	5.50±0.11	59.32
LMDTM <sub>4</sub>	5.49±0.10	23.17±0.12	2.93±0.15	3.10±0.10	5.60±0.20	58.10

LMDTM <sub>5</sub>	5.69±0.01	25.12±0.07	3.41±0.03	3.13±0.05	6.70±0.00	59.61
LMDTM <sub>6</sub>	7.40±0.03	23.09±0.04	2.49±0.05	3.90±0.03	4.90±0.10	60.22
LMDTM <sub>7</sub>	7.90±0.01	26.20±0.03	2.40±0.02	3.10±0.09	5.20±0.03	58.06
LMDTM <sub>8</sub>	8.20±0.03	23.10±0.10	3.20±0.02	3.10±0.08	3.90±0.02	56.37
LMDTM <sub>9</sub>	8.40±0.03	26.15±0.20	3.40±0.05	2.41±0.05	4.20±0.01	57.00
LMDTM <sub>10</sub>	8.60±0.15	24.10±0.05	3.50±0.05	2.40±0.03	5.30±0.04	55.84
LMDTM <sub>11</sub>	8.10±0.02	26.06±0.15	3.60±0.03	2.50±0.02	5.90±0.02	55.27
LMDTM <sub>12</sub>	8.20±0.02	24.03±0.12	3.20±0.04	2.10±0.06	6.20±0.05	55.99
LMDTM <sub>13</sub>	9.21±0.05	27.40±0.19	3.90±0.10	2.90±0.03	6.40±0.03	54.09
LMDTM <sub>14</sub>	9.10±0.03	24.12±0.05	3.20±0.02	1.31±0.02	6.40±0.03	54.22
LMDTM <sub>15</sub>	9.10±4.02	27.41±0.07	3.10±0.10	2.40±0.05	4.30±0.02	55.79
LMDTM <sub>16</sub>	9.10±0.53	24.24±0.80	3.30±0.20	1.31±0.03	4.50±0.02	54.78
LMDTM <sub>17</sub>	9.00±0.26	27.52±0.07	3.40±0.20	2.50±0.02	4.60±0.05	55.26
LMDTM <sub>18</sub>	9.00±0.27	24.24±0.14	3.40±0.30	2.10±0.02	7.20±0.02	52.75

Values are means of triplicate determinations± standard error mean (SEM).

flour and moringa powder (LMDTM<sub>2</sub>) had the least protein content (18.38 %) while the sample with 30 % sesame flour+70 % AYB (LMDTM<sub>17</sub>) had the highest protein content (27.52 %). Sesame seed flour and AYB flour seem to have a similar effect on protein contents probably on account of the fact that both are legumes. That notwithstanding, Oluoba *et al.* (2021), Eden *et al.* (1990), as well as Apata and Ologhobo (1990), reported that the African Yam bean is an underutilized crop with high protein content (15.8 -34.7 %) and a fairly good source of amino acids. Also, the presence of MLP appeared to increase the protein contents of samples. Hence, each sample with 5 % MLP had higher protein content compared with the corresponding sample with 0 % MLP (cf LMDTM<sub>3</sub> and LMDTM<sub>4</sub>; LMDTM<sub>5</sub> and LMDTM<sub>6</sub>; etc).

The crude fat contents of flour blends ranged between 0.18 % and 3.90 %. Due to the defatting and fermentation of sesame seed, the lipid content was very low in LMDTM<sub>1</sub> (0.18 %) while LMDTM<sub>2</sub> which contained AYB that was not defatted nor fermented had one of the highest crude fats (3.79 %). That notwithstanding, the increased substitution of DSDS<sub>F</sub> with TDAYB<sub>F</sub> did not appear to influence the fat content of the flour blends because the increase

in TDAYB<sub>F</sub> did not result in to increase in the lipid content of the flour blends. MLP addition caused marginal differences in fat contents of the flour blends as higher (5 %) MLP diluted the lipid contents compared to corresponding flour blends with lower (0 %) MLP contents (cf: LMDTM<sub>3</sub> and LMDTM<sub>4</sub>; LMDTM<sub>9</sub> and LMDTM<sub>10</sub>; etc).

**Ash content of the flour blends:** The ash contents of the flour blends ranged from 1.31±0.02 % to 3.90±0.03 %. The first control sample (LMDTM<sub>1</sub>) containing 100 % sesame seed flour had a value of 3.70±0.12 % which was higher than the second control blend (LMDTM<sub>2</sub>) with 100 % AYB flour with a value of 2.04 %. The differences could be attributable to species differences and differences in the processing methods of the flour samples. Sample LMDTM<sub>14</sub> had the lowest ash content (1.31 ± 0.02 %) while LMDTM<sub>6</sub> had the highest value (3.90 ± 0.03 %). From Table 1, it could be seen that the increase in substitution of DSDS<sub>F</sub> with TDAYB<sub>F</sub> reduced the ash contents of the blends, probably because of the lower ash content of TDAYB flour (2.04%) compared to sesame seed flour (3.70 %). The addition of MLP appeared to increase the ash content of the flour blends. As shown in Table 1, samples with 5 % MLP had higher ash content compared with corresponding samples containing 0 % MLP, except LMDTM<sub>5</sub> and LMDTM<sub>6</sub>.

**The crude fiber content of flour blends:** The crude fiber content of the flour blends is shown in Table 1. The crude fiber contents ranged from 3.2±0.22 % to 8.88 %. The first control sample (LMDTM<sub>1</sub>) had the lowest crude fiber content while the second control sample (LMDTM<sub>2</sub>) had the highest. Fermentation of sesame seed could be responsible for the very low value of crude fiber in the LMDTM<sub>1</sub> sample. Increased substitution of DSDS<sub>F</sub> with TDAYB<sub>F</sub> increased the crude fiber contents of samples but the inclusion of MLP (5 %) reduced the crude fiber content of samples.

**The carbohydrate content of flour blends:** The carbohydrate contents of the flour blends are shown in Table 1. The carbohydrate contents ranged from 52.75 % to 65.45 %. The first

control sample (LMDTM<sub>1</sub>) which was composed of 100 % defatted and dehulled sesame seed flour had the highest value of 65.45 % while the second control sample (LMDTM<sub>2</sub>) which was composed of 100 % TDAYB<sub>F</sub> had a value of 59.11 % while LMDTM<sub>18</sub> had the lowest value of 52.75 %. This suggests that increased substitution of DSDS<sub>F</sub> with TDAYB<sub>F</sub> reduced the carbohydrate contents of the flour blends. The inclusion of MLP did not appear to influence the carbohydrate contents of the blends presumably because the carbohydrate content (43.54±0.09 %) of the processed moringa (MLP) was the least among the three flour samples.

### **Functional Properties of Flour Blends**

Table 2 shows the functional properties of the flour blends. The bulk density of the flour blends ranged from 0.610 g/cm<sup>3</sup> to 0.711 g/cm<sup>3</sup>. The first control sample (LMDTM<sub>1</sub>) which had 100 DSDS<sub>F</sub> had the highest value of 0.711 g/cm<sup>3</sup> while the second (LMDTM<sub>2</sub>) which contained 100 % TDAYB<sub>F</sub> had a value of 0.643 g/cm<sup>3</sup>, and the least value was seen in LMDTM<sub>5</sub> with a value of 0.610 g/cm<sup>3</sup>. However, the results showed that there were no significant differences between the samples ( $p > 0.05$ ). Bulk density plays a vital role in products' overall acceptability; the appearance of the snack (chips) and attractiveness to consumers. Bulk density is an important functional property in designing suitable packaging materials for snacks.

The water absorption capacity (WAC) of the flour blends ranged from 124.00 % to 167.66 % (Table 2). LMDTM<sub>1</sub> had a higher WAC (165.52 %) compared to LMDTM<sub>2</sub> (152.90 %). WAC reduced with an increase in substitution of DSDS<sub>F</sub> with TDAYB<sub>F</sub>, with LMDTM<sub>14</sub>-LMDTM<sub>18</sub> having the lowest values (124.00-124.02%). There were significant differences in water absorption capacity ( $p < 0.05$ ). The inclusion of MLP slightly increased the water absorption capacity. This is evidenced by Table 2 which showed that samples that contained 5 % MLP had higher WAC compared to corresponding samples with 0 % MLP. The water

absorption affects the quality of flaked snacks (chips) and depends partly on the damaged starch contained in the flour, the protein contents, and particle size (Kulkani *et al.*, 1991).

The oil absorption capacity (OAC) of the flour blends ranged from 64.20 % to 94.5 %. Sample LMDTM<sub>1</sub> had the highest value of 94.5 % while samples LMDTM<sub>15</sub> and LMDTM<sub>16</sub> had the lowest OAC values. The first control sample, LMDTM<sub>1</sub> which contained 100 % DSDS<sub>F</sub>, had a higher OAC (94.5 %) compared to the second control sample, LMDTM<sub>2</sub> which had 100 % TDAYB<sub>F</sub>, with 84.56 %. The differences between the two control samples could be attributed to plant species differences and differences in methods of processing the flours. An increase in substitution of DSDS<sub>F</sub> with TDAYB<sub>F</sub> reduced the OAC because as shown in Table 2, OAC continued to reduce as

**Table 2: Functional properties of flour blends**

S/N	Sample flour	Bulk density (g/cm <sup>3</sup> )	Water Absorption Capacity (%)	Oil absorption capacity (%)	Solubility (%)	Swelling power	Foaming capacity (%)	Emulsification (%)
1.	LMDTM <sub>1</sub>	0.711 <sup>a</sup>	165.52 <sup>a</sup>	94.50 <sup>a</sup>	13.40 <sup>a</sup>	3.50 <sup>ab</sup>	8.00 <sup>a</sup>	46.20 <sup>cd</sup>
2	LMDTM <sub>2</sub>	0.643 <sup>b</sup>	152.90 <sup>b</sup>	84.56 <sup>b</sup>	12.31 <sup>a</sup>	4.85 <sup>a</sup>	0.00 <sup>c</sup>	47.20 <sup>bc</sup>
3	LMDTM <sub>3</sub>	0.618 <sup>b</sup>	165.11 <sup>a</sup>	88.34 <sup>a</sup>	11.21 <sup>ab</sup>	4.63 <sup>a</sup>	0.00 <sup>c</sup>	47.60 <sup>bc</sup>
4	LMDTM <sub>4</sub>	0.611 <sup>b</sup>	164.33 <sup>ab</sup>	86.14 <sup>a</sup>	11.61 <sup>a</sup>	4.96 <sup>a</sup>	0.00 <sup>c</sup>	47.40 <sup>bc</sup>
5	LMDTM <sub>5</sub>	0.610 <sup>b</sup>	167.66 <sup>a</sup>	81.30 <sup>b</sup>	8.91 <sup>bc</sup>	5.06 <sup>a</sup>	0.00 <sup>c</sup>	48.90 <sup>b</sup>
6	LMDTM <sub>6</sub>	0.624 <sup>b</sup>	159.71 <sup>ab</sup>	75.82 <sup>ab</sup>	9.21 <sup>bc</sup>	5.02 <sup>a</sup>	0.00 <sup>c</sup>	48.20 <sup>bc</sup>
7	LMDTM <sub>7</sub>	0.639 <sup>b</sup>	158.67 <sup>ab</sup>	73.90 <sup>ab</sup>	10.01 <sup>b</sup>	4.82 <sup>a</sup>	0.00 <sup>c</sup>	51.40 <sup>b</sup>
8	LMDTM <sub>8</sub>	0.639 <sup>b</sup>	142.22 <sup>bc</sup>	73.29 <sup>ab</sup>	9.41 <sup>c</sup>	4.81 <sup>a</sup>	0.00 <sup>c</sup>	51.00 <sup>b</sup>
9	LMDTM <sub>9</sub>	0.655 <sup>a</sup>	133.77 <sup>bc</sup>	72.43 <sup>ab</sup>	9.91 <sup>b</sup>	4.82 <sup>a</sup>	0.00 <sup>c</sup>	50.80 <sup>b</sup>

10	LMDTM <sub>10</sub>	0.654 <sup>a</sup>	135.66 <sup>bc</sup>	71.26 <sup>ab</sup>	9.61 <sup>b</sup>	4.91 <sup>a</sup>	0.00 <sup>c</sup>	53.20 <sup>b</sup>
11	LMDTM <sub>11</sub>	0.653 <sup>a</sup>	127.68 <sup>d</sup>	71.40 <sup>ab</sup>	9.61 <sup>b</sup>	4.99 <sup>a</sup>	0.10 <sup>c</sup>	54.00 <sup>b</sup>
12	LMDTM <sub>12</sub>	0.653 <sup>a</sup>	127.69 <sup>d</sup>	69.41 <sup>a</sup>	9.31 <sup>bc</sup>	4.65 <sup>a</sup>	0.00 <sup>c</sup>	55.00 <sup>ab</sup>
13	LMDTM <sub>13</sub>	0.656 <sup>a</sup>	125.64 <sup>d</sup>	69.56 <sup>ab</sup>	9.01 <sup>bc</sup>	4.20 <sup>ab</sup>	0.00 <sup>c</sup>	56.20 <sup>ab</sup>
14	LMDTM <sub>14</sub>	0.659 <sup>a</sup>	124.02 <sup>d</sup>	68.89 <sup>ab</sup>	7.21 <sup>d</sup>	3.95 <sup>ab</sup>	0.60 <sup>b</sup>	60.10 <sup>a</sup>
15	LMDTM <sub>15</sub>	0.668 <sup>a</sup>	124.00 <sup>d</sup>	64.20 <sup>c</sup>	7.31 <sup>d</sup>	3.62 <sup>ab</sup>	5.70 <sup>b</sup>	62.30 <sup>a</sup>
16	LMDTM <sub>16</sub>	0.668 <sup>a</sup>	124.00 <sup>d</sup>	64.20 <sup>c</sup>	7.31 <sup>d</sup>	3.62 <sup>ab</sup>	5.70 <sup>b</sup>	62.30 <sup>a</sup>
17	LMDTM <sub>17</sub>	0.658 <sup>a</sup>	124.02 <sup>d</sup>	68.91 <sup>ab</sup>	7.31 <sup>d</sup>	3.96 <sup>a</sup>	5.70 <sup>b</sup>	60.20 <sup>a</sup>
18	LMDTM <sub>18</sub>	0.669 <sup>a</sup>	124.01 <sup>d</sup>	65.24 <sup>c</sup>	7.31 <sup>d</sup>	3.63 <sup>ab</sup>	5.60 <sup>b</sup>	60.10 <sup>a</sup>

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Values are means of triplicates determinations. Mean values with different superscripts in a column are significantly ( $p \leq 0.05$ ) different from each other.

fermented sesame seed flour decreased and AYB flour increased. The inclusion of MLP increased oil absorption capacity. As shown in Table 2, samples that contained 5 % MLP had higher OAC compared to corresponding samples with 0 % MLP.

The solubility index of the flour blends is shown in Table 2. The solubility index ranged from 7.21 % to 13.4 %. Sample LMDTM<sub>1</sub> (the first control sample) which contained 100 % DSDS<sub>F</sub> and no TDAYB<sub>F</sub> had the highest value (13.4 %) while LMDTM<sub>14</sub> had the lowest value (7.21 %). Also, LMDTM<sub>1</sub> (first control sample with 100 DSDS<sub>F</sub>) had a higher solubility index (13.4 %) compared to LMDTM<sub>2</sub> (second control sample with 100 5 TDAYB<sub>F</sub> which had a value of 12.31 %. The differences could be attributed to plant species differences and flour processing differences. Solubility index continued to decrease with an

increase in substitution of  $\text{DSDS}_F$  with  $\text{TDAYB}_F$ , at least up to  $\text{LMDTM}_{14}$  which contained 50 %  $\text{DSDS}_F + 50$  %  $\text{TDAYB}_F$ , suggesting that AYB ( $\text{TDAYB}_F$ ) had more soluble substances than fermented sesame seed flour ( $\text{DSDS}_F$ ). No differences in solubility index were recorded from  $\text{LMDTM}_{15}$  to  $\text{LMDTM}_{18}$ . Inclusion of 5 % MLP (within the range of  $\text{LMDTM}_3$  to  $\text{LMDTM}_{14}$ ) showed a higher solubility index compared to corresponding samples with 0 % MLP but beyond  $\text{LMDTM}_{14}$ , the inclusion of 5 % MLP did not show any difference from 0 % inclusion.

The swelling power ranged from 3.50 to 5.06 % (Table 2). The two control samples  $\text{LMDTM}_1$  and  $\text{LMDTM}_2$  had values of 3.50 % and 4.85 %, respectively. The differences could be due to methods of processing and species differences. The swelling power reduced with an increase in substitution of  $\text{DSDS}_F$  with  $\text{TDAYB}_F$ , with  $\text{LMDTM}_{18}$  having one of the least values of 3.63 %. The presence (5 %) or absence (0 %) of MLP did not appear to have a major influence on the swelling power of the flour blends. The swelling power of the flour blends showed that there were significant differences between the samples ( $p < 0.05$ ). The swelling power has been related to the association binding within the starch granules and apparently the strength and character of the micelle network as related to the amylase content of the flour. Low amylase content produces high swelling power (Adewale *et al.*, 2005).

The foaming capacity of the flour blends ranged from 0 % to 8.0 % (Table 14). The results show that the first control sample ( $\text{LMDTM}_1$ ) which contained 100 %  $\text{DSDS}_F + 0$  %  $\text{TDAYB}_F$  had a foaming capacity of 8.0 % whereas the second control sample ( $\text{LMDTM}_2$ ) with 100 %  $\text{TDAYB}_F + 0$  %  $\text{DSDS}_F$  had no value for foaming capacity, suggesting that toasting damaged the foaming components of AYB or that the African yam bean (AYB) has no foaming substances. Foaming capacity could not be detected in the flour blends from  $\text{LMDTM}_3$  to  $\text{LMDTM}_{13}$  showing that toasted AYB diluted the foaming capacity of the flour blends. However, at higher levels of addition of toasted AYB (from  $\text{LMDTM}_{11}$ ), the foaming

ability was noticed to be very low (LMDTM<sub>11</sub> = 0.10 %) but increased from LMDTM<sub>14</sub> to LMDTM<sub>18</sub> with a range of 0.6 to 5.70 %. Results in Table 2 show that presence (5 % inclusion) or absence (0 % inclusion) did not affect the foaming capacity of the flour blends. The emulsification capacity of the flour blends is shown in Table 2. The emulsification capacity ranged from 46.20 % to 62.30 %. The emulsification capacity of LMDTM<sub>1</sub> and LMDTM<sub>2</sub> were similar and lower than all other blends. The emulsification capacity increased with the increase substitution of DS<sub>DS<sub>F</sub></sub> with TD<sub>AYB<sub>F</sub></sub> from 47.6 % (LMDTM<sub>3</sub>) to 60.30 % (LMDTM<sub>15</sub> and LMDTM<sub>16</sub>). However, it appears from Table 2 that a threshold was reached with the addition of 55% and 60 % TD<sub>AYB</sub> (LMDTM<sub>15</sub> and LMDTM<sub>16</sub>) both of which had a value of 62.30%) beyond which there were reductions in the emulsification capacity of the blends (LMDTM<sub>17</sub> = 60.20 % and LMDTM<sub>18</sub> = 60.10 %). The effects of presence (5 %) and absence (0 %) were variable but seem to be close to each other.

### **Analysis of Anti-nutrients**

The results in Table 3 revealed that phytate contents ranged from 7.89 – 16.29 mg/100g. Phytate is the salt form of phytic acid and is found in plants. There were significant differences ( $p < 0.05$ ) between the blended flour samples in the phytate contents. The first control sample (LMDTM<sub>1</sub>) contained significantly the highest amount of phytate (16.29 mg/100g) while the second control sample (LMDTM<sub>2</sub>) contained the least phytate (7.89 mg/100g). The differences could be due to plant species differences or that toasting of AYB was more effective in reducing phytate than fermentation of sesame seed. Phytate continued to reduce with an increase in the substitution of DS<sub>DS<sub>F</sub></sub> with TD<sub>AYB<sub>F</sub></sub> due to the dilution effect resulting from the low phytate content of TD<sub>AYB</sub> flour. The higher inclusion of MLP increased the phytate content of the flour blends. As shown in Table 3, samples containing 5% MLP had higher phytate content compared with the samples containing 0 % MLP.

The tannin contents of the flour samples and 4.00 – 4.89 mg/100g (Table 3). Sample LMDTM<sub>1</sub> (100 % dehulled solid-state fermented sesame seed flour) had a higher amount of phytate (16.29 mg/100g) than sample LMDTM<sub>2</sub> (4.57 mg/100g). The differences could be due to species differences or that fermentation was less effective in reducing tannins in sesame seed than toasting used for AYB. Tannin significantly ( $p<0.05$ ) reduced with an increase in substitution of DSDS<sub>F</sub> with TDAYB<sub>F</sub> due to the dilution effect resulting from low tannin in TDAYB<sub>F</sub> flour. The effects of presence (5 %) or absence (0 %) were variable and it is seen in Table 15 that tannin contents differed significantly ( $p<0.05$ ) between 5 % and 0 % inclusion (compare LMDTM<sub>7</sub> with LMDTM<sub>8</sub> and LMDTM<sub>15</sub> with LMDTM<sub>16</sub>).

The trypsin inhibitor contents of the flour blends (Table 2) ranged from 0.27 mg/100g to 1.2 mg/100g. The first control sample (LMDTM<sub>1</sub>) had significantly ( $p<0.05$ ) the highest trypsin inhibitor (1.2 mg/100g) while the second control sample (LMDTM<sub>2</sub>) had a value of 0.93 mg/100g which was, however, not significantly ( $p>0.05$ ) different from LMDTM<sub>1</sub>. Trypsin inhibitor significantly ( $p<0.05$ ) reduced with an increase in substitution of DSDS<sub>F</sub> with TDAYB<sub>F</sub> from 0.83 mg/100g (LMDTM<sub>3</sub>) to 0.27 mg/100g (LMDTM<sub>17</sub>). The effects of presence (5 %) and absence (0 %) MLP were variable but were significantly ( $p<0.05$ ) different from each corresponding pair.

**Table 3: Anti-nutrient content of flour blends**

Samples	Phytate (mg/100g)	Tannin (mg/100g)	Trypsin inhibitor
LMDTM <sub>1</sub>	16.29±0.04 <sup>a</sup>	4.64±0.02 <sup>a</sup>	1.20±0.78 <sup>a</sup>
LMDTM <sub>2</sub>	7.89±0.02 <sup>fg</sup>	4.57±0.05 <sup>a</sup>	0.93±0.36 <sup>a</sup>
LMDTM <sub>3</sub>	16.01±0.02 <sup>a</sup>	4.51±0.01 <sup>a</sup>	0.83±0.22 <sup>a</sup>
LMDTM <sub>4</sub>	15.02±0.05 <sup>b</sup>	4.89±0.01 <sup>a</sup>	0.56±0.36 <sup>a</sup>
LMDTM <sub>5</sub>	16.10±0.03 <sup>a</sup>	4.01±0.02 <sup>b</sup>	0.35±0.75 <sup>bc</sup>

LMDTM <sub>6</sub>	13.00±0.03 <sup>c</sup>	4.00±0.03 <sup>b</sup>	0.94±0.33 <sup>a</sup>
LMDTM <sub>7</sub>	12.34±0.04 <sup>cd</sup>	4.43±0.10 <sup>b</sup>	0.80±0.66 <sup>a</sup>
LMDTM <sub>8</sub>	11.11±0.05 <sup>d</sup>	4.49±0.01 <sup>a</sup>	0.73±0.23 <sup>a</sup>
LMDTM <sub>7</sub>	11.33±0.05 <sup>d</sup>	4.34±0.01 <sup>b</sup>	0.47±0.72 <sup>b</sup>
LMDTM <sub>8</sub>	10.01±0.05 <sup>e</sup>	4.49±0.05 <sup>a</sup>	0.27±0.94 <sup>c</sup>
LMDTM <sub>9</sub>	14.99±0.05 <sup>b</sup>	4.33±0.10 <sup>b</sup>	0.18±0.21 <sup>c</sup>
LMDTM <sub>10</sub>	9.00±0.03 <sup>f</sup>	4.44±0.05 <sup>b</sup>	0.61±0.43 <sup>a</sup>
LMDTM <sub>11</sub>	12.13±0.03 <sup>d</sup>	4.24±0.03 <sup>b</sup>	0.98±0.18 <sup>a</sup>
LMDTM <sub>12</sub>	10.00±0.05 <sup>e</sup>	4.24±0.02 <sup>b</sup>	0.61±0.76 <sup>a</sup>
LMDTM <sub>13</sub>	10.13±0.02 <sup>e</sup>	4.24±0.02 <sup>b</sup>	0.57±0.82 <sup>a</sup>
LMDTM <sub>14</sub>	11.14±0.02 <sup>d</sup>	4.21±0.04 <sup>b</sup>	0.33±0.71 <sup>c</sup>
LMDTM <sub>15</sub>	9.22±0.02 <sup>f</sup>	4.26±0.03 <sup>b</sup>	0.33±0.42 <sup>c</sup>
LMDTM <sub>16</sub>	9.13±0.02 <sup>f</sup>	4.11±0.02 <sup>c</sup>	0.34±0.55 <sup>c</sup>
LMDTM <sub>17</sub>	12.29±0.04 <sup>cd</sup>	4.14±0.10 <sup>c</sup>	0.27±0.59 <sup>c</sup>
LMDTM <sub>18</sub>	8.00±0.05 <sup>h</sup>	4.12±0.05 <sup>c</sup>	0.52±0.79 <sup>b</sup>

Values are means of triplicates determinations. Means with different superscripts in a column are significantly different ( $p \geq 0.05$ )

## CONCLUSION

The flour produced from the raw materials (sesame seed, African yam bean, and moringa leaves), as well as their various blends, had high-quality characteristics, with respect to nutritive values, functional properties, and anti-nutrient composition for healthy 'biscuit-like' production.

## RECOMMENDATIONS

Storage studies should be carried out at accelerated conditions on the supplemented and non-supplemented legume mixes for one month to monitor kinetics and physiochemical changes in product qualities. Generate information on the kinetics of physicochemical changes in the snack chips during storage. The nutritional evaluation of the supplemented and non-supplemented legume mixes using rat studies and human trials should be performed to support the utilization of the product.

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