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 ^{0}C, defatted and milled into flour and tagged as $DSDS_F$, African yam bean was toasted at 125 ^{0}C for 40 min, dehulled, milled into flour and tagged as $TDAYB_F$ 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 $LMDTM_{1-18.}$ The ratios of DSDSF:TDAYBF: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 fibre and 52.75-65.45 % carbohydrate. Each proximate component varied significantly ($p<0.05$) between samples. While LMDTM13 had significantly($p<0.05$) highest moisture content, protein and fat LMDTM6 had the highest ash content, LMDTM2 had highest crude fibre 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 o f 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 incorporated to African yam bean and moringa leaf powder to increase the quality and flavour 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 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 been one of the tropical countries cannot grow wheat in commercial quantities due to the country’s’ climatic conditions. Only three percent of the country’ total consumption of the 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 Nigria is one of the 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.

African yam bean (AYB) is botanically known as *Sphenostylis stenocurpa* 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 widely cultivated in the southern parts of Nigeria. The colour of the seed coat varies from white to various shades of cream, brown, grey and some are mottled. It originated in Ethiopia, but both wild and cultivated varieties, now occur in tropical African 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, authentication . Analysis was done at 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. 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 ^{0}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 ^{0}C for 3 h. The dehulled, fermented and dried sesame seeds were roasted for 5-10 min at 180-210 ^{0}C with a roaster. The roasted sesame seeds were ground using a FOSS Tecador grinder (Cyclotec^{TM} 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 ^{0}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 vacuum and stored at 40 ^{0}C before analysis. The dehulled solid-state fermented and defatted sesame seed flour was identified as $DSDS_f$. 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 tripod stand fueled with firewood. The toasting was done in batches using 2 kg of African

Yam Bean (AYB) per batch, at 125 ^{0}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 attrition mill (locally fabricated in Nigeria) and sieved into fine flour with 1 mm mesh sieve. The dehulled and toasted African Yam Bean flour was identified as $TDAYB_f$.

Analysis of samples

Proximate Analysis of blended flour samples

Moisture content analysis of samples

Moisture content of each sample was determined by the hot air oven method described by Association of Official Analytical Chemist (AOAC, 2012). Stainless steel oven dishes were cleaned and dried in the oven (Fulton, Model N YC-101) at 100 ^{0}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 ^{0}C. The samples were removed from the oven and placed in desiccators to cool to room temperature (32 ^{0}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:

$$\% \text{ Moisture content} = \frac{W2 - W3}{W2 - W1} \times \frac{100}{1}$$

Where W1= weight of empty moisture dish

W2= weight of empty moisture dish + flour sample

W3= weight of moisture dish + dried samples

Where:

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 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 collected in conical flask containing 10 mL of 2 % boric acid with few drops of bromocresol indicator. The distillate was titrated with 0.05N H_2SO_4 until color changed from lilac colour to blue- green. The Nitrogen content was calculated with the expression

$$\% \text{ Nitrogen} = \frac{Is - IB \times N \times 1.4}{W}$$

Where,

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

IB = volume of 0.05N H_2SO_4 titrated with blank

W = weight of $DSDS_f$ or $TDAYB_f$ sample

N = normality of 0.05N H_2SO_4

Hence,

% Protein = % Nitrogen × conversion factor (5.95)

Determination of Crude fat (Soxhlet extraction method)

Triplicates 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 boiling flask. After 4 h, the flask containing the extracted fat was dried in a hot air oven at 100 ^{0}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 ^{0}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 ^{0}C for 6 h until no black carbon was present. The crucible was cooled and weighed after ashing. The ash content was calculated with expression,

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

Crude fibre 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 ^{0}C and cooled in the desecrator. Weight of 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_2S0_4 was added, the flask 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 to 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 filtrate was free from alkaline. Each sample residue and filter paper were placed in a crucible, dried in the oven at 105 ^{0}C, and the weight (S) was recorded, after which the crucible was placed in the muffle furnace at 550 ^{0}C and ashed completely (A).

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

Where:

W = weight of defatted $DSDS_f$ sample $TDAYB_f$

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

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

Carbohydrate (%) = 100- (% moisture + % crude protein +% crude fat + % crude fibre + % ash)

Analysis of Functional Properties of Samples

Foaming Capacity (FC)

Foaming capacity of $DSDS_f$ and $TDAYB_f$ were determined by the method of Coffman and Garcia, (1977).Two grams of flour samples was 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 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 samples (2 g) was dispersed in distilled water (100 mL) and height of 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

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

EA= Emulsifying Activity

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

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 (g/cm^3) was defined as weight of sample divided by the volume of sample. $Bulk\ Dencity = \frac{\text{Weight 0f sample}}{\text{Volume of sample}}$

Water holding capacity measurement

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 over the dry weight of flour.

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

Oil absorption capacity (OAC)

Oil absorption capacity (OAC) of the flour samples was determined using the method of Nidhina and Muthukumar (2015) with some modifications. Flour sample (1.0 g) was mixed with 10.0 g canola oil in 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 centrigugation, the supernatant was carefully decanted and the weight of the pellet was recorded. OAC was calculated by dividing the weight of hold oil over the dry weight of flour.

Swelling power

Swelling power (SP) mea**s**urement of flour samples was performed according to Lin *et al.* (2011) with slight modifications. Two grams of sample was 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 ^{0}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 ($DSDS_f$ or $TDAYB_f$ 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 sulphate was added (which was prepared by dissolving 0.2 g of NH_4Fe) Wu *et al.* (2010). $(SO_4)_2$. $12H_20$ was made into 100 mL of 2 mol/L HCl and the reagent was made to 1000 ^{0}C for 30 min. A 2 mL of (1 % v/v) of 2^1, 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 µg phytic acid per g sample using a standard curve prepared by diluting stock solution of phytic acid sodium salt hydrate.

T**annin 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 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 into each flask, followed by 2.5 mL of saturated Na_2Co_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

% Tannin-An/As **x** C **x** 100/w **x** Five

Where:

An=Absorbance of test sample

As=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 ^{0}C to begin the reaction. Five mL of N α- benzoyl –DL-arginine-*p*-nitroanilide hydrochloride (BAPA) solution (40 mg BAPA) in 100 mL 0.05 mol/L Tris buffer containing $CaCl_2$, 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 were calculated as:

TI (mg/g Soybean) = absorbance standard – absorbance Sesame Sample) X (dilution factor) all divided by19. (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 $LMDTM_1$, which contained 100% dehulled solid-state fermented and defatted sesame seed flour had darker brown colour than $LMDTM_2$ which contained 100% toasted and dehulled AYB flour. Colours 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 decresased. Also, samples $LMDTM_4$, $LMDTM_6$ and up to samples $LMDTM_{18}$ had lighter colours and smoother particle sizes, fracturability, hardness and cohesiveness except for those containing 5 % moringa added such as samples $LMDTM_5$, $LMDTM_7$, $LMDTM_9$, $LMDTM_{11}$, $LMDTM_{13}$, $LMDTM_{15}$ and $LMDTM_{17}$. Both

individual flours ($DSDS_F$ and $TDAYB_F$) as well as blended flours ($LMDTM_{1-18}$) had pleasant and attractive aroma.

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 ($LMDTM_1$) having the lowest value of 3.37 % and sample with 100 % toasted dehulled African yam bean flour ($LMDTM_2$) having the highest value of 9.80 %. The moisture contents of the control samples ($LMDTM_1$ and $LMDTM_2$) appear to influence the moisture contents of the subsequent blends. As shown in Table 1, higher $TDAYB_F$ in the samples lead to higher moisture content compared with corresponding samples with lower $TDAYB_F$ at least up to 50 % $TDAYB_F$ substitution (cf $LMDTM_{3-4}$ with $LMDTM_{13-14}$). Beyond 50 % substitution of $DSDS_F$, moisture contents appeared to be stabilized and similar (see $LMDTM_{14-18}$). Dehulled solid state fermented and defatted sesame seed flour (reduced from 95% to 30 %) and substituted with $TDAYB_F$ increased in moisture content as the supplementation with $TDAYB_F$ increased, thus, suggesting that $TDAYB_F$ had higher hydrophilic groups that readily bind water. Addition of 5 % MLP seemed to have marginally cause reduction in moisture content compared with no addition (cf $LMDTM_3$ and $LMDTM_4$; $LMDTM_5$ and $LMDTM_6$; $LMDTM_7$ and $LMDTM_8$, etc).

Protein content: The protein content of the flour samples were 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 fibre (%)	Carbohydrate (%)
$LMTDM_1$	3.37±0.05	24.98±0.02	0.18±0.04	3.70±0.12	3.20±0.22	65.45
$LMDTM_2$	9.80±0.10	18.38±0.03	3.79±0.06	2.04±0.02	8.88±0.00	59.11

$LMDTM_3$	5.39±0.10	25.19±0.16	2.48±0.01	3.21±0.05	5.50±0.11	59.32
$LMDTM_4$	5.49±0.10	23.17±0.12	2.93±0.15	3.10±0.10	5.60±0.20	58.10
$LMDTM_5$	5.69±0.01	25.12±0.07	3.41±0.03	3.13±0.05	6.70±0.00	59.61
$LMDTM_6$	7.40±0.03	23.09±0.04	2.49±0.05	3.90±0.03	4.90±0.10	60.22
$LMDTM_7$	7.90±0.01	26.20±0.03	2.40±0.02	3.10±0.09	5.20±0.03	58.06
$LMDTM_8$	8.20±0.03	23.10±0.10	3.20±0.02	3.10±0.08	3.90±0.02	56.37
$LMDTM_9$	8.40±0.03	26.15±0.20	3.40±0.05	2.41±0.05	4.20±0.01	57.00
$LMDTM_{10}$	8.60±0.15	24.10±0.05	3.50±0.05	2.40±0.03	5.30±0.04	55.84
$LMDTM_{11}$	8.10±0.02	26.06±0.15	3.60±0.03	2.50±0.02	5.90±0.02	55.27
$LMDTM_{12}$	8.20±0.02	24.03±0.12	3.20±0.04	2.10±0.06	6.20±0.05	55.99
$LMDTM_{13}$	9.21±0.05	27.40±0.19	3.90±0.10	2.90±0.03	6.40±0.03	54.09
$LMDTM_{14}$	9.10±0.03	24.12±0.05	3.20±0.02	1.31±0.02	6.40±0.03	54.22
$LMDTM_{15}$	9.10±4.02	27.41±0.07	3.10±0.10	2.40±0.05	4.30±0.02	55.79
$LMDTM_{16}$	9.10±0.53	24.24±0.80	3.30±0.20	1.31±0.03	4.50±0.02	54.78
$LMDTM_{17}$	9.00±0.26	27.52±0.07	3.40±0.20	2.50±0.02	4.60±0.05	55.26
$LMDTM_{18}$	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 ($LMDTM_2$) had the least protein content (18.38 %) while the sample with 30 % sesame flour+70 % AYB ($LMDTM_{17}$) had the highest protein content (27.52 %). Sesame seed flour and AYB flour seem to have similar effect on protein contents probably on account of the fact that both are legumes. That notwithstanding, Ohuoba *et al.* (2021), Eden *et al.* (1990) as well as Apata and Ologhobo (1990) reported that African Yam bean is an underutilized crop with high protein content (15.8 -34.7 %) and a fairly good source of amino acids. Also, presence of MLP appeared to increase the protein contents of samples. Hence, each sample with 5 % MLP had higher protein content compared with corresponding sample with 0 % MLP (cf $LMDTM_3$ and $LMDTM_4$; $LMDTM_5$ and $LMDTM_6$; etc).

The crude fat contents of flour blends ranged between 0.18 % and 3.90 %. Due to defatting and fermentation of sesame seed, the lipid content was very low in $LMDTM_1$ (0.18 %) while $LMDTM_2$ which contained AYB that was not defatted nor fermented had one of the highest crude fats (3.79 %). That notwithstanding, the increased substitution of $DSDS_F$ with

$TDAYB_F$ did not appear to influence fat content of the flour blends because increase in $TDAYB_F$ did not result to increase in 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: $LMDTM_3$ and $LMDTM_4$; $LMDTM_9$ and $LMDTM_{10}$; 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 ($LMDTM_1$) containing 100 % sesame seed flour had a value of 3.70±0.12 % which was higher than the second control blend ($LMDTM_2$) 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 $LMDTM_{14}$ had the lowest ash content (1.31 ± 0.02 %) while $LMDTM_6$ had the highest value (3.90 ± 0.03 %.). From Table 1, it could be seen that increase in substitution of $DSDS_F$ with $TDAYB_F$ 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 %). 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 $LMDTM_5$ and $LMDTM_6$.

Crude fibre content of flour blends: The crude fibre content of the flour blends are as shown in Table 1. The crude fibre contents ranged from 3.2±0.22 % to 8.88 %. The first control sample ($LMDTM_1$) had the lowest crude fibre content while the second control sample ($LMDTM_2$) had the highest. Fermentation of sesame seed could be responsible for the very low value of crude fibre in $LMDTM_1$ sample. Increased substitution of $DSDS_F$ with $TDAYB_F$ increased the crude fibre contents of samples but inclusion of MLP (5 %) reduced crude fibre content of samples.

Carbohydrate content of flour blends: The carbohydrate contents of the flour blends are as shown in Table 1. The carbohydrate contents ranged from 52.75 % to 65.45 %. The first control sample ($LMDTM_1$) which was composed of 100 % defatted and dehulled sesame seed flour had the highest value of 65.45 % while the second control sample ($LMDTM_2$) which was composed of 100 % $TDAYB_f$ had a value of 59.11 % while $LMDTM_{18}$ had the lowest value of 52.75 %. This suggests that increased substitution of $DSDS_F$ with $TDAYB_F$ reduced 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^3 to 0.711 g/cm^3. The first control sample ($LMDTM_1$) which had 100 $DSDS_F$ had the highest value of 0.711 g/cm^3 while the second ($LMDTM_2$) which contained 100 % $TDAYB_F$ had a value of 0.643 g/cm^3, and the least value was seen in $LMDTM_5$ with a value of 0.610 g/cm^3. 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; appearances 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). $LMDTM_1$ had a higher WAC (165.52 %) compared to $LMDTM_2$ (152.90 %). WAC reduced with increase in substitution of $DSDS_F$ with $TDAYB_F$, with $LMDTM_{14}$-$LMDTM_{18}$ having the lowest values (124.00-124.02%). There were significant differences in water absorption capacity ($p<0.05$). Inclusion of MLP slightly increased the water absorption

capacity. This is evidenced from the 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 snack (chips) and depends partly on the damaged starch contained in the flour, the protein contents and particle size (Kulkani *et al*., 1991).

The oil absoption capacity (OAC) of the flour blends ranged from 64.20 % to 94.5 %. Sample $LMDTM_1$ had the highest value of 94.5 % while samples $LMDTM_{15}$ and $LMDTM_{16}$ had the lowest OAC values. The first control sample, $LMDTM_1$ which contained 100 % $DSDS_F$, had a higher OAC (94.5 %) compared to second control sample, $LMDTM_2$ which had 100 % $TDAYB_F$, 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. Increase in substitution of $DSDS_F$ with $TDAYB_F$ 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^3)	Water Absorption Capacity (%)	Oil absorption capacity (%)	Solubility (%)	Swelling power	Foaming capacity (%)	Emulsification (%)
1.	$LMDTM_1$	0.711^{a}	165.52^{a}	94.50^{a}	13.40^{a}	3.50^{ab}	8.00^{a}	46.20^{cd}
2	$LMDTM_2$	0.643^{b}	152.90^{b}	84.56^{b}	12.31^{a}	4.85^{a}	0.00^{c}	47.20^{bc}
3	$LMDTM_3$	0.618^{b}	165.11^{a}	88.34^{a}	11.21^{ab}	4.63^{a}	0.00^{c}	47.60^{bc}
4	$LMDTM_4$	0.611^{b}	164.33^{ab}	86.14^{a}	11.61^{a}	4.96^{a}	0.00^{c}	47.40^{bc}
5	$LMDTM_5$	0.610^{b}	167.66^{a}	81.30^{b}	8.91^{bc}	5.06^{a}	0.00^{c}	48.90^{b}
6	$LMDTM_6$	0.624^{b}	159.71^{ab}	75.82^{ab}	9.21^{bc}	5.02^{a}	0.00^{c}	48.20^{bc}
7	$LMDTM_7$	0.639^{b}	158.67^{ab}	73.90^{ab}	10.01^{b}	4.82^{a}	0.00^{c}	51.40^{b}

8	$LMDTM_8$	0.639^{b}	142.22^{bc}	$7\ 3.29^{ab}$	9.41^{c}	4.81^{a}	0.00^{c}	51.00^{b}
9	$LMDTM_9$	0.655^{a}	133.77^{bc}	72.43^{ab}	9.91^{b}	4.82^{a}	0.00^{c}	50.80^{b}
10	$LMDTM_{10}$	0.654^{a}	135.66^{bc}	71.26^{ab}	9.61^{b}	4.91^{a}	0.00^{c}	53.20^{b}
11	$LMDTM_{11}$	0.653^{a}	127.68^{d}	71.40^{ab}	9.61^{b}	4.99^{a}	0.10^{c}	54.00^{b}
12	$LMDTM_{12}$	0.653^{a}	127.69^{d}	69.41^{a}	9.31^{bc}	4.65^{a}	0.00^{c}	55.00^{ab}
13	$LMDTM_{13}$	0.656^{a}	125.64^{d}	69.56^{ab}	9.01^{bc}	4.20^{ab}	0.00^{c}	56.20^{ab}
14	$LMDTM_{14}$	0.659^{a}	124.02^{d}	68.89^{ab}	7.21^{d}	3.95^{ab}	0.60^{b}	60.10^{a}
15	$LMDTM_{15}$	0.668^{a}	124.00^{d}	64.20^{c}	7.31^{d}	3.62^{ab}	5.70^{b}	62.30^{a}
16	$LMDTM_{16}$	0.668^{a}	124.00^{d}	64.20^{c}	7.31^{d}	3.62^{ab}	5.70^{b}	62.30^{a}
17	$LMDTM_{17}$	0.658^{a}	124.02^{d}	68.91^{ab}	7.31^{d}	3.96^{a}	5.70^{b}	60.20^{a}
18	$LMDTM_{18}$	0.669^{a}	124.01^{d}	65.24^{c}	7.31^{d}	3.63^{ab}	5.60^{b}	60.10^{a}

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. 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 as shown in Table 2. Solubility index ranged from 7.21 % to 13.4 %. Sample $LMDTM_1$ (first control sample) which contained 100 % $DSDS_F$ and no $TDAYB_F$ had the highest value (13.4 %) while $LMDTM_{14}$ had the lowest value (7.21 %). Also $LMDTM_1$ (first control sample with 100 $DSDS_F$) had a higher solubility index (13.4

%) compared to $LMDTM_2$ (second control sample with 100 5 $TDAYB_F$ 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 increase in substitution of $DSDS_F$ with $TDAYB_F$, at least up to $LMDTM_{14}$ which contained 50 % $DSDS_F$ + 50 % $TDAYB_F$, suggesting that AYB ($TDAYB_F$) had more soluble substances than fermented sesame seed flour ($DSDS_F$). No differences in solubility index were recorded from $LMDTM_{15}$ to $LMDTM_{18}$. Inclusion of 5 % MLP (within the range of $LMDTM_3$ to $LMDTM_{14}$) showed a higher solubility index compared to corresponding samples with 0 % MLP but beyond $LMDTM_{14}$, 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 $LMDTM_1$ and $LMDTM_2$ 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 increase in substitution of $DSDS_F$ with $TDAYB_F$, with $LMDTM_{18}$ having one of the least value of 3.63 %. 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 produce 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 ($LMDTM_1$) which contained 100 % $DSDS_F$ + 0 % $TDAYB_F$ had foaming capacity of 8.0 % whereas the second control sample ($LMDTM_2$) with 100 % $TDAYB_F$ + 0 % $DSDS_F$ 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

$LMDTM_3$ to $LMDTM_{13}$ showing that toasted AYB diluted the foaming capacity of the flour blends. However, at higher levels of addition of toasted AYB (from $LMDTM_{11}$), foaming ablity was noticed to be very low ($LMDTM_{11}$ = 0.10 %) but increased from $LMDTM_{14}$ to LMDTM18 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 are as shown in Table 2. The emulsification capacity ranged from 46.20 % to 62.30 %. The emulsification capacity of $LMDTM_1$ and $LMDTM_2$ were similar and lower than all other blends. The emulsification capacity increased with increase substitution of $DSDS_F$ with $TDAYB_F$ from 47.6 % ($LMDTM_3$) to 60.30 % ($LMDTM_{15}$ and $LMDTM_{16}$). However, it appears from Table 2 that a threshold was reached with addition of 55% and 60 % TDAYB ($LMDTM_{15}$ and $LMDTM_{16}$) both of which had a value of 62.30%) beyond which there were reductions in the emulsification capacity of the blends ($LMDTM_{17}$ = 60.20 % and $LMDTM_{18}$ = 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 are found in plants. There were significant differences ($p<0.05$) between the blended flour samples in the phytate contents. The first control sample ($LMDTM_1$) contained significantly the highest amount of phytate (16.29 mg/100g) while the second control sample ($LMDTM_2$) contained the least phytate (7.89 mg/100g). The differences could be due plant species differences or that toasting of AYB was more effective in reducing phytate than fermentation of sesame seed. Phytate continued to reduce with increase in substitution of $DSDS_F$ with $TDAYB_F$ due to dilution effect resulting from the low phytate content of TDAYB flour. Higher inclusion of MLP increased 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 $LMTDM_1$ (100 % dehulled solid state fermented sesame seed flour) had the higher amount of phytate (16.29 mg/100g) than sample $LMDTM_2$ (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 increase in substitution of $DSDS_{F\ with}$ $TDAYB_F$ due to dilution effect resulting from low tannin in $TDAYB_F$ 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 $LMDTM_{7}$ with $LMDTM_8$ and $LMDTM_{15}$ with $LMDTM_{16}$).

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 ($LMDTM_1$) had significantly ($p<0.05$) the highest trypsin inhibitor (1.2 mg/100g) while the second control sample ($LMDTM_2$) had a value of 0.93 mg/100g which was, however, not significantly ($p>0.05$) different from $LMDTM_1$. Trypsin inhibitor significantly ($p<0.05$) reduced with increase in substitution of $DSDS_F$ with $TDAYB_F$ from 0.83 mg/100g ($LMDTM_3$) to 0.27 mg/100g ($LMDTM_{17}$). 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-nutrients content of flour blends

Samples	Phytate (mg/100g)	Tannin (mg/100g)	Trypsin inhibitor
$LMDTM_1$	16.29 ± 0.04^{a}	4.64 ± 0.02^{a}	1.20 ± 0.78^{a}
$LMDTM_2$	7.89 ± 0.02^{fg}	4.57 ± 0.05^{a}	0.93 ± 0.36^{a}
$LMDTM_3$	16.01 ± 0.02^{a}	4.51 ± 0.01^{a}	0.83 ± 0.22^{a}

$LMDTM_4$	15.02 ± 0.05^{b}	4.89 ± 0.01^{a}	0.56 ± 0.36^{a}
$LMDTM_5$	16.10 ± 0.03^{a}	4.01 ± 0.02^{b}	0.35 ± 0.75^{bc}
$LMDTM_6$	13.00 ± 0.03^{c}	4.00 ± 0.03^{b}	0.94 ± 0.33^{a}
$LMDTM_7$	12.34 ± 0.04^{cd}	4.43 ± 0.10^{b}	0.80 ± 0.66^{a}
$LMDTM_8$	11.11 ± 0.05^{d}	4.49 ± 0.01^{a}	0.73 ± 0.23^{a}
$LMDTM_7$	11.33 ± 0.05^{d}	4.34 ± 0.01^{b}	0.47 ± 0.72^{b}
$LMDTM_8$	10.01 ± 0.05^{e}	4.49 ± 0.05^{a}	0.27 ± 0.94^{c}
$LMDTM_9$	14.99 ± 0.05^{b}	4.33 ± 0.10^{b}	0.18 ± 0.21^{c}
$LMDTM_{10}$	9.00 ± 0.03^{f}	4.44 ± 0.05^{b}	0.61 ± 0.43^{a}
$LMDTM_{11}$	12.13 ± 0.03^{d}	4.24 ± 0.03^{b}	0.98 ± 0.18^{a}
$LMDTM_{12}$	10.00 ± 0.05^{e}	4.24 ± 0.02^{b}	0.61 ± 0.76^{a}
$LMDTM_{13}$	10.13 ± 0.02^{e}	4.24 ± 0.02^{b}	0.57 ± 0.82^{a}
$LMDTM_{14}$	11.14 ± 0.02^{d}	4.21 ± 0.04^{b}	0.33 ± 0.71^{c}
$LMDTM_{15}$	9.22 ± 0.02^{f}	4.26 ± 0.03^{b}	0.33 ± 0.42^{c}
$LMDTM_{16}$	9.13 ± 0.02^{f}	4.11 ± 0.02^{c}	0.34 ± 0.55^{c}
$LMDTM_{17}$	12.29 ± 0.04^{cd}	4.14 ± 0.10^{c}	0.27 ± 0.59^{c}
$LMDTM_{18}$	8.00 ± 0.05^{h}	4.12 ± 0.05^{c}	0.52 ± 0.79^{b}

Values are means of triplicates determinations. Means with different superscripts in a column are significantly different ($p\geq0.05$)

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-nutrients 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 a period of one month to monitor kinetics and physiochemical changes of products 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 of the utilization of product.

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