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Proximate, Chemical and Functional Properties of Wheat, Soy and Moringa Leaf Composite Flours

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Abstract

The study presents the effect of utilizing wheat, soy and moringa leaf flour and quality analysis of the flour. The composite flour was prepared using refined wheat flour, soy flour and moringa leaf flour. Four composite flour, compositions were formulated such as 100% wheat flour (control) designated as sample A. Sample B consisted of 75% wheat, 20% soybean and 5% moringa leaf. Sample C consisted of 70% wheat, 20% soybean and 10% moringa leaf. Sample D was 65% wheat, 20% soybean and 15% moringa leaf. Sample E was 60% wheat, 20% soybean and 20% moringa leaf, respectively. Proximate, chemical, and functional properties of wheat, soy and moringa leaf flours were studied in composite flour variation and preparations. The present study highlighted the nutrients enrichment of flour on incorporation of soy and moringa leaf. Relevant statistical tests were done to analyse the significance of means for all tested parameters. Composite flour composition with 20% soybean was identified to produce optimal nutrient, mineral quality and yield. The addition of soybean and moringa flour in baked products has been shown in this study to improve the nutrition and health benefits of the body. It also serves as a good cut on the cost of wheat importation in communities with supply challenges.

Keywords

Proximate Analysis, Composite Flour, Soybeans Wheat Flour and Moringa Leaf

1. Introduction

Composite flour has been defined in numerous researches as a combination of wheat and non-wheat flours to produce bread and other baked product [1]. It is the use of wheat and non-wheat flour. It is also the binary or ternary mixture of flour from other crops with or without the addition of wheat flour [1] [2]. Composite flour technology was initiated by the food and health organization was targeted to reducing the cost of support for temperate countries by encouraging the utilization of viable substitutes such as yam, cassava for wheat flour [3] [4] [5]. Efforts have been made to promote the use of composite flours in which flour from locally grown and high protein crops will replace a portion of wheat flour. This blend is expected to be used in bread and other bread product, thereby decreasing the demand for imported wheat and producing protein enriched bread. Although there is now a substantial amount of available composite bread technology, such breads still require at least 70 percent wheat flour to be able to rise [2].

Wheat flour approximately consists of 72% carbohydrates, 8% to 13% protein, 12% to 13% moisture, 2.5% sugar, 1.5% fat, 1.0% soluble protein and 0.5% minerals salts [4] [5]. Wheat flour is the main ingredient used in the manufacturing of bread, noodles and characteristics of wheat used for milling are very important [6] [7]. The use of wheat and soybeans will balance the amino acids and may also improve the nutritive value of cereal-based food products [8]. Therefore, legumes can be successfully used in breads and other baked products to obtain protein-enriched foods with improved amino acid balance [9] [10].

Soybean is one of the most important oil and protein crops of the world containing 30% to 45% protein [11]. It is an excellent source of protein because it contains all the essential amino acids, is very rich in minerals and is a good source of fat-soluble vitamins [12]. Therefore, the inclusion of soybeans, *Moringa oleifera*, defatted sesame, pomegranate peel, and cray fish flour in wheat will enhance the nutrients of the product [7] [13] [14]. Moringa leaves are a good source of micronutrients and are concentrated with protein [15] [16]. The leaves are exceptionally excellent source of β-carotene, vitamin C, calcium, iron, potassium, magnesium, selenium, zinc, and a good balance of all the essential amino acids [17] [18]. Moringa leaf proteins ranged from 29.1 to 35.3 g/100g dry weight [19]. The formulation of wheat, soybeans and moringa leaf would diversify their use, enhance value addition and nutritional content of the bread and other baked products, especially the micronutrients.

Limited researches are available on the use of soybean and Moringa as non-wheat flour addition for composite flour. This study therefore intends to investigate the functional nutrient and mineral properties of the addition of soybean and Moringa leaf flour as protein and vitamin rich plant as composite flour in wheat.

2. Materials and Method

The Moringa leaves used in this research study were collected from Federal

University of Agriculture, Makurdi farm and the soybean were purchased at the seed store house in Barnada office premises Makurdi. The specimens were both identified at the botany laboratory, Benue State University, Makurdi, North Central, Nigeria as *Moringa oleifera* and Glycine Max, respectively. Wheat flour was purchased at modern market Makurdi town of Benue State, Nigeria.

2.1. Preparation of Raw Materials

Soybeans flour was produced using the method of Akubor *et al.* [20] modified by cleaning manually and washing before boiling. Soybeans were manually cleaned by hand picking the chaff and the stones. The cleaned soya beans were washed with water in order to remove the adhering dirt and pour in heated water of 100˚C to boil for 30 minutes to remove the anti-nutritional factors and beany flavour. The boiled soya beans were dehulled and washed properly. The grains were dried in an oven (Pax 2 & Pax 3 vented oven lid 2.0) at 60˚C for 24 - 48 hours to a moisture content of about 10%. The dried grains were milled using Attrition milling machine and the flour was sieved into fine flour of uniform particle size by passing them through a 0.4 mm mesh sieve and packaged in polyethylene bags and kept at room temperature for later use. The flow chart to produce soy flour is shown in **Figure 1**.

Moringa leaf flour was produced using the method of Aye [21]. Moringa leaves were removed by hand from the stems and washed in water to remove dirt and other contaminants. The leaves were removed from water using plastic baskets and allow for 30 minutes to drain the water. The leaves were spread on clean sacks and dried in a clean house at room temperature for 25 days. The leaves were pounded in a mortar and later milled or grinded to pass through a 0.4 mm sieve mesh size, the moringa leaves flour were packaged in airtight containers for later use. The flow chart to produce moringa leaf flour is shown in **Figure 2**.

2.2. Formulation of Flour Blends

Composite flour of wheat, soybean and moringa leaf samples were prepared as reported below. The five (5) blends were formulated by replacement as follows. One hundred percent wheat (100% wheat) flour was the control designated as sample A. Sample B consisted of 75% wheat, 20% soybean and 5% moringa leaf. Sample C consisted of 70% wheat, 20% soybean and 10% moringa leaf. Sample D was 65% wheat, 20% soybean and 15% moringa leaf. Sample E was 60% wheat, 20% soybean and 20% moringa leaf, respectively. The blends were thoroughly mixed using a Kenwood blender (BLG 450 Blender/Grinder) to achieve uniform blending and the ratio of the formulation in w/w is as shown in **Table 1**.

2.3. Proximate Analyses of Wheat, Soy and Moringa Leaf Composite

The moisture, ash, fat, crude fiber, protein contents of the flour was determined

using the method of Association of Official Analytical Chemist (AOAC) [22]. The carbohydrate content would be determined by difference. Therefore, the total sum of the percentage of moisture, ash, fat, crude fiber, and protein was subtracted from the sum total composition, following the method of Egounlety [23].

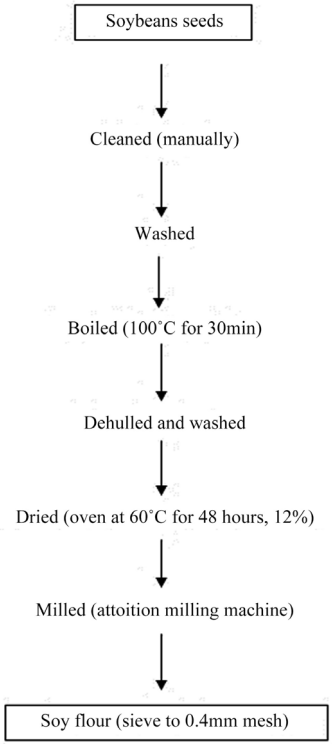

Figure 1. Flow chart for preparation of soybeans flour [20].

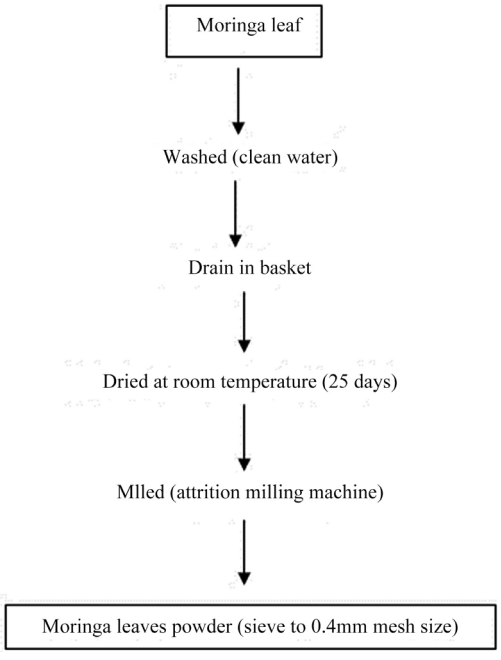

Figure 2. Flow chart for preparation of moringa leaf powder [21].

Table 1. Formulation of wheat, soybean and moringa leaf composite flour.

[i]Samples	Wheat %	soybeans %	moringa leaf %
A	100	0	0
B	75	20	5
C	70	20	10
D	65	20	15
E	60	20	20

[i]Composite flour samples A - E to produce bread and other baked products.

2.3.1. Determination of Protein

About 2 g of the flour sample was weighed into a digestion tube and 15 mL of concentrated H_2SO_4 was added to dissolve the sample. Kjedhal tablets were added to start up the digestion process in a fume cupboard pre-set at 410˚C for 45 minutes until it gives a clear solution and 75 mL of distilled water was added to prevent it from solidifying after digestion. The tube was placed in a distilling unit and 50 ml of 40% NaOH dispensed into the diluted solution, and the digested distillate into 25 ml of 40% boric acid for 5 minutes. The distillate was titrated against 0.47 HCl until the first grey colour was seen. A blank was first run, and the titre value was recorded in line with AOAC [22]. The percentage nitrogen is a product of total nitrogen and the conversion factor.

$$\text{Total Nitrogen} = \frac{\text{Titre value} \times 14.01 \times 0.47}{\text{Weight of sample} \times 100} \quad (1)$$

Molecular weight of nitrogen = 14.0, molarity of HCl = 0.47, conversion factor = 6.25.

2.3.2. Determination of Moisture Content

The moisture content of flour sample was determined using the force air oven. (AOAC, 2015) [22]. This method involves the measurement of weight lost due to the evaporation of water and other components.

$$\%\ \text{Moisture} = \frac{\left(\text{weight of dish} + \text{sample before drying}\right) - \left(\text{weight of dish} + \text{sample after drying}\right)_1}{\left(\text{weight of dish} + \text{sample before drying}\right)} \times 100 \quad (2)$$

A clean dish with a lid was dried in an oven at 100˚C, it was cooled in a desiccator and weighed. Two grams of the sample was weighed into the dish. The dish with its content was put in the oven at 105˚C and dried to a constant weight. The moisture content was calculated as the percentage of the original sample weight.

2.3.3. Determination of Ash Content

Using the AOAC method, sample of 5 g was weighed into an ash dish that has been ignited, cooled in a desiccator, and weighed soon after reaching room temperature. It was ignited in a muffle furnace at 550˚C for 6 - 7 hours. The dish was cooled in a desiccator and weighed soon after reaching room temperature.

The procedure was repeated for the remaining samples and the total ash was calculated as the percentage of the original sample weight as shown below:

$$\%\ \text{Ash} = \frac{(\text{weight of empty dish} + \text{content after ashing}) - (\text{weight of empty dish} + \text{sample})}{(\text{Weight of empty dish}) - (\text{weight of empty dish} + \text{content after ashing})} \times 100 \quad (3)$$

2.3.4. Determination of Fat Content

Flour sample of 10 g (W) was weighed and put into a test tube. 10 ml of conc. HCl was added and put in a boiling water bath until solid particles dissolve and the mixture became brown. It was taken off and cooled, then transferred into a separating funnel. 10 mL of ethanol and 30 mL of diethyl ether was added and shake, the solution was left to stand and separate.

A clean dried conical flask (W_1) was weighed and the ether layer was taken into the conical flask. The extraction was repeated twice with 25 mL of diethyl ether and the solvent was evaporated in a water bath. The fat at 105˚C in an oven was Cooled and weighed (W_2). The procedure was repeated for the remaining samples and the % fat was calculated as shown below:

$$\%\ \text{Fat} = \frac{(\text{Weight of dried conical flask} + \text{content after drying}_2) - \text{Weight of dried conical flask}_1}{\text{Weight of the sample}} \times 100 \quad (4)$$

2.3.5. Determination of Crude Fibre

Crude fibre was determined using the method of AOAC [22]. About 2 g of flour samples were weighed into a 600 mL long beaker. About 200 mL of hot 1.25% H_2SO_4 was added. Beaker was placed on digestion apparatus with preheated plates, boiled, refluxed for 30 mins and filtered through Whiteman GF/A paper by gravity. The beaker was rinsed with distilled water. The residue was washed on the paper with distilled water until the filtrate was neutral. The residue was transferred from the paper back to the beaker containing 200 mL of hot 1.25% NaOH. Steps 4 and 5 were repeated. The paper with residue was transferred into a crucible, dried at 100˚C overnight, cooled in a desiccator and reweighed (weight A). The samples were put in furnace at 600˚C for 6 hrs, cooled in a desiccator and reweighed (weight B). The loss in weight during incineration represents the weight of crude fibre.

$$\%\ \text{crucible fibre} = (\text{weight A}) - (\text{weight B}) \times 100 \quad (5)$$

2.3.6. Determination of Carbohydrate

The method of (AOAC, 2015) [22] was used to calculate the carbohydrate value. The carbohydrate content of each sample was determined using the formula below:

$$\text{Carbohydrate} = 100 - (\%\ \text{moisturecontent} + \%\ \text{ash} + \%\ \text{protein} + \%\ \text{fat}) \quad (6)$$

2.3.7. Determination of Calorific Content of Composite Flour from Wheat, Soy and Moringa Leaf

The calorific value was calculated using the method of (AOAC, 2015) [22]. The

value was obtained for protein, fats and carbohydrates were used to calculate the calorific content value of the sample as expressed below

$$\text{Calorific Value}\left(\frac{\text{KCal}}{100\text{ g}}\right)=(\text{Protein}\times 4.0)+(\text{Fat}\times 9.0)+(\text{Carbohydrate}\times 3.75) \quad (7)$$

2.4. Determination of Functional Properties of Composite Flour from Wheat, Soybean and Moringa Leaf

Foaming capacity (FC) was determined by the method of Sathe *et al.* [24]. The volume of foam at 30 sec of whipping was expressed as FC. The volume of foam was recorded 1 h after whipping to determine FC as a percent composition of the initial foam volume. Bulk density was determined by the method of Onimawo and Egbekwun [25]. Water and oil absorption capacities were determined following the methods of Sosulski *et al.* [26]. Swelling index was determined by the method of [25].

2.4.1. Foaming Capacity

This was determined by the method described by Coffman and Garcia [27]. About 2 g of sample was blended with 100 mL distilled water in a Kenwood blender. The suspension was whipped in an ace homogenizer (NSEIAM-6) at 1600 rpm for 5 min. The mixture was poured into a 250 mL graduated cylinder and the volume was recorded after 30 sec. The foaming capacity was expressed as percentage increase in volume using the formula:

$$\text{Foam Capacity}=\frac{\text{Volume after whipping}-\text{Volume before whipping}}{\text{Volume before whipping}}\times 100 \quad (8)$$

2.4.2. Bulk Density

Bulk density was determined by the method described by Onwuka *et al.* [28]. Ten (10 mL) capacity graduated measuring cylinder was filled gently with each sample. The bottom of the cylinder was gently tapped on a laboratory bench several times until there was no further diminution of the sample level. Bulk density was calculated as shown below.

$$\text{Bulk Density}=\frac{\text{Final Weight}-\text{Initial Weight}}{\text{Volume}} \quad (9)$$

2.4.3. Water Absorption Capacity (WAC)

This was determined using the method of Sosulski *et al.* [26] and Ikpeme *et al.* [29]. One gram of the sample was dispensed into a weighed centrifuge tube with 10ml of distilled water and mixed thoroughly. The mixture was allowed to stand for 1 hour before being centrifuged at 3500 rpm for 30 minutes. The excess water (unabsorbed) was decanted and the tube inverted over an adsorbent paper to drain dry. The weight of water absorbed was determined by difference. The water absorption capacity was calculated as:

$$\text{WAC}=\frac{\text{Volume of water used}-\text{Volume of free water}}{\text{Weight of sample used}}\times 100 \quad (10)$$

2.4.4. Swelling Index

The flour for the bread samples was analysed to obtain the value for the swelling index. The method described by Ukpabi and Ndimele [30] was used. Ten grams (10 g) of the sample was measured into a 300 mL measuring cylinder. Then 150 mL of distilled water was added to the sample and allowed to stand for four hours. The final volume after swelling was recorded. The percentage swelling was calculated as:

$$\text{Swelling Index } \% = \frac{\text{Final Volume} - \text{Initial Volume}}{\text{Initial Volume}} \times 100 \quad (11)$$

2.4.5. Oil Absorption Capacity

The oil absorption capacity was performed in line with the method described by Sosulski *et al.* [26]. 10 mL distilled oil was mixed with 1 g of the flour sample, the mixture was allowed to rest at 30˚C ± 2˚C for 30 min and then centrifuged at 200 xg for 30 min.

2.5. Determination of Mineral Content of Composite Flours from Wheat, Soy and Moringa Leaf

Two grams (2 g) of each composite flour sample were weighed into a clean ceramic crucible using the method of AOAC [22]. A blank was prepared with empty crucible. The crucible was placed in a muffle furnace at 500˚C for 4 hours. The samples were allowed to cool down in the oven after which it was removed carefully. The ash samples were poured into already labelled 50 mL centrifuge tube. The crucible was rinsed with 5 mL of distilled water into the centrifuge tube. The crucible was rinsed again with 5 mL of aqua regid. This was repeated to make a total volume of 20 mL. The sample was mixed properly and centrifuged by 10 min. The supernatant was decanted into clear vials for minerals determination. The absorbance was read on atomic absorption spectrophotometer (Buck Scientific Model 200A) at different wavelengths for each mineral element.

2.5.1. Determination of Zinc

Zinc in the samples of composite four was determined according to Onwuka [31] by molybdate method using hydroquinone as a reducing agent. Five milliliters (5 mL) of the test solution was pipetted into 50 ml graduated flask. Then 10 mL of molybdate mixture was added and diluted to mark with water. It was allowed to stand for 30 minutes for colour development. The absorbance was measured at 660 nm against a blank. A curve relating absorbance to mg zinc present was constructed. Using the zinc standard solution, and following the same procedure for the test sample, a standard curve was plotted to determine the concentration of zinc in the composite flour sample.

$$\% \text{ Zinc} = \frac{\text{graph reading} \times \text{solution volume}}{100} \quad (12)$$

2.5.2. Determination of Iron

Iron was determined following the phenanthroline method of Lee and Stumm

[32]. Five milliliters of digested sample of composite four was placed in a 50 mL volumetric flask. Then 3 mL of phenanthroline solution, 2 mL of hydrochloric acid and 1mL of hydroxylamine solution were added to the sample in sequence. The sample solution was boiled for 2 minutes and 9 ml of ammonium acetate buffer solution was added to the solution. The solution was diluted with water to 50 mL volume. The absorbance was determined at 510 nm wavelength. Iron standard solution was prepared in order to plot a calibration curve to determine the concentration of the sample. Standard solution containing 100 mg/mL of ferric irons was prepared from 1g pure iron wires. The wires were dissolved in 100 mL concentrated nitric acid, boiled in a water bath and diluted to 100 mL with distilled water after cooling. Standard solutions of known concentrations were prepared by pipetting 2, 4, 6, 8 and 10 mL standard iron solution into 100 mL volumetric flasks and made up to volume.

2.5.3. Determination of Potassium

Potassium was determined by a procedure described by Osborne and Voogt [33] using a flame photometer. Potassium standard was prepared. The standard solution was used to calibrate the instrument read out of composite four. The meter reading was at 100% E (emission) to aspire the top concentration of the standards. The %E of all the intermediate standard curves were plotted on linear graph paper with these readings. The sample solution was aspired on the instrument and the readings (% E) were recorded. The concentration of the element in the sample solution was read from the standard curve.

$$\%\ \text{Potassium} = \frac{\text{Ppm} \times 100 \times \text{DF}}{1\ \text{million}} \tag{13}$$

2.5.4. Determination of Calcium

Calcium was determined using the method described by Pearson [34]. Twenty-five milliliter (25 mL) of the digested samples of composite four was pipetted into 250 mL conical flask and a pinch of Eriochrome Black-T-Indicator (EBT) was added. Thereafter, 2 mL of 0.1N NaOH solution was added and the mixture titrated with standard EDTA (0.01M EDTA) solution.

$$\text{Calcium}\left(\text{mg/L}\right) = \frac{\text{Titre value} \times \text{Molarity of EDTA} \times \text{Equiv. Wt. of calcium} \times 1000}{\text{Vol. of sample used}} \tag{14}$$

2.6. Determination of Vitamins Content of Composite Flour of Wheat, Soy and Moringa Leaf

2.6.1. Determination of Vitamin A

The AOAC [35] method using the colorimeter was adopted for determination of either flour. This measures the unstable colour at the absorbance of 620 nm that result from the reaction between vitamin A and SbL3. 100 volume solution × reading graph million 1 DF × 100 × Ppm Pyrogallol (antioxidant) was added to 2 g sample of either flour or bread prior to saponification with 200 ml alcoholic KOH. The saponification took place in water bath for 30 minutes. The solution

was transferred to a separating funnel where water was added. The solution was extracted with 1 - 2.5 mL of hexane. The extraction was washed with equal volume of water. The extract was filtered through filter paper containing 5 g anhydrous Na_2SO_4 into volumetric flask. The filter paper was rinsed with hexane and made up to volume. The hexane was evaporated from the solution and blank. About 1 mL chloroform and SbL3 solution were added to the extract and 32 blanks. The reading of the solution and blank was taken from the colorimeter adjusted to zero absorbance or 100%. Calculation

$$\text{Vit A}\left(\text{mg}\right) = \text{Absorbance at 620 nm} \times \text{Std. curve slope} \times \left(\text{Final} \frac{\text{Volume}}{\text{Sample}} \text{Wt.} \right) \quad (15)$$

2.6.2. Determination of Vitamin C

Metaphosphoric acid-acetic solution (5 mL) was pipette and added to a 2 mL ascorbic acid standard solution in Erlenmeyer flasks in triplicates. The composite four was titrated against indophenols solution until a distinct rose-pink colour formed and persisted for more than 5 sec. The initial and final readings of the burette were recorded. Blanks were prepared in the same way as above and the average titre of indophenols dye used was calculated.

The pulverized mixed fruit leather pieces were dissolved in water and 2 mL sample of composite four or leavened and unleavened bread was added to 5 mL of metaphosphoric acid-acetic acid solution in a 50 mL Erlenmeyer flask and was titrated with the indophenol dye solution until a distinct rose-pink colour persisted for more than 5 s. This was done in triplicate and the initial and final readings of the burette were taken and used to calculate the average titre of dye used.

2.6.3. Determination of Vitamin B_1 (Thiamine)

Thiamine content was determined using the scalar analyzer method of AOAC [22]. Five grams (5 g) of each sample of composite four was homogenized in 5 ml normal ethanoic sodium hydroxide solution. The homogenate was filtered and made up to 100 ml with the extract solution. A 10ml aliquot of the extract was dispensed into a flask and 10 mls of potassium dichromate solution added. The resultant solution was incubated for 15 mins at room temperature (25˚C ± 331˚C). The absorption was read from the spectrophotometer at 360 nm using a reagent blank to standardize the instrument at zero. The thiamine content was calculated as follows:

$$\text{Vit B1}\left(\text{Thiamine mg}/100\text{ g}\right) = \frac{100}{\text{Sample Wt.}} \times \frac{\text{Sample Absorbance}}{\text{Conc. of Soln.}} \times \text{Conc.} \times \text{Dil. Factor} \quad (16)$$

2.6.4. Determination of Vitamin B_2 (Riboflavin) and Vitamin B_3

Riboflavin was determined according to AOAC [22] methods. Two grams (2 g) of composite four samples were placed in a conical flask and 50 ml of 0.2N HCl was added to the sample, boiled for 1 hour, and then cooled. The pH was adjusted to 6.0 using sodium hydroxide 1N HCl was added to the sample solution

to lower the pH to 4.5. The solution was filtered into 100 mL measuring flask and made to volume with water. In order to remove interference, two tubes were taken, labeled 1 and 2. Ten milliliter of filtrate and 1 mL of riboflavin standard were added to test tube 2. About 1 ml of glacial acetic acid was added to each tube and mixed, and then 0.5 mL of 3% $KMnO_4$ solution was added to each tube. They were allowed to stand for 2 minutes, after which 0.5 ml of 3% H_2SO_4 was added and mixed well. The fluorimeter was adjusted to excitation wavelength of 470 nm and emission wavelength of 525 nm. The fluorimeter was adjusted to zero deflection against 0.1N H_2SO_4 and 100 against tube 2 (standard). The fluorescence of tube 1 was read. Two milliliter of sodium hydrogen sulphate was added to both tubes and the fluorescence measured within 10 seconds. This was recorded as blank reading.

$$\text{Vit. B2} = \frac{\left(\text{Sample Rd.} - \text{Blank Rd.}\right)}{\left(\text{Sample Rd.} - \text{Blank Rd.}\right) - \left(\text{Sample Rd.} + \text{Std. Tube} - \text{Sample Rd.} + \text{Std. Blank}\right)} \times \frac{1}{\text{Sample Wt.}} \quad (17)$$

3. Results and Discussion

3.1. Proximate Composition and Energy Values of Wheat, Soybean and Moringa Leaf Composite

Table 2 shows the proximate composition and energy value of wheat, soybean and moringa leaf composite flour. The protein content of Sample A-E varied from 10.24% - 28.81% that was 5% - 10% level of significant with sample A containing the least value of 10.24% while sample E had the highest value of 28.81%. The protein content of the flour increased with a decrease in wheat, an increase in moringa leaf and 20% soybean flour constant. The low protein content of sample A (control) could be because of 100% wheat flour and wheat is deficient in protein [36] [37]. The increase was significant at 5% level of probability. This result agrees with the work done by Teixeria *et al.* [38] and Soetan *et al.* [39] who reported on fractionation of protein from moringa leaves, protein in the moringa seeds and leaves of African locust bean.

Table 2. Proximate composition (%) and energy value (kcal/100g) of flour blends from wheat, soybean and moringa leaf composite flours.

Sample	Protein	Fat	Crude fibre	Ash	Moisture	Carbohydrate	Calorific value (kcal/100mg)
A	$10.24^{e} \pm 0.03$	$1.52^{e} \pm 0.01$	$2.05^{e} \pm 0.03$	$5.60^{e} \pm 0.02$	$10.20^{a} \pm 0.42$	$67.67^{a} \pm 0.01$	$328.40^{d} \pm 0.28$
B	$19.88^{d} \pm 0.03$	$1.54^{d} \pm 0.00$	$2.25^{d} \pm 0.01$	$6.11^{d} \pm 0.01$	$10.59^{e} \pm 0.04$	$60.83^{b} \pm 0.01$	$321.49^{a} \pm 0.01$
C	$22.52^{c} \pm 0.01$	$1.85^{c} \pm 0.03$	$2.50^{c} \pm 0.00$	$7.10^{c} \pm 0.01$	$11.021^{d} \pm 0.03$	$55.77^{c} \pm 0.01$	$315.87^{b} \pm 0.04$
D	$25.83^{b} \pm 0.02$	$2.16^{b} \pm 0.01$	$2.80^{b} \pm 0.01$	$7.92^{b} \pm 0.03$	$11.74^{c} \pm 0.06$	$49.55^{d} \pm 0.03$	$308.57^{c} \pm 0.03$
E	$28.81^{a} \pm 0.01$	$2.37^{a} \pm 0.02$	$3.00^{a} \pm 0.14$	$8.66^{a} \pm 0.02$	$12.22^{b} \pm 0.04$	$44.94^{e} \pm 0.01$	$305.10^{e} \pm 0.03$
LSD (0.05)	0.06	0.05	0.17	0.06	0.50	0.05	0.33

Values are shown as mean ± standard deviation of replicates (3 repetitions of each group were made with mean average presented for robust analysis). Mean values followed by different superscripts in a column are significantly different ($P < 0.05$). Key: A = (100% Wheat), B = (75% Wheat, 20% Soybeans, 5% Moringa leaf), C = (70% Wheat, 20% Soybeans, 10% Moringa leaf), D = (65% Wheat, 20% Soybeans, 15% Moringa leaf), E = (60% Wheat, 20% Soybeans, 20% Moringa leaf), LSD = Least Significant Different.

The fat content of the wheat, soybeans and moringa leaf flour varied from sample A - E (1.52% - 2.37%), with sample A comprising of the least value of 1.52% while sample E recorded the highest value of 2.37%. The fat content increased with increase in moringa leaf flour and 20% soybean flour. The increase in fat content was moderately low with significant decrease in wheat flour, increase in moringa leaf and 20% soybeans constant. The low increase in fat could elongate the storage performance of the composite flour as rancidity may occur in the flour blends of high amount of fats. The increased was significant at 5% level of probability following the work of Soetan *et al.* [39] on the fat content of African locust beans.

The crude fibre augmented from 2.05% - 3.00% of Sample A - E with sample A registering the smallest value of 2.05% meanwhile sample E encompassed the largest value of 3.00%. The crude fibre content of the flour enhanced with increase in moringa leaf flour and 20% soybean flour constant. This could be so as soybean and moringa leaf are excellent source of fibre as reported by Gidamis *et al.* [40] and Sivakumar [41] based on previous report on adsorption study on municipal solid waste leachate using moringa seed. The increase was significant at 5% level of probability.

The Ash content of the composite flour varied from 5.60% - 8.66% of Sample A - E with sample A containing the least value of 5.60% while sample E had the highest value of 8.66%. The ash content increased with increase in moringa leaf flour and 20% soybean flour. The increase was significant at 5% level of probability. The ash content of the samples increased with increase in the moisture content of the flour formulations. These findings agree with the work done by Iskandar *et al.*, [42] on moringa leaf extracts supplementation and Abdelghafor *et al.* [43] on the ash content of composite flour of sorghum and hard white wheat. Increase in ash content of the flour shows that samples with high amount of ash will be excellent in mineral content.

The Moisture content arranged from 5% - 10% (Sample A - E) with sample A comprising the least value of 10.20% while sample E had the highest value of 12.22% which is in agreement with the research work of Nour and Ibrahim [44] on moisture effect of supplementation with moringa leaf powder and Alaunyte *et al.* [45] on combination of enzymes in straight dough. The moisture content increased with decrease in the carbohydrate value of the samples enhancing nutritional products.

The carbohydrate content assorted from 67.67% - 44.94% of Sample A comprising the highest value of 67.67% while sample E had the lowest value of 44.94%. The carbohydrate value decreased with increase in moringa leaf flour and 20% soybean flour. The decrease was significant at 5% level of probability and the carbohydrate value decreased between the flour samples which create room for high amount of nutrients. This finding is in line with the work done by Nour and Ibrahim [46] and, Steyn and Mchiza [47] on millet flour supplementa-

tion with moringa seeds. This is in addition to Freire *et al.* [48] on obesity and carbohydrate in Sub-Saharan Africa reported under nutrition and excess body weight.

The Calorific value ranged from 328.40% - 305.10% (Sample A - E) with the variation of 5% - 10% level of significant with sample A recording the highest energy value of 328.40% with sample E containing the lowest calorific value at 305.10%. The calorific content decrease with decrease in wheat flour, increase in moringa leaf flour and 20% soybean flour. This agrees with the report of Alaunyte *et al.* [45] on combination of enzyme in straight dough and sourdough bread making. The carbohydrate content and calorific value of the formulated samples decreased with increase in composite flour of soybeans and moringa leaf flour blends, this could be attributed to high protein, fibre, ash and moisture content of soybeans and moringa leaf flour combined with decrease in wheat flour.

3.2. Functional Properties of the Composite Flour of Wheat, Soybeans and Moringa Leaf

Table 3 shows the functional properties of the wheat, soybeans and moringa leaf flour before value addition. Foaming capacity, bulk density, water absorption capacity, swelling index and oil absorption capacity of the flours were evaluated. Functional properties are the characteristics that determine the suitability of the food material for specific purpose. Foaming capacity of the composite flour for the production of bread decrease from 29.26% sample A to 18.50% Sample B and later raise to 22.20% Sample C, 25.89% Sample D and 29.60% Sample E having the highest foaming capacity and sample B having the least value. The higher the foaming capacity, the better the reconstitutional properties of the flour which has a marked effect on the kneading quality [49] [50].

Table 3. Functional properties of wheat, soybean and moringa leaf composite flour.

Sample	Foaming Capacity (%)	Bulk Density (g/ml)	Water Absorption Capacity (%)	Swelling Index	Oil Absorption Capacity (%)
A	$29.26^{a} \pm 0.03$	$0.73^{b} \pm 0.01$	$80.27^{b} \pm 0.01$	$6.73^{a} \pm 0.01$	$91.54^{b} \pm 0.01$
B	$18.50^{d} \pm 0.14$	$0.50^{e} \pm 0.01$	$56.80^{e} \pm 0.01$	$3.56^{e} \pm 0.02$	$61.36^{e} \pm 0.03$
C	$23.50^{c} \pm 2.12$	$0.60^{d} \pm 0.01$	$68.20^{d} \pm 0.02$	$4.30^{d} \pm 0.02$	$73.63^{d} \pm 0.01$
D	$25.89^{b} \pm 0.04$	$0.70^{c} \pm 0.01$	$79.50^{c} \pm 0.01$	$5.00^{c} \pm 0.01$	$85.90^{c} \pm 0.01$
E	$29.60^{a} \pm 0.28$	$0.80^{a} \pm 0.01$	$91.00^{a} \pm 0.01$	$5.70^{b} \pm 0.00$	$98.17^{a} \pm 0.02$
LSD (0.05)	2.47	0.05	0.05	0.05	0.05

Values are shown as mean ± standard deviation of replicates. Means values followed by different superscripts in a Column are significantly different ($P < 0.05$). Key: A = (100% Wheat), B = (75% Wheat, 20% Soybeans, 5% Moringa leaf), C = (70% Wheat, 20% Soybeans, 10% Moringa leaf), D = (65% Wheat, 20% Soybeans, 15% Moringa leaf), E = (60% Wheat, 20% Soybeans, 20% Moringa leaf), LSD = Least Significant Different.

The value for the bulk density (g/ml) augmented from 0.73% to 0.80% of sample A had the least value and sample E having the highest value. There was a significant difference among the flour samples. Swelling index (%) was arranged from 6.73 (sample A) to 5.70 (sample E) with 100% wheat flour recording the highest value of swelling index and sample B recording the least value. Meanwhile, there was significant difference across the samples. Water absorption capacity and oil adsorption capacity were ranges from 80.27 for sample A to 91.0 for sample E respectively. Sample E recorded the highest value and Sample B the least. In oil absorption capacity (sample A) 91.54, (Sample B) 61.36, (Sample C) 73.63, (Sample D) 85.90 and (sample E) 98.17. Meanwhile, there was significant difference ($P < 0.05$) between the flour formulations.

The swelling index and bulk density values of composite flour in this study is lower than the previous works reported by Wang *et al.* [50] but agrees with the fact that swelling and bulk density in this research are less than that of cassava flour but generally more than those of maize. Water absorption capacity of sample B which was lower than other samples may be due to moringa leaf having a weaker internal structure as reported by Soliva *et al.* [51]. Water absorption capacity is a function of water holding ability of the flour sample. It is an important processing parameter that has implication for viscosity in the interim there was a significant difference ($P < 0.05$) between the samples. This result shows that fortification of wheat with soybeans and moringa leaf flour has a few advantages specifically in nutritional improvement, cost-effectiveness, a key functional benefit (less oil absorption) and overall health benefits [45]. With increase in the formulation there happens a more starch damage than 100% wheat flour by blending process. With high proportion of starch damage, water absorption rises, and it realizes high starch gelatinization and finally the crumb becomes softer [52] [53].

The result in this work is in an agreement with the work of Coskuner and Karababa [54] that water absorptions of flours used for flat bread production are in wide limits. Although flour that is used for pan bread making has optimum water absorption of 60% - 65%, flour used for flat bread production has optimum water absorption varying between 38% and 85% [54]. The result of composite flour used in this research is in line with the findings of Gernah *et al.* [37], and, Coskuner and Karababa [54].

3.3. Mineral Composition of the Composite Flour of Wheat, Soybeans and Moringa Leaf

Table 4 reported the mineral composition of the composite flour of wheat, soybeans and moringa leaf blends to produce leavened and unleavened bread. The mineral content is indicated across the flour starting with Zinc (Zn) registered from 0.76 mg/100g sample A to 15.40 mg/100g sample E as a result of decreased in wheat flour, increase in moringa leaf and 20% soybean flour. There was a significant difference ($P < 0.05$) across the samples with sample A having

Table 4. Mineral composition (mg/100g) of wheat, soybean and moringa leaf flour blends.

Sample	Zinc (Zn)	Iron (Fe)	Potassium (K)	Calcium (Ca)
A	$0.76^{e} \pm 0.01$	$3.45^{e} \pm 0.01$	$184.37^{e} \pm 0.01$	$71.47^{e} \pm 0.01$
B	$9.63^{d} \pm 0.01$	$11.76^{d} \pm 0.01$	$799.58^{d} \pm 0.02$	$705.99^{d} \pm 0.03$
C	$11.55^{c} \pm 0.01$	$14.12^{c} \pm 0.02$	$959.50^{c} \pm 0.02$	$847.20^{c} \pm 0.01$
D	$13.48^{b} \pm 0.01$	$16.46^{b} \pm 0.01$	$1119.41^{b} \pm 0.01$	$988.39^{b} \pm 0.01$
E	$15.40^{a} \pm 0.01$	$18.81^{a} \pm 0.01$	$1279.32^{a} \pm 0.00$	$1129.59^{a} \pm 0.02$
LSD (0.05)	0.05	0.05	0.04	0.05

Values are shown as mean ± standard deviation of replicates. Means values followed by different superscripts in a Column are significantly different ($P < 0.05$). Key: A = (100% Wheat), B = (75% Wheat, 20% Soybeans, 5% Moringa leaf), C = (70% Wheat, 20% Soybeans, 10% Moringa leaf), D = (65% Wheat, 20% Soybeans, 15% Moringa leaf), E = (60% Wheat, 20% Soybeans, 20% Moringa leaf), LSD = Least Significant Different.

the least value of zinc content and sample E enclosing the highest content of zinc with increase in moringa leaf and 20% soybean flour for the formulations. This result concord with the work done by [52] [53] [55] who reported on improving the quality of nutrient-rich bread by combination of enzymes in straight dough and sourdough bread making, influence of the soluble fibre on quality of dough and quality minerals of bread produced from composite flour of wheat, plantain and soybean.

The Iron (Fe) content of the bread formulation increased from 3.45 mg/100g of sample A to 18.81 mg/100g of sample E. There was a decreased in wheat flour with increase in moringa leaf and 20% soybeans. There was a significant difference among the sample blends. The value of potassium (k) is ranged from 184.37 mg/100g of sample A to 1279.32 mg/100g of sample E respectively and there is a significant difference ($P < 0.05$) between the samples, this finding agrees with the result of [56] [57] who report increase in mineral content of bread fortified with tilapia fish.

The value of Calcium increased from 71.47 mg/100g sample A to 1129.59 mg/100g sample E this result is within the values of experiment done by [58] [59]. The result shows that there was a significant difference ($P < 0.05$) between the minerals content across the flour formulation and is also in agreement with the findings of other researchers about the mineral content found in other bread and baked products [19] [60]. The mineral content of the flour increased with increase in the high amount of ash which triggers the formulation of the flour blends to meet up with the required mineral content of the bread products.

3.4. Vitamin Composition of the Composite Flour of Wheat, Soybean and Moringa Leaf

The result reported by **Table 5** shows the vitamin composition of wheat, soybeans and moringa leaf flour blends. Vitamins C content varied from 0.23 mg/100g of sample A to 18.29 mg/100g of sample E which reported similar with the work of Olson [19]. In the result of vitamin, A ranged from 0.12 IU/100g

Table 5. Vitamin composition (mg/100g) of wheat, soybean and moringa leaf composite flour.

Sample	Vitamin C	A (IU/100g)	B1	B2	B3
A	$0.23^{e} \pm 0.01$	$0.12^{e} \pm 0.01$	$0.54^{e} \pm 0.02$	$0.15^{e} \pm 0.01$	$0.07^{e} \pm 0.01$
B	$11.43^{d} \pm 0.01$	$11.70^{d} \pm 0.01$	$1.54^{d} \pm 0.01$	$7.70^{d} \pm 0.09$	$4.02^{d} \pm 0.00$
C	$13.72^{c} \pm 0.01$	$14.04^{c} \pm 0.01$	$1.90^{c} \pm 0.01$	$9.24^{c} \pm 0.01$	$4.82^{c} \pm 0.01$
D	$16.01^{b} \pm 0.02$	$16.38^{b} \pm 0.01$	$2.20^{b} \pm 0.01$	$10.78^{b} \pm 0.02$	$5.62^{b} \pm 0.01$
E	$18.29^{a} \pm 0.02$	$18.72^{a} \pm 0.01$	$2.50^{a} \pm 0.01$	$12.32^{a} \pm 0.02$	$6.43^{a} \pm 0.00$
LSD (0.05)	0.05	0.05	0.01	0.02	0.01

Values are shown as mean ± standard deviation of replicates. Mean values followed by different superscripts in a Column are significantly different ($P < 0.05$). Key: A = (100% Wheat), B = (75% Wheat, 20% Soybeans, 5% Moringa leaf), C = (70% Wheat, 20% Soybeans, 10% Moringa leaf), D = (65% Wheat, 20% Soybeans, 15% Moringa leaf), E = (60% Wheat, 20% Soybeans, 20% Moringa leaf), LSD = Least Significant Different.

for sample A to 18.72 IU/100g for sample E. This increase in vitamin A content is due to the decrease in wheat flour, increase in moringa leaf and 20% soybeans and there is a significant difference among the samples. The result of vitamin B_1 ranges from 0.54 mg/100g of sample A to 2.50 mg/100g of sample E. This result indicates that sample A is least with 0.54 mg/100g and sample E is 2.50 mg/100g. This shows that the vitamin content of wheat bread increased with increase in moringa leaf [61].

Vitamin B_1 ranged from 0.54 mg/100g for sample A to 2.50 mg/100g for sample E. sample A having the least value and sample E had the highest value. The increase in vitamin B_1 resulted in the decrease in wheat flour with increase in moringa leaf and 20% soybean. There was a significant difference ($p < 0.05$) among the samples.

Vitamin B_2 enlarged from 0.15 mg/100g for sample A to 12.32 mg/100g for sample E. Vitamin B_2 increased with increase in moringa leaf and 20% soybean. There was a significant difference ($p < 0.05$) among the samples. Vitamin B_3 content ranged from 0.07 mg/100g for sample A to 6.43 mg/100g for sample E. There was a significant difference ($P < 0.05$) between the vitamin composition of the flour formulations with sample A having the least vitamin content follow by Sample B, C, D and E. The result of vitamin B_2 and B_3 confirms the result obtained in previous studies [62] [63] on the nutrients quality of wheat bread. According to Ebert [8], Moringa leaves powder in combination with soybeans flour is useful as nutritional supplement for treating malnourishment. Therefore, the formulation of wheat, soybeans and moringa flour helps to achieve this purpose.

4. Conclusions

In a bid to enhance the nutrient quality of flour across protein, ash, fibre, moisture and fats content, this study investigated the right mix for wheat, soy and

moringa leaf flour. The quality analysis of different mixes of wheat, soy and moringa leaf flour were obtained and analysed to evaluate the effect of their addition on food quality such as protein, fibre, moisture, ash and fat content.

Protein content of the flour increased with increasing moringa leaf, decreased with up to 20% soybean flour. Fat composition was observed to moderately reduce as wheat flour reduces with increased moringa leaf at 20% soybean flour. The calorific value of the flour mix decreases with decreasing wheat, increased moringa leaf flour also at 20% soybean flour. The mineral content of composite flour of wheat, soybean and moringa leaf such as zinc, iron, potassium and calcium were enhanced with an increase in the formulation of wheat, soybeans and moringa leaf flour. Also, the vitamins such as Vitamin A, C, B_1, B_2 and B_3 content of the flours significantly increased with an increase in the formulations. The use of soybeans and moringa leaf flour in bread and other baked products would diversify its utilization, enhance nutrition, health benefit and good living of the consumers and reduce the dependence on wheat flour. This could cut down considerably the cost of importing wheat flours for societies with limited production capacity.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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