WWW.IJRPR.COM

**International Journal of Research Publication and Reviews**

Journal homepage: www.ijrpr.com ISSN 2582-7421

# Quality Evaluation of Wheat, Soybean and Moriche Palm Fruit Flour Blends

***[1]Shar Faustina Mbanengen, [2]Girgih Tartenger Abraham, [2]Ikya Kwagh-Hal Julius, [1]Amove Julius Tarza, [3]FamuwagunAkinsola Albert, [2]Mbachiantim James.***

[1]Department of Food Science and Technology, J.S Tarka University, Makurdi, Benue State Nigeria.
[2]Department of Human Nutrition and Dietetics, J.S Tarka University, Makurdi, Benue State Nigeria.
[3]Department of Food Science and Technology, Obafemi Awolowo University, Ile-Ife, Nigeria
E-mail: girgihusa@yahoo.com

**ABSTRACT**

The Quality of flour blends from wheat, soybean and moriche palm fruit whole flour, protein concentrate, protein isolate and protein hydrolysate were determined. Flour blends were prepared from 80:10:10 wheat, soybean and moriche palm fruit whole flour; 80:10:10 wheat, soybean and moriche palm fruit protein concentrate; 80:10:10 wheat, soybean and moriche palm fruit protein isolate and 80:10:10 wheat, soybean and moriche palm fruit protein hydrolysate respectively. The Flour Blends were then analysed for proximate composition, mineral elements, vitamin C and A, Amino acids composition, Antinutrients and Functional Properties. Results of the analyses for the flour blends showed nutritional superiority over the control (100% wheat) in terms of ash, fibre, protein, vitamins, mineral elements and amino acid composition with significant differences ($p<0.05$). Ash, fibre, and protein, ranged from1.89 -2.31%; 1.19 -1.43%; 24.32 -56.81% respectively; Sodium, Zinc, Iron, Calcium and magnesium content ranged from 3.07 -4.55mg/100g, 11.28 -16.49mg/100g, 3.11 -8.51mg/100g, 183.69 – 288.80mg/100g and 185.43 -233.93mg/100g respectively; Vitamin A and C content ranged from 167.08 - 207.17 µg/g and 2.89 and 3.95 mg/ 100 g respectively. All the 20 amino acids were present in all the flour blends and at higher levels ($p<0.05$) compared to the control. Result for Antinutrients content indicated safe levels for consumption. Results of analysis for functional properties showed that water and oil absorption capacities ranged from 1.95 -2,71 and 2.11 -2.95% respectively; Foaming capacity and Stability ranged from 1.23 -2.19 and 35.95 -58.35% respectively; Emulsion Capacity and Stability ranged from 2.09 - 2.17($g/m^2$) and 48.25 -53.45 % respectively with flour blends containing whole moriche palm fruit flour having lower values. Flour blends from wheat, soybean and moriche palm fruit flours is highly recommended for use in Food Systems. The high protein contents of these composite flours suggest that these two sets of composite flours could be recommended as potential mixture to alleviate protein energy malnutrition.

**Key words:** Wheat, Soybean, Moriche Palm Fruit (Aguaje) Flour Blends, protein concentrate, Protein isolate, Protein hydrolysate and Quality.

## 1. INTRODUCTION

Fruits and vegetables are important sources of vitamins, dietary minerals, fibres, and antioxidative compounds. They are rich source of biologically active compounds, known as phytochemicals, which are an essential and beneficial part of the human diet. Antioxidants are abundant phytochemicals that prevent some of the processes involved in the development of various degenerative disorders and diseases, including cancer and cardiovascular diseases. Recent research has, therefore, become increasingly interested in the search for natural antioxidants from natural origins for use in the treatment and control of several human health disorders and diseases (Felhi *et al*., 2016).

Moriche palm fruit also known as *aguaje* (in Peru) *buriti* (in Colombia) and *ichor* (in Tiv) are consumed by both adults and children and is known for its rich nutrient profile, including vitamins, and bioactive compounds, high content of β-carotene - vitamin A precursor and reasonable quantity of other important phenolic compounds. Recently, there has been growing interest in the potential health benefits and functional properties of Moriche palm fruit flours, which are derived from the fruit's pulp and seeds (Felhi *et al*., 2016).

This aim of this study was to fill the knowledge gap by systematically investigating the chemical and functional properties of wheat, soybean and Moriche palm fruit flour blends.

Understanding these properties could lead to the development of new food products with enhanced nutritional value and health benefits. Additionally, it could provide a scientific basis for promoting the use of Moriche palm fruit flours in various applications, contributing to food security and economic development in regions where the palm is endemic.

Moreover, the findings could pave the way for further research into other underutilized tropical fruits, fostering biodiversity and sustainability.

Wheat is used predominantly for baking due to its elastic gluten protein but relatively low in protein and generally low in lysine and certain other amino acids (Dabels *et al*., 2016). Such deficiencies could be complemented with legumes such as soybeans. (Dabels *et al.,* 2016). Blending of cereal (wheat) with soy-bean alone results to a product of higher nutritional value in terms of protein but low in micronutrient content (Shar *et al.*, 2016).

Additional blending with Moriche palm fruits with high content of β-carotene - vitamin A precursor and reasonable quantity of other important phenolic compounds (Felhi *et al*., 2016) could provide product rich in bioactive properties. Also, Prolonged use of certain antidiabetic medications is associated with negative side effects, which coupled with rising health care costs calls for alternative strategies **(**Onuh *et al.,* 2015). This Study would diversify the use of soybean and moriche palm fruit for value addition and at the same time improve on African moriche palm cultivation and production by farmers.

The main objective of this study therefore was to determine the quality of composite flours from wheat, soybean and moriche palm fruit in terms of Proximate composition, Mineral Elements, Vitamin A and C, Amino Acid composition, Total Phenolic Content, Phytochemical and Functional properties.

## 2. MATERIALS AND METHODS

### *2.1 Source of Raw materials*

The ripe aguaje fruits were purchased on the palm tree from Mbashar village located in Mbagbera District, Vandeikya Local Government Area of Benue State.

### *2.2 Preparation of Moriche Palm Fruit Whole Flour (MPFWF)*

Whole moriche palm fruit flour was prepared according to methods described by Vásquez-Ocmín (2010) with slight modifications. One morphotype of Moriche palm fruit classified by the color of the mesocarpium, presenting reddish coloured Shells with yellow coloured mesocarpium were collected for use. These fruits were randomly collected from different moriche palm fruit palm trees from the same locality. The collected fruits were put in separate plastic Containers and then washed and disinfected with a continuous water flow. Damaged or discolured fruits were discarded. Water at 60°C was added to each of the containers for an hour, with the purpose of removing the exocarpium (shells), the mesocarpium (pulp) and seed were separated by hand. The mesocarpium (pulp) obtained was sundried using a tray on a raised platform for 6-7 hours. The dried Mesocarpium was stored in airtight containers till when needed for use. The dried mesocarpium was then milled using electric blender to obtain the aguaje whole flour. The whole flour was then sieved using 0.08µm diameter sieve. The sieved flour was then packaged in airtight polythene bags until when needed for laboratory analysis and for preparation of defatted flour, Protein concentrate, Protein isolate and protein hydrolysate.

### *2.3 Production of Moriche Palm Fruit Protein Concentrate protein concentrate*

Protein concentrate was prepared by a method modified by Gbadamosi *et al.* (2012). A known weight (200 g) of the defatted flour was dispersed in distilled water (2,000 ml) to give final flour to water ratio of 1:10. The dispersion was then gently stirred on a magnetic stirrer for 10 min to form a suspension, after which the pH of the resultant slurry was adjusted with 0.1 M HCl to the point at which the protein was least soluble (pH 4; a value obtained from preliminary solubility results of the defatted flour during preliminary investigation) to precipitate the proteins. The precipitation process was allowed to proceed with gentle stirring for 4 h keeping the pH constant. Soluble carbohydrates (oligosaccharides) and minerals was removed by centrifugation at 3,500 × g for 30 min using a centrifuge (Bosch, TDL-5, United Kingdom). The precipitate (concentrate) was afterward washed twice with distilled water to remove the residual minerals and soluble carbohydrates and the pH was adjusted with 0.1 M NaOH to 7.0 for neutralization and then centrifuged at 3,500 × g for 10 min. The resultant precipitate (concentrate) was collected and dried in an oven at 45 ºC for 8 h (Uniscope SM9053 Laboratory Oven, Singerfriend, England) and kept for further analysis.

### *2.4 Preparation of Moriche palm Fruit Protein Isolate*

Protein isolate was prepared by a method described by Gbadamosi *et al.* (2012). About 100 g of the defatted flour was dispersed in 1000 ml of distilled water to give final flour to liquid ratio of 1:10. The suspension was gently stirred on a magnetic stirrer for 10 min. The pH of the resultant slurry was adjusted by drop-wise addition of 1M HCl with constant stirring until the pH was adjusted to the point at which the protein was most soluble (pH 10.0) and the extraction was allowed to proceed with gentle stirring for 4 h keeping the pH constant to solubilize the proteins. The mixture was centrifuged (Harrier 15/80 MSE) at 3500 × g for 10 min in order to remove the non-soluble materials (residue). The proteins were precipitated from the supernatant by adjusting the pH to the point at which the proteins are least soluble (pH 4.0) and the soluble proteins was recovered by centrifugation (3500 × g for 10 min). After separation of proteins by centrifugation, the precipitate was washed twice with distilled water to remove the excess salt formed during the pH adjustment. The precipitated protein was re-suspended in distilled water and the pH was adjusted to 7.0 with 1M NaOH prior to freeze-drying. The freeze-dried protein was stored in air-tight plastic container at room temperature for further use.

### *2.5 Preparation of Moriche palm Fruit Protein Hydrolysate*

Protein hydrolysate was prepared using combined enzymes (pepsin and pancreatin with different optimum reaction conditions) acting on the isolate (Pancreatin with pH 7.5 at $40^0$C and Pepsin with pH 2 at $37^0$C) using the method of Akinyede *et al*., (2006). A 1:20 w/v protein isolate's slurry was adjusted to pH 2.0 and incubated at 37 ºC followed by addition of pepsin (4% w/w, on the basis of protein content of protein isolate), and then the same slurry adjusted to pH 7.5 and incubated at 40 °C followed by the addition of pancreatin (4% w/w, on the basis of protein content of protein isolate). The digestion was carried out for 4 h and the pH is maintained by adding 1 M NaOH or HCl when necessary. The digestion was terminated by adjusting the pH to 4.0 and then placed the mixtures in boiling water for 30 min to inactivate the enzymes which ensure complete denaturation of enzyme protein and coagulation of undigested proteins. The mixture was allowed to cool to room temperature and later centrifuged (3,500 × g for 30 min). The resulting supernatants was freeze-dried to produce the enzymatic hydrolysates.

### *2.6 Preparation of Soybean Flour*

The method described by Ojinnaka & Okudu (2017) was used (with slight modification) in the preparation of the soybean flour. The soybeans were cleaned from dirt by sorting out contaminants such as sands, sticks and leaves, and were later washed, boiled for 30 minutes and oven dried at 55 ºC for 16h. The soybeans were later milled using a laboratory grinder and sieved into fine flour of uniform particle size, by passing it through a 0.5 mm mesh sieve.

***Table 1: Formulation (%) of Wheat, soybean and moriche palm fruit Flour Blends***

| SAMPLE | WHEAT FLOUR | SOYBEAN FLOUR (%) | MORICHE PALM FRUIT FLOURS (%) |
|---|---|---|---|
| **A** | 100 | 0 | 0 |
| **B** | 80 | 10 | 10 MPFWF |
| **C** | 80 | 10 | 10 MPFPC |
| **D** | 80 | 10 | 10 MPFPI |
| **E** | 80 | 10 | 10 MPFPH |

**KEY:**

A = 100% Wheat flour (Control); B = 80% Wheat flour + 10% Soybean flour + 10% Moriche Palm fruit whole flour (MPFWF) C= 80% Wheat flour + 10% Soybean flour + 10%Moriche palm fruit protein concentrate (MPFPC); D = 80% Wheat flour + 10% Soy flour + 10% Moriche palm fruit protein isolate (MPFPI); E= 80% Wheat flour + 10% Soybean flour + 10% Moriche palm fruit protein hydrolysate (MPFPH).

**3. Analyses**

### *3.1. Determination of Proximate Composition of Flour Blends from Wheat, Soybean and Moriche palm fruit, Whole Flour, protein concentrate, protein Isolate and Protein Hydrolysate*

#### *3.1.1. Moisture conten*

Moisture content of the sample was determined by the standard AOAC (2000) official method by drying about 3 g ($W_1$) of the samples in a hot air-oven (Uniscope, SM9053, England) at 105 ± 1 ºC until constant weight ($W_2$) was obtained. The sample was removed from the oven, cooled in a desiccator and weighed repeatedly until constant weight was obtained. The result was expressed as percentage of dry matter.

$$Moisture\ content\ (\%) = \frac{W_1 - W_2}{W_1} \times 100$$

$$W_1 = weight\ of\ flour\ before\ drying$$

$$W_2 = weight\ of\ flour\ after\ drying$$

#### *3.1.2 Crude fat content*

Crude fat was determined by the AOAC (2005) in Famuwagun and Gbadamosi (2021) method using soxhlet apparatus (Sunbim, India). About 5 grams (W3) of the ground sample was placed into a thimble which was placed inside soxhlet extractor and n-hexane was poured into a pre-weighed round bottom flask ($W_2$), used to extract the oil from the sample. The extraction was carried out for about 6 h. The solvent was removed from the extracted oil by distillation. The oil in the flask was further dried in a hot-air oven at 90 ºC for 30 minutes to remove residual organic solvent and moisture. This was cooled in a desiccator and flask and its content weighed ($W_1$). The quantity of oil obtained was expressed as percentage of the original sample used using equation (iii) given below:

$$Ether\ extract\ (\%) = \frac{W_1 - W_2}{W_3} \times 100$$

### *3.1.3 Crude fibre content*

Crude fibre content was determined using the method described by AOAC (2005) in Famuwagun and Gbadamosi (2021). Two grams (W3) of sample was dissolved in 200 ml of 1.25 % (v/v) sulphuric acid in a conical flask and was placed on a hot plate and boiled for 30 min. The content was filtered using filter paper (Whatman No.1) and the residue on the filter paper was washed with 70 ml distilled water. The washed residue was transferred back into the flask and about 200 ml 1.25 % (w/v) NaOH is added and boiled for 30 min. The content was filtered as described earlier and the residue obtained was washed with distilled water and then filtered again using filter paper (Whatman No.1). The residue is then transferred to an ashing dish and dried at 130 ºC for 2 h, cooled in a desiccator and weighed ($W_1$). This was then beashed at 550 ºC inside the muffle furnace chamber (Carbolite AAF1100, United Kingdom) for 30 min, cooled and reweighed ($W_2$). The ash obtained was subtracted from the residue and the difference expressed as percentage of the starting material as shown in equation below;

$$Cf\ = \left(\frac{W_1 - W_2}{W_3}\right) \times 100$$

where,

*Cf = Crude fibre* (%)

$W_1 = mass\ of\ crucible\ with\ the\ dried\ residue\ (g)$

$W_2 = mass\ of\ crucible\ with\ the\ ash\ (g)$

### *3.1.4 Crude protein content*

The protein content of the samples was determined using the AOAC (2000) method. Ground sample (0.20 g) was weighed into a Kjeldahl flask. Ten millilitres of concentrated sulphuric acid was added followed by one Kjeltec tablet. The mixture was digested on heating racket to obtain a clear solution. The digestate was cooled, and made up to 75ml with distilled water and transferred onto kjeldahl distillation unit followed by the addition of 50 mL of 40 % sodium hydroxide solution. The mixture was then distilled and the ammonia formed in the mixture was subsequently distilled into 25 ml, 2 % boric acid solution containing 0.5 ml of the mixture of 100 ml of bromocresol green solution (prepared by dissolving 100 mg of bromocresol green in 100 ml of methanol) and 70 ml of methyl red solution (prepared by dissolving 100 mg of methyl red in 100 ml methanol) as indicators. The distillate collected was titrated with 0.05M HCl. Blank determination was carried out by excluding the sample from the above procedure

$$Crude\ protein\ (\%) = \frac{1.401 \times M \times F\ (ml\ titrant - ml\ blank)}{sample\ weight}$$

$M = Molarity\ of\ acid\ used = 0.05$

$$F = kjeldahl\ factor = 6.25$$

### *3.1.5 Ash content*

*A*sh content of the sample was determined by the official AOAC (2000) method using muffle furnace (Carbolite AAF1100, United Kingdom). About 2 g ($W_3$) of the samples was weighed into a pre-weighed ashing crucible ($W_2$) and placed in the muffle furnace chambers at 550 ºC until the samples turned into ashes usually within 5 h. The crucibles were removed, cooled in a desiccator and weighed ($W_1$). Ash content was expressed as the percentage of the weight of the original sample as shown in equation below;

$$\text{Ash content}(\%) = \left(\frac{W_1 - W_2}{W_3}\right) \times 100$$

$W_1 = \text{weight of crucible} + \text{ash}$

$W_2 = \text{weight of empty crucible}$

$W_3 = \text{weight of sample}$

### *3.1.6 Carbohydrate content*

Carbohydrate will be expressed as a percentage of the difference between the addition of other proximate components and 100.

$$Carbohydrate\ (\%) = 100 - (moisture\ content + ash\ content + crude\ protein)$$

### *3.2 Determination of Mineral Elements and Vitamin A and C content of Flour Blends*

### *3.2 Determination of Mineral Elements and Vitamin C and A contents of Wheat, soybean and Moriche palm fruit Flour Blends*

#### *3.2.1 Determination of Mineral Elements*

The Atomic Absorption Spectrophotometric (AAS) method was used to determine the Sodium, iron, calcium zinc and Magnesium contents of the products. The mineral content of the bread samples was determined using the method described in AOAC, (2005) in Famuwagun and Gbadamosi (2021). The ash obtained from the ash analysis earlier was used in the determination of the minerals content. The ash was placed in porcelain crucibles, then few drops of distilled water was added, followed by 2ml of concentrated hydrochloric acid and 10 ml of 20% $HNO_3$ was added and evaporated on the hot plate. The samples were filtered through a Whiteman filter paper into 100 ml volumetric flask. The mineral elements; Sodium, iron, zinc, calcium and magnesium were determined by atomic absorbance spectrophotometer (AA800 Perkin-Elmer, Germany).

#### *3.2.2 Vitamin A (β-Carotene) Determination of Wheat, Soybean and Moriche palm Fruit Flour Blends*

β-carotene was determined using the method described by AOAC, (2005) in Famuwagun and Gbadamosi (2021). Five grams of sample was weighed into a separating funnel (250 ml), 2 ml of NaCl solution was introduced into it and shaken vigorously, followed by 10 ml of ethanol, then 20 ml of methane. The mixture was shaken vigorously for 5 minutes and allowed to stand for 30 minutes after which the lower layer was ran off. The absorbance of the top layer was determined at a wavelength of 460 nm using a Hachdrel/5 model spectrophotometer (England).

$$\text{Total carotenoid } \left(\frac{\text{mg}}{100\text{g}}\right) = \frac{\text{absorbance}}{\text{specific extinction coefficient} \times \text{path length of cell}}$$

Where, molar extinction coefficient ($\sum$) = $15 \times 10^{-4}$

Specific extinction efficient = $\sum \times$ molar mass of beta-carotene

Molar mass of β - carotene = 536.88 g/mol.

Path length of cell = 1 cm

#### *3.2.3 Vitamin C determination of Wheat, Soybean and Moriche palm Fruit Flour Blends*

Vitamin C was determined using the method of AOAC, (2005) in Famuwagun and Gbadamosi (2021) Two (2g) grams of each sample was dissolved with 2ml distilled water

Trichloroacetic acid (TCA) was added to develop the colour 2.6 dichloroindophenol. The color, which was pink, was read with a spectrophotometer.

$$\% \text{ Vitamin C} = \frac{a \times (V_2 - V_1) \times 0.0052}{\text{weight of sample}}$$

Where a = volume of filtrate

$V_1$ = Initial burette reading

$V_2$ = final burette reading

### *3.3 Determination of Amino Acid Composition of Wheat, Soybean and Moriche palm Fruit Flour Blends*

Amino acid composition of the wheat, soybean and moriche palm fruit flour blends were determined following the method described by Gbadamosi *et al*., (2012) using S433Amino Acid Analyzer (SYKAM, Eresing, Germany). Samples were freeze-dried and then hydrolysed for 24 h at 110 °C with 6 M HCl. After hydrolysis, the samples were freeze-stored in sodium citrate buffer at pH 2.2. When ready for analysis; a 50 $\mu$L of the hydrolysates was directly injected into the analyser. Tryptophan was determined separately by hydrolysis of the sample with sodium hydroxide. Cysteine and methionine were determined after performic acid oxidation prior to hydrolysis in 6 M HCl, and measured as cysteic acid and methionine sulphone respectively (Girgih *et al*. 2011).

### *3.4 Determination of Total Phenolic Content and Phytochemical Properties (TPC) for Wheat, Soybean and Moriche palm Fruit Flour Blends*

#### *3.4.1 Determination of Total Phenolic Content of Wheat, Soybean and Moriche palm Fruit Flour Blends*

Determination of total phenolic content was carried out using Folin-Ciocalteu's phenol reagent reaction as described by Hoff and Singletone (1977). The calibration curve solutions were prepared by pipetting 0.0, 0.2, 0.4, 0.6, 0.8, and1.0 ml of Gallic acid standard solution (1.0 mg/ml gallic acid) in triplicate into clean dried test tubes. Each test tube was made up to 1.0 ml with distilled water. To each of the test tube was added 1.5 ml of Folin-

Ciocalteu's reagent, incubated at room temperature for 5 min followed by the addition of 1.5 ml of 10% (w/v) $NaHCO_3$ solution to give a total volume of 4.0 ml. The reaction mixtures were further incubated for additional one and half hours and the absorbance was read at 725 nm against blank containing all reagents except the standard gallic acid which was replaced with distilled water. The standard curve was obtained by plotting absorbance against the concentration. The determination of total phenol in methanolic extract of A esculents was done by pipetting 0.5 ml each of 1 mg/ml methanolic extract into clean dry test tubes in triplicate. The volumes were adjusted to 1.0 ml with distilled water. To each of the tubes was added 1.5 ml of Folin-Ciocalteu's reagent. The reaction mixture was incubated at room temperature for 5 min. To the reaction mixture was added 1.5 ml of 10% (w/v) $NaHCO_3$ solution. The reaction mixture was incubated for one and half hour (1½ hr). The absorbance was read at 725nm against blank containing the extract and all reagents except Folin-Ciocalteu's reagent which was replaced with distilled water. The concentrations of the phenolics in the extract was extrapolated from standard curve and expressed as milligram gallic acid equivalent per g of extract (mg GAE/g extract).

### *3.4.2 Tannin determination for Wheat, Soybean and Moriche palm Fruit Flour Blends*

0.2g of finely ground sample was weighed into a 50ml sample bottle. 10ml of 70% aqueous acetone was added and properly covered. The bottle was put in an ice bath shaker and shaken for 2hours at 300C. Each solution was then centrifuge and the supernatant storein ice. 0.2ml of each solution was pipetted into the test tube and 0.8ml of distilled water was added. Standard tannin acid solutions were prepared from a 0.5mg/ml of the stock and the solution made up to 1ml with distilled water. 0.5ml of Folinciocateau reagent was added to both sample and standard followed by 2.5ml of 20%*Na2CO3* the solution was then vortexed and allow to incubate for 40minutes at room temperature, its absorbance was read at 725nm against a reagent blank concentration of the same solution from a standard tannic acid curve was prepared (Makkar and Goodchild. 1996).

### *3.4.3 Phytate contents determination for Wheat, Soybean and Moriche palm Fruit Flour Blends*

Phytate contents of the samples were determined as described in Gemede (2020) after extraction of sample with 2.4% HCl for 1 h and centrifuged. 3 ml of the supernatant was added to 1 ml of wade reagent (0.03% $FeCl_3 \cdot 6H_2O$ and 0.3% sulphosalicyclic acid in distilled water). The absorbance of the mixture was measured at 500 nm wavelength using a UV–vis Spectrophotometer. The value obtained was subtracted from the blank absorbance value and the phytate content (mg/100 g sample) was estimated from the phytic acid standard calibration curve (5–35 mg/kg) which was prepared in a similar way as the sample.

### *3.4.4 Oxalate determination for Wheat, Soybean and Moriche palm Fruit Flour Blends*

Briefly, the determination was as previously described by Bonkoungou *et al*. (2024). 2 g of the sample was digested with 10 ml 6 M HCl for one hour and made up to 250 ml in a volumetric flask. The pH of the filtrate was adjusted with conc. $NH_4OH$ solution until the colour of solution changed from salmon pink colour to a faint yellow colour. Thereafter, the filtrate was treated with 10 ml of 5% $CaCl_2$ solution to precipitate the insoluble oxalate (left overnight). The suspension is now centrifuged at 2500 rpm, after which the supernatant was decanted and precipitate completely dissolved in 10 ml of 20% (v/v) $H_2SO_4$. The total filtrate resulting from the dissolution in $H_2SO_4$ is made up to 300 ml. An aliquot of 125 ml of the filtrate was heated until near boiling point and then titrated against 0.05 M of standardized $KMnO_4$ solution to a faint pink colour which persisted for about 30 s after which the burette reading was taken. The oxalate content was evaluated from the titre value. The overall redox reaction is:

*1 ml of 0.05M KMn04 =2 mg sodium oxalate equivalent/g of sample*

### *3.4.5 Determination of Saponin Content of wheat, soybean and moriche palm fruit flour blends*

The spectrophotometric method of Brunner (1994) was used for Saponin determination. 2g of the finely ground sample was weighed into a 250ml beaker and 100ml of Isobutyl alcohol was added. Shaker was used to shake the mixture for 5hours to ensure uniform mixing. The mixture was filtered with No 1 Whatman filter paper into 100ml beaker containing 20ml of 40%saturated solution of magnesium carbonate (MgCO3). The mixture obtain again was filtered though No 1 Whatman filter paper to obtain a clean colourless solution. 1ml of the colourless solution was taken into 50ml volumetric flask using pipette, 2ml of 5% iron (iii) chloride ($FeCl_3$) solution was added and made up to the mark with distilled water. It was allowed to stand for 30 minutes for the colour to develop. The absorbance was read against the blank at 380nm.

### *3.5 Functional properties of Wheat, Soybean and Moriche Palm fruit Flour Blends*

### *3.5.1 Water absorption capacity*

The WAC was determined at room temperature and at temperatures ranging between 60 to 90°C using a combination of the AACC (2001) method and those of Iwe *et al*., (2016). A 2 g sample was dispersed in20 ml of distilled water. The contents were mixed for 30 s every 10min using a glass rod and after mixing five times, centrifuged at 4000 g for 20 min. The supernatant was carefully decanted and then the contents of the tube were allowed to drain at an angle of 45° for 10 min and then weighed. The water absorption capacity was expressed as percentage increase of the sample weight.

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

Oil absorption capacity of the flour samples was determined by the centrifugal method elicited by Singh *et al*., (2021) with slight modifications. One gram of sample was mixed with 10 ml of pure canola oil for 60 secs, the mixture was allowed to stand for 10 min at room temperature, centrifuged at 4000 g for 30 min and the oil that separated was carefully decanted and the tubes were allowed to drain at a 45° angle for 10 min and then weighed. Oil absorption was expressed as percentage increase of the sample weight

### *3.5.3 Foaming capacity and stability*

Foam capacity and foam stability was determined by a modification of the method described by Singh *et al*., (2021). Approximately 500 mg of protein sample was dispersed in 100 ml of distilled water. The solution was then homogenized for 2 min using a blender (O'Qlink, China) set at high speed $5_{max}$ then poured into 250 ml measuring cylinder. The percentage ratio of the volume increase to that of the original volume of protein solution in the measuring cylinder was calculated and expressed as foam capacity or whippability. Foam stability was expressed as percentage of the volume of foam remaining in the measuring cylinder to that of the original volume after 30 min of quiescent period.

$$Foaming\ capacity\ (\%) = \frac{V_2 - V_1}{V_1} \times 100$$

$$Foaming\ stability\ (\%) = \frac{V_3 - V_1}{V_1} \times 100$$

$$V_1 = volume\ before\ whipping\ (ml)$$

$$V_2 = volume\ after\ whipping\ (ml)$$

$$V_3 = volume\ after\ standing\ (ml)$$

### *3.5.4 Emulsifying Activity and Stability Index*

The emulsifying activity index (EAI) was determined by a modified turbidmetric method described by Pearce and Kinsella (1978). About 500 mg sample will be dispersed in 80 mL of distilled water. The sample slurry will be mixed with 20 ml of vegetable oil and the mixture was homogenized using a blender (VLC, Saphire, England) set at high speed for 60 s. Fifty microlitres of the aliquot of the emulsion was transferred from the bottom of the blender after homogenization, and mixed with 5 ml of 0.1 % sodium dodecyl sulphate (SDS) solution. The absorbance of the diluted emulsions will be measured at 500 nm using spectrophotometer (722-2000 Spectronic 20D, England) in 1 cm path length cuvette. The absorbance was read initially, after that turbidity and EAI was calculated using the following formula:

$$T = \frac{2.303\ x\ A}{I}$$

*Where T = turbidity, A = absorbance at 500 nm and I = path length of cuvette (cm).*

*The emulsion activity index (EAI) will then be calculated as:*

$$Emulsifying\ activity\ index\ (m^2/g) = \frac{2\ x\ T}{0.2\ x\ C}$$

Where T is the turbidity, C is the weight of protein per unit volume of aqueous phase before the emulsion was formed (g/ml); 0.2 is the volumetric fraction of oil and 2 is a constant. The emulsion stability index (ESI) was determined after the emulsion was allowed to stay for 10 minutes and the absorbance of the mixture was read at 500 nm and calculated using the formula below:

$$Emulsion\ stability\ index\ = \frac{EAI\ at\ 10\ min}{EAI\ at\ 0\ min}\ x\ 100$$

### *3.5.5 Bulk density of the samples*

Bulk density was determined by the method of Singh *et al*., (2021). A 10ml graduated cylinder, previously tarred, was gently filled with the 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 after filling to the 10ml mark. Bulk density was calculated as weight of sample per unit volume of sample (g/ml).

### *3.6. Statistical Analyses*

Proximate composition, Mineral elements, Vitamin A and C, Amino Acid composition Total Phenolic content and Phytochemical and Functional Properties assays were conducted in triplicate. The method of Wahua (1999) was used to analyze the data using analysis of variance (ANOVA). All means were separated using Duncan Multiple Ranger Test (DMRT) at 5% probability level ($p<0.05$) using SPSS version 25.0 software 2011.

## 4. RESULTS AND DISCUSSION

### *4.1 Proximate composition*

Results for proximate composition of the wheat, soybean and moriche palm fruit flour blends showed that the moisture content of the samples ranged between 12.83 and 14.01 % and the values obtained were significantly different ($p<0.05$) from one another. The result showed that sample A (wheat flour only) was the least while the mixture of flours that contained protein hydrolysate had the highest moisture content. The fat content ranged between 1.85 and 4.54 % and the values were significantly different ($p<0.05$) from one another. The highest value (4.54 %) was obtained in sample B (that was 10% wheat, Soybean and morriche palm fruit whole flour blends) while the least was obtained in sample A, that was 100% wheat flour. The higher fat content of the sample could be an added advantage as fats supply essential fatty acids and are known to enhance flavor (Msugh *et al*., 2024).

The fibre content of the flour blends ranged between 0.94 and 1.43 %. The results obtained for fat content of the flour blends were similar when compared with the fibre contents of the samples. In the same vein, the ash content of the samples was between 1.78 and 2.31 %. The highest value was obtained in sample B which was 80% wheat, 10% soybean and 10% moriche palm fruit whole flour and was significantly higher ($p<0.05$) when compared with samples A (100% wheat flour) and the samples that contained protein concentrate, protein isolate and protein hydrolysate. Consumption of food rich in dietary fibre has been reported to reduce the risk of diabetes mellitus, cancer, cardiovascular diseases, constipation, colon etc. (McRae, 2018; Masrul & Nindrea, 2019).

The highest protein content of the samples was obtained in sample that contained protein hydrolysate, and followed by sample that contained protein isolate. The least value was obtained in sample which was only wheat flour. The value obtained among the samples were significantly different ($p<0.05$ from one another. The values obtained for the carbohydrate content of the samples ranged between 22.02 and 72.18 %. The trend of carbohydrate content of the sample assumed an inverse trend when compared with that of protein content of the samples. The proximate composition showed that addition of protein hydrolysate to the wheat flour and soy bean flour increased the moisture content of the composite flour. This trend may be attributed to the nature of hydrolysates added as being hygroscopic material with the potential to absorb atmospheric moisture if left opened after mixing. However, the non-significant trend in the values of composite flours that contained protein isolate and hydrolysate could be due to the fact that protein, being a crystalline material if well dried could also absorb moisture from the atmosphere and become wet after mixing. The values obtained were within the range of moisture content reported by Sanni *et al.,* (2020) and Mashayekh *et al*., (2024) on the addition of protein products to wheat flours. The addition of moriche palm fruit flour increased the fat, fibre and ash contents of the composite flours. This may be attributed to the fact that the whole flour had not been subjected to process of protein isolation that could remove the fibrous materials and even the oils. The low fibre and ash contents obtained in samples D and E could be due to the same reason fats and fibrous material removal during protein isolate and hydrolysate preparation as protein isolate and hydrolysate are not expected to contribute to fibre, fat and even ash contents of the composite flours. The trend of results was in line with the reports of Akoja *et al*., (2018) and Hasan (2020) on the addition of protein products and wheat flour in baked and fried products. Ash content is a measure of mineral elements in food material. By implication, sample B is expected a good number of mineral elements to the body.

Protein is an important parameter in proximate composition that determines the trend of most of the functional properties of composite flours. In addition to the trend in the amino acid composition of protein, several intrinsic factors of protein, such as molecular weight and the size of the protein molecule could influence the trend of functional properties (Onipe *et al*., 2018; Pongpichaiudom *et al.,* 2018). In this study, a high protein mixture of flour is required. To this end, sample E, that contained protein hydrolysate, soybean flour and wheat flour had the highest protein content and closely followed by sample D, which was made up of protein isolate. The high protein contents of these composite flours, especially samples D and E suggested that these two sets of composite flour as could be recommended as potential mixture to alleviate protein energy malnutrition. The trend of results was in agreement with the studies reported by Akubor *et al*., (2023) and Adebowale and Adebowale (2008). In a similar manner, the carbohydrate contents of the samples were highest in sample A, that was 100% wheat and lowest in sample E that contained the hydrolysate. This is expected because the value is a function of the trends of values for other proximate parameters.

***Table 2 Proximate composition (%) of Wheat, Soybean and Moriche palm Fruit Flour Blends***

| | Moisture | Fat | Fibre | Ash | Protein | Carbohydrate |
|---|---|---|---|---|---|---|
| **A** | $12.83^{e} \pm 0.04$ | $1.85^{e} \pm 0.05$ | $0.94^{e} \pm 0.04$ | $1.78^{e} \pm 0.09$ | $10.42^{e} \pm 0.43$ | $72.18^{a} \pm 1.32$ |
| **B** | $12.99^{d} \pm 0.54$ | $4.54^{a} \pm 0.12$ | $1.43^{a} \pm 0.04$ | $2.31^{a} \pm 0.12$ | $24.32^{d} \pm 0.94$ | $54.41^{b} \pm 0.84$ |
| **C** | $13.74^{c} \pm 0.84$ | $4.33^{b} \pm 0.45$ | $1.32^{b} \pm 0.32$ | $2.23^{b} \pm 0.143$ | $32.44^{c} \pm 1.23$ | $45.94^{c} \pm 0.88$ |
| **D** | $13.99^{b} \pm 0.42$ | $4.11^{c} \pm 0.33$ | $1.23^{c} \pm 0.09$ | $2.09^{c} \pm 0.09$ | $45.93^{b} \pm 0.39$ | $32.65^{d} \pm 1.22$ |
| **E** | $14.01^{a} \pm 0.04$ | $4.08^{d} \pm 08$ | $1.19^{d} \pm 0.08$ | $1.89^{d} \pm 0.05$ | $56.81^{a} \pm 1.21$ | $22.02^{e} \pm 0.49$ |

***Note: Values with superscripts along the columns are different significantly (p<0.05) from one another***

**KEY:**

A = 100% Wheat flour (Control); B = 80% Wheat flour + 10% Soybean flour + 10% Moriche Palm fruit whole flour; C= 80% Wheat flour + 10% Soybean flour + 10%Moriche palm fruit protein concentrate; D = 80% Wheat flour + 10% Soybean flour + 10% Moriche palm fruit protein isolate; E= 80% Wheat flour + 10% Soybean flour + 10% Moriche palm fruit protein hydrolysate.

### *4.2 Mineral Elements and Vitamin A and C content of Wheat, Soybean and Moriche Palm Fruit Flour Blends*

Result of analysis for mineral elements and vitamins showed that there were significant differences ($p<0.05$) among the samples and the highest values were reported in the flour blend of wheat, soybean and moriche palm fruit whole flour. As shown in Table 3, The values obtained for the sodium content of the samples ranged between 2.20 to 4.55 mg/ 100 g. Flour blend that contained moriche palm fruit whole flour had the highest sodium content while the wheat flour (sample A) had the least. The values were found to be significantly ($p<0.05$) different from one another. The values for the Zinc content also ranged between 6.95 and 11.28 mg/ 100 g. There were significant differences ($p<0.05$) among the samples and the highest values were reported in the flour blend of wheat, soybean and moriche palm fruit whole flour. As shown in Table 3, the iron content ranged between 2.29 and 8.51 mg/ 100 g. The results showed a reduction in the iron content of the samples as the protein purification processes increased. The least value of iron content was obtained in sample A that was 100% wheat flour, while the highest value was obtained in sample B that contained 80% wheat; 10% soybean flor and 10%moriche palm fruit whole flour. Just like the trend of result obtained for Iron content, the calcium content of the sample ranged between 138,69 to 288.80 mg/ 100 g. The values obtained were significantly different ($p<0.05$) from one another. Sample B had the highest calcium content while the least was obtained in sample A. In a similar trend, the Magnesium content of the mixtures of flour ranged between 145.38 to 233.93 mg/ 100 g. There were significant differences ($p<0.05$) among the values obtained. The highest value was reported in the sample that contained the moriche palm fruit whole flour and soybean and the least value was obtained in the100% wheat flour.

Mineral elements are needed for normal growth and development of the body and therefore an important component of our diets and has been found to be related to the trend of ash content of food material. Iron, is known as vital mineral element essential for the transport of oxygen and several activities within the cells. Calcium, also helps in the maintenance of fluid balance and the transmission of nerves. It also helps in the control of blood pressure and giving strength to the bones (Esan *et al*., 2017). Zinc, as an important element is available all through the body parts. It is required for the defence of the body and gives the body the immunity to work well. It performs actively in the division of cells, healing of wounds as well as carbohydrates metabolism (Abulude *et al*., 2012). The results in this study showed that the presence of whole flour of moriche palm fruit in sample B might be responsible for the high concentrations of Sodium, Zinc, Iron, Calcium as well as Magnesium content. Studies have shown that inadequate of these minerals could result to serious incidence of malnutrition and also lead to disorder or mental illness (Wardlaw, 2004). The results from this study had shown that sample B, that contained wheat flour, soybean flour and moriche palm fruit whole flour has the potential to manage mineral deficient in the body.

The values for vitamin C (ascorbic) content of the samples ranged between 2.89 and 3.95 mg/ 100 g and were significantly different ($p<0.05$) from one another. The result showed that the sample that contained 80% wheat, 10% soybean and 10% moriche palm fruit whole flour had the highest value of ascorbic acid when compared to the values for other samples. The high value of ascorbic acid in sample B might be due to the presence of oils in the moriche palm fruit whole flour and the soybean flour. It is possible that ascorbic acid is chemically bonded originally with the moriche palm fruit oils which raised the contents of the more than those that did not contain whole flour from the fruits (Famuwagun *et al*., 2024).

The values obtained for the Vitamin A content of the wheat, soybean and moriche palm fruit flour blends were found to range between 167.08 and 207.17 µg/g and these values were found to be significantly different ($p<0.05$) from one another. Just like the trend in the ascorbic acid content, the highest value was obtained in sample B which contained 80% wheat, 10% soybean and 10% moriche palm fruit whole flour, while the least value of vitamin A was found in the sample that was 100% wheat flour. Vitamins are organic compounds, that are essential nutrients within the body of living organisms and are supplied by the food consumed. Conventionally, vitamins are grouped into two classes, which are fat soluble and water-soluble vitamins. Some of these vitamins could be synthesized in the body while some cannot. For those being able to synthesize in the body, they are needed in minute amount for normal growth and functions of the body. In this study, Vitamin C, also known as ascorbic acid was highest in sample B, that contained moriche palm fruit whole flour while sample A which is majorly wheat flour had the lowest value of ascorbic acid than in samples C, D and E and this might be due to the removal of the lipids from the samples during the protein purification processes. Ascorbic acid is a very important vitamin needed for the normal growth and repairs of tissues and other parts of the body. Ascorbic acid could be used to form a very important protein in the body that is called collagen needed for skins making and for repairs of blood vessels. The results in this study showed that sample mixture that contained whole flour and soybean (sample B) has the potential to perform these functions

In a similar manner, the vitamin A, which is also called retinol, is a fat-soluble vitamin that is more common in fruits and vegetables. The results in this study showed that sample B, that contained wheat flour and moriche palm fruit whole flour had the highest value for retinol content. Literature had reported that for adults with age range between 19 to 64 years, the amount of vitamin A needed is 700 µg a day for men, 600 µg a day for women. In this study, the retinol contents ranged between 167.08 to 207.17 µg/ 100 g, suggesting that sample B can supply about 30 to 35 % of the vitamin A content needed by men and women adult in a day (Al-Attar 2020; Carazo et al., 2021).

***Table 3: Mineral elements and Vitamin A and C content (mg/100g) of Wheat, Soybean and Moriche Palm Fruit Flour Blends***

| Sample | Na | Zn | Fe | Ca | Mg | Vitamin A (mcg RAE) | Vitamin C |
|---|---|---|---|---|---|---|---|
| **A** | 2.20$^{e}$±0.32 | 6.95$^{e}$ ±0.11 | 2.29$^{e}$±0.11 | 138.03$^{e}$±1.04 | 145.38$^{e}$ ±0.04 | 167.08$^{e}$±0.43 | 2.89$^{e}$ ±0.94 |
| **B** | 4.55$^{a}$±0.04 | 16.49$^{a}$±0.09 | 8.51$^{a}$ ±0.13 | 288.80$^{a}$±1.22 | 233.93$^{a}$ ±0.83 | 207.17$^{a}$±0.31 | 4.61$^{a}$ ±1.94 |
| **C** | 4.18$^{b}$±0.09 | 15.36$^{b}$±0.04 | 5.49$^{b}$±0.05 | 218.48$^{b}$±1.04 | 226.07$^{b}$ ±0.98 | 201.08$^{b}$±0.64 | 3.95$^{b}$ ±1.04 |
| **D** | 3.21$^{c}$±0.05 | 12.40$^{c}$±0.12 | 3.26$^{c}$ ±0.09 | 201.49$^{c}$±1.20 | 218.66$^{c}$ ±0.43 | 182.43$^{c}$±1.03 | 3.45$^{c}$ ±0.94 |
| **E** | 3.07$^{d}$±0.09 | 11.28$^{d}$±0.04 | 3.11$^{d}$±0.03 | 183.69$^{d}$±0.04 | 185.43$^{d}$ ±0.93 | 175.53$^{d}$±1.44 | 3.01$^{d}$ ±0.44 |
| **USRDA** | 2000 | 12-15 | 10-15 | 1000 | 350 | 700 | 75-90 |

***Note: Values with superscripts along the columns are different significantly (p<0.05) from one another***

***KEY: USRDA = United States Recommended Daily Intake***

*A = 100% Wheat flour (Control); B = 80% Wheat flour + 10% Soybean flour + 10% Moriche Palm fruit whole flour;* C= 80% Wheat flour + 10% *Soy flour + 10%Moriche palm fruit protein concentrate; D = 80% Wheat flour + 10% Soy flour + 10% Moriche palm fruit protein isolate; E= 80% Wheat flour + 10% Soy flour + 10% Moriche palm fruit protein hydrolysate.*

### *4.3 Amino Acid Composition of Wheat, Soybean and Moriche Palm Fruit Flour Blends*

Results of analysis for amino acid composition showed that all the 20 amino acids were present in all the samples and were significantly (p<0.05) different from one another. In all the individual amino acids, sample A which was only wheat flour contained the least amino acid while sample E (80% Wheat flour + 10% Soy flour + 10% Moriche palm fruit protein hydrolysate) had the highest value of amino acid. The result showed that the purer the protein present in the mixture of flours, the higher the percentage amino acids. In this case, flour blends that contained protein hydrolysate had the highest value. Glutamine amino acid was dominant in the flour samples while the least amino acid in the samples was tryptophan and cysteine. The total amino acid of the samples ranged between 33.66 and 60.39 %, with sample E having the highest value and sample A the lowest. The hydrophobic amino acid (HAA) ranged between 15.69 and 27.06 % and the result showed that flour blends that contained protein isolate (D) had the highest HAA. Similarly, the aromatic amino acid (AAA) ranged between 4.95 and 6.97 %, with sample E having the highest value (6.97 %). Positively charged amino acid (PCAA) had values that ranged between 5.22 and 10.27 %, with the highest value at sample E. The trend of the PCAA agreed with the trend for negatively charged amino acids (NCAA). The values for the NCAA ranged between 8.45 and 10.27 %. The level of essential amino acids in the samples ranged between 17.07 and 27.40 %. Sample D that contained protein isolate had the highest essential amino acid of 27.40 % and closely followed by sample E that contained protein hydrolysate. The sulphur containing amino acid (SCAA) of the samples ranged between 1.47 and **2.77** %. Also, the trend showed that the highest value was obtained in sample D that contained protein isolate, while the least value was obtained in sample A that contained only wheat flour.

***TABLE 4: Amino acid composition (%) of wheat, soybean and moriche palm fruit flours***

| | *A* | *B* | *C* | *D* | *E* |
|---|---|---|---|---|---|
| **Asp** | 3.02±0.12 | 6.15±0.05 | 6.94±0.43 | 7.02±0.32 | 7.15±0.13 |
| **Thr** | 1.74±0.04 | 2.72±0.32 | 2.78±0.08 | 2.84±0.01 | 2.94±0.18 |
| **Ser** | 1.44±0.11 | 3.13±0.08 | 2.19±0.04 | 2.33±0.12 | 2.45±0.43 |
| **Glu** | 5.43±0.43 | 6.98±0.75 | 7.01±0.01 | 7.32±0.15 | 7.43±0.14 |
| **Pro** | 1.04±0.01 | 2.93±0.02 | 2.96±0.11 | 3.01±0.09 | 3.04±0.42 |
| **Gly** | 1.12±0.12 | 2.93±0.09 | 2.95±0.04 | 3.11±0.05 | 3.22±0.13 |
| **Ala** | 1.84±0.03 | 3.60±0.03 | 3.61±0.05 | 3.74±0.09 | 3.84±0.09 |
| **Cys** | 0.43±0.04 | 0.95±0.09 | 0.98±0.01 | 1.03±0.02 | 1.23±0.31 |
| **Val** | 2.01±0.05 | 3.24±0.11 | 3.21±0.08 | 3.24±0.12 | 3.43±0.13 |
| **Met** | 1.04±0.04 | 1.32±0.03 | 1.46±0.32 | 1.74±0.14 | 1.32±0.15 |
| **Iso** | 1.44±0.08 | 2.69±0.12 | 2.55±0.05 | 2.64±0.12 | 2.34±0.15 |
| **Leu** | 2.94±0.04 | 4.96±0.09 | 4.83±0.22 | 4.93±0.09 | 4.76±0.19 |

| | | | | | |
|---|---|---|---|---|---|
| **Tyr** | 2.19±0.05 | 2.45±0.05 | 2.53±0.09 | 2.56±0.03 | 2.61±0.15 |
| **Phe** | 2.33±0.09 | 3.04±0.11 | 3.11±0.43 | 3.22±0.09 | 3.33±0.84 |
| **His** | 1.04±0.04 | 1.75±0.05 | 1.78±0.12 | 2.11±0.11 | 2.19±0.13 |
| **Lys** | 2.34±0.05 | 4.07±0.09 | 4.11±0.15 | 4.12±0.05 | 4.19±0.09 |
| **Arg** | 1.84±0.09 | 3.62±0.02 | 3.69±0.11 | 3.69±0.12 | 3.89±0.43 |
| **Try** | 0.43±0.07 | 0.84±0.08 | 0.91±0.10 | 0.95±0.09 | 1.03±0.04 |
| **Asx** | 3.02±0.04 | 6.15±0.12 | 6.94±0.13 | 7.02±0.03 | 7.15±0.13 |
| **GLX** | 5.43±0.43 | 6.98±0.09 | 7.01±0.15 | 7.32±0.09 | 7.43±0.18 |
| **Total** | 33.7s±1.04 | 57.4±0.11 | 57.6±1.04 | 59.6±0.43 | 60.4±1.03 |
| **HAA** | 15.7±0.84 | 26.01±0.13 | 26.2±1.03 | 27.1±0.13 | 26.9±0.42 |
| **AAA** | 4.95±0.09 | 6.33±0.21 | 6.55±0.43 | 6.73±0.43 | 6.97±0.14 |
| **PCAA** | 5.22±0.04 | 9.44±0.04 | 9.58±0.49 | 9.92±0.55 | 10.3±0.11 |
| **NCAA** | 8.45±0.04 | 13.1±0.11 | 13.9±0.11 | 14.3±0.13 | 14.6±0.43 |
| **EAA** | 17.1±0.12 | 26.2±0.04 | 26.4±0.24 | 27.4±0.18 | 27.1±0.99 |
| **SCAA** | 1.47±0.01 | 2.27±0.09 | 2.44±0.21 | 2.77±0.44 | 2.55±0.43 |

**KEY:**

Values are mean ± standard deviation of duplicate determinations. ASX= aspartic acid and asparagine; GLX = glutamic acid and glutamine; Combined total of hydrophobic amino acids (HAA) = alanine, val, Ile, leu, Tyr, phe, Trp, pro, met and cys; Positively charged amino acids (PCAA) = arg, his, Lys; Negatively charged amino acids (NCAA) = ASX and GLX; Aromatic amino acids (AAA) = phe, Trp and Tyr; Essential amino acids (EAA) = His, Ile, Leu, Lys, Met, Phe, Thr, Try, and Val. Sulhur-containing amino acids (SCAA) = Met and Cys.

A = 100% Wheat flour (Control); B = 80% Wheat flour + 10% Soybean flour + 10% Moriche Palm fruit whole flour; C= 80% Wheat flour + 10% Soybean flour + 10%Moriche palm fruit protein concentrate; D = 80% Wheat flour + 10% Soybean flour + 10% Moriche palm fruit protein isolate; E= 80% Wheat flour + 10% Soy flour + 10% Moriche palm fruit protein hydrolysate.

Amino acids are molecules that combine to form proteins. Amino acids and proteins are the building blocks of life. When proteins are digested or broken down, amino acids are the result. The human body then uses amino acids to make proteins to help the body. The body that consumes high concentrations of amino acid has the benefits of breaking down food in real time, repairs of body tissues, manufactures hormones and brain chemicals, get multiple sources of energy, get immune boosters, sustains a normal digestive system and maintain healthy skins and nails (Jia *et al*., 2013; Ajibola *et al*., 2011). The twenty amino acids identified in the samples showed that the dominant amino acid was glutamic acid. The high total amino acid in sample E (that contained soybean and protein hydrolysate) may be related to the processes that the hydrolysate had undergone, giving it the privilege to freely release amino acids for quantifications. Sample D that contained protein isolate as part of the component had the highest hydrophobic amino acid (27.06 %), which may enhance antioxidant activities. Similarly, sample E that contained protein hydrolysate as part of its components had the highest aromatic amino acid (6.97 %), positively charged amino acid (10.27 %), negatively charged amino acid (14.58 %), while sample D (that contained protein isolate as part of its composition) had the highest value (2.77 %) for Sulphur containing amino acids. The concentrations of amino acids had been reported by Lyu *et. al*. (2022) and Shuluwa et al. (2021) to play crucial roles in enhancing antioxidant properties like the radical, metal and hydroxyl scavenging properties of food material.

### *4.4 Total phenolic content and Phytochemical properties*

The results for Total Phenolic content and Phytochemicals are as shown in Table 4. In this study, the sample that contained soybean flour and whole flour from moriche palm fruit had the highest phenolic content, while the sample with wheat flour only had the least. The trend may be connected with the levels of phenolic compounds present within the lipids in fats, as well as the soybean. Zhang *et al*. (2021) reported that wheat flour is a good phenolic food material. However, the claim may be true if the wheat is not yet processed. Also, the synergistic effect of the phenols in soybean and that of the moriche palm fruit whole flour could overcome that of the processed wheat flour. The result also indicated that samples that contained protein isolate and hydrolysate had lower values of phenols when compared to the one with less protein component. This could be attributed to the fact that the phenols in the material had been reduced drastically during the protein isolation and hydrolysis process, hence, the presence of the low level of Total Phenolic Content. The total phenolic content and phytochemical properties of wheat, soybean and moriche palm fruit flour blends as shown in Table 5 indicated that there was a gradual decrease in the content of all the anti-nutrients (tannins, oxalates, phytates and saponins) with replacement of moriche palm fruit purer proteins for whole flour. Tannins ranged from 0.54 to 1.69mg/100g; Phytates ranged from 0.36 to 3.05mg/100g; Oxalate value ranged from 0.43 to 2.15mg/100g and saponins ranged from 0.22 to 5.88mg/100g.

The result showed that the level of tannin obtained in the wheat flour was the lowest, while that of the sample B was high. The trend is a clear indication that some phytochemicals could be resident in the oil component of the moriche palm fruit flour (Adeyinka *et al*., 2017: Adebiyi *et al*., 2016). The low values of tannin obtained in samples, C-E suggested the removal of the component as the protein purification progressed. Tannins are a class of astringent, polyphenolic biomolecules that bind to and precipitate proteins and various other organic compounds including amino acids and alkaloids (Adebiyi et al., 2016). The tannin content (0.54 to 1.69mg/100g) of the wheat, soybean and moriche palm fruit flour in this study is lower than 2.34-8.25 mg/100g reported for maize-cassava-soybeans flour obtained in the study by Adejo and Igbua (2020) and also lower than the tannin content of 23.8 to 26.7% as reported in sorghum cultivars (Idris *et al*., (2020) and sorghum-soy-plantain flour 23.8-27.4% as reported in literature (Onoja *et al*., (2014). The result is also lower than tannin content of 35.8% as reported in malted sorghum flour (Singh et al., 20020).

Oxalate is an antinutrient present in a wide range of foods, with plant products, especially green leafy vegetables, being the main sources of dietary oxalates. This compound has been largely associated with hyperoxaluria, kidney stone formation, and, in more severe cases, systematic oxalosis (Ekeanyanwu *et al*., 2010). The oxalate content of the wheat flour was low and this may be due to the fact that wheat has low level of antinutrient. The high content of oxalate in sample B might be due to the presence of whole flour, having the oil component within. Similarly, the samples C-E that had low level of oxalate might be due to the fact that the samples had been subjected to protein purification procedures that have taken care of the oxalate as an antinutrient. The presence of oxalate in the body can hinder the absorption of other nutrients in the body. However, the oxalates contents which ranged from 0.43 to2 .15 in this study is lower than 1.63 to 2.32 mg/100g reported in maize-cassava-soy flour blends by Adejo and Igbua (2020).

Phytic acid is a six-fold dihydrogen phosphate ester of inositol, also called inositol hexaphosphate, inositol hexakisphosphate or inositol polyphosphate. At physiological pH, the phosphates are partially ionized, resulting in the phytate anion (Mathew and Panonnummal, 2021). Phytate does not have any other adverse effect except the fact that it affects the uptake of mineral component of food. In this study, phytate content was highest in sample B that had soybean flour and moriche palm fruit flour while other samples that contain either wheat flour only, or soybean and protein products contained lower values due to removal of this antinutrient by the process of protein purifications Mateos-Aparicio *et al*., 2010). Similar studies had been reported in phytate content of flours by Liang *et al*., (2001) and Gan *et al*., (2017). Phytate content of 0.36 to 3.05mg/100g reported in this study is lower than the phytate content of 39.4% for raw oat cereal (Norhaizan &Norfaizadatul 2009). The result is also lower than 36.6% and 25.7-39.4% for malted sorghum-soy flour (Oskar *et al*., 2024).

Saponins are a group of organic compounds that are found in plants and marine invertebrates and have a variety of biological activities. Saponins are bitter-tasting, have a high molecular weight, and are toxic. They are amphiphilic, meaning they have both a hydrophilic sugar moiety and a lipophilic aglycone. When shaken in water, saponins produce a foam similar to soap. Saponins are used as foaming agents, emulsifiers, and stabilizers in food products. They can contribute to the texture and stability of food· Saponin has many potentials uses in pharmaceuticals, including as anti-inflammatory, antimicrobial, antiviral, and antiparasitic agents. They can also be used as adjuvants to enhance the immune response to vaccines. Despite the pharmaceutical applications of saponins, not withstanding, it has been reported to exhibit adverse effects on man and animals, which include the occurrence of hemolysis and making nutrient unavailable when foods that contained saponin is consumed. In this case, isolation of protein and hydrolysis of hydrolysates had enhanced the reduction in the amount of saponins present in the samples. The high value of saponin observed in raw sample could be related to the fact that the sample had not undergone any processing techniques to the extent that the saponin content could be removed or reduced.

***Table 5: Total phenolic content and Phytochemical properties***

| Sample | Total phenolic content | Tannins (Mg/100g) | Oxalate (Mg/100g) | Phytate (Mg/100g) | Saponin (Mg/100g) |
|---|---|---|---|---|---|
| **A** | $29.23^{e}$ ±0.24 | $0.54^{e}$ ±0.02 | $0.43^{e}$ ± 0.02 | $0.36^{e}$ ±03 | $0.22^{e}$ ± 0.02 |
| **B** | $94.53^{a}$ ±0.11 | $1.69^{a}$ ±0.05 | $2.14^{a}$ ±0.02 | $3.05^{a}$ ±0.03 | $5.88^{a}$ ±0.04 |
| **C** | $78.49^{b}$±0.06 | $1.32^{b}$ ±0.02 | $2.09^{b}$ ±0.01 | $2.98^{b}$ ±0.02 | $5.45^{b}$ ±0.06 |
| **D** | $56.8^{c}$±0.09 | $1.22^{c}$ ±0.01 | $2.03^{c}$ ±0.01 | $2.76^{b}$ ±0.02 | $4.72^{b}$ ±0.01 |
| **E** | $48.71^{d}$ ±0.14 | $1.13^{d}$ ±0.02 | $1.86^{d}$ ±0.02 | $2.38^{d}$ ±0.03 | $3.8^{d}$ ±0.03 |

### *4.5 Functional Properties of Wheat, Soybean and Moriche Palm Fruit Flour Blends*

Functional properties indicate the behaviour of flours or composite flours in food systems and this play vital roles in the manufacturing of food products. The nature of the functional properties of food would essentially determine whether or not, a particular food would be useful for a named food product (Sanni *et al*., 2019). Table 5 shows the Functional properties of the Wheat, Soybean and Moriche palm Fruit Flour Blends. Water absorption capacities of flour material involve the addition of water to samples. The ability of the flour samples to absorb the water is dependent upon several factors, which include but not limited to the fibre content, protein content, size particulate matter of the flour materials (Köhn *et al*., 2015). The ability of the flour

sample to hold the water is known as the water absorption capacities of the flour sample. In this study, the least value was obtained in sample A that contained only wheat flour sample while the highest value was obtained in sample E, that was made up of wheat flour, soybean and protein hydrolysate. The high-water absorption capacities in the flour sample that contained soybean and protein products could be related to the high protein contents and the ability of the component of the flour to hold and absorb water for a longer period of time. Similar results had been reported by Sanni *et al*. (2020) and Ajata *et al*. (2016) on the improvement of water absorption capacities of composite flours that include high protein component. This result suggests the potentials of the samples in the formulation of acceptable bakery products.

The oil absorption capacities (OAC) are the physical entrapment of oils into the flour samples (Akubor *et al*., 2023). The property is useful in fried and in products where high absorption of oil is needed. The extent of the exposure of the sides of protein determines the level of the oil absorption capacities of the flour material. The balance between the hydrophobic and hydrophilic levels determine the level of entrapment, the oil will have. The oil absorption capacities (OAC) of the flour blends as shown in Table 7 had values between 1.53 to 2.95 g/g. The values, which were significantly different ($p<0.05$) from one another had sample E that contained protein hydrolysate with the highest value, while the least value was obtained in the sample that was 100% wheat. Similar trend was observed in the oil and water absorption capacities. The presence of the moriche palm fruit protein material (whole flour, protein isolate and hydrolysate) enhanced the ability of the composite flour to absorb oil. The results agreed with the published work of Zhang, Peng & Chen (2024), where samples that had component with high protein contents are found to have highest water and oil absorption capacities (Martín -Mateos *et al.*, 2022. The flours with high OAC are potentially beneficial in structural interactions in foods especially for improvement of palatability, extension of shelf life, and flavor retention particularly in bakery products where fat absorption is desirable (Suresh *et al*. 2015).

Bulk density determines how heavy or light a particular flour material is. It is very essential in food powder industry as it determines the requirement for designs of packaging materials (Barretto *et al.*, 2022), which is mostly dependent on the size of particles of the food materials. The bulk density of flour or composite flour is known to increase with increase in the addition of different particles of flour in the samples. Du *et al*. (2014) had reported that both the high values and low values of samples density are essential in the packaging technologies. In this work, the highest value for bulk density was E that contained protein hydrolysates while the lowest was obtained in sample A that had only wheat flour as its base. The low bulk density of sample A could be related to single flour present in the sample. The high bulk density in sample E could related to the multiple used flour used during the preparation of the samples from B-D. The high bulk density could be an indication that they are suitable to be used in preparing food products. The samples that have low bulk densities could be a good choice for preparing foods needed for ease of digestibility (Du *et al*., 2014; Kaur et al., 2021).

Foaming properties could be measured by foam capacities and stabilities. Zhu *et al*. (2017). Foam capacity measures the level of interfacial area that is created by the nature of protein during foaming. Foaming, as a property of flour rich protein are necessary in preparing various food products (Lawal). The result in this study showed that blend sample E that contained protein hydrolysates had the highest foaming capacity while the least value was obtained in sample A that contained only wheat flour. Sample D that contained soybean and protein isolate also had higher foam capacity than the one that contained whole flour. The result indicated that protein and its purity play a major role in the enhancement of foam capacity. This assertion is being supported by Suresh and Samsher (2013) and Kaur et al. (2021) on the fact that high protein content results in high foaming capacity of composite flour samples. The high foaming capacity of samples with high protein content may be related to the reduction in the surface tension, leading to good foamability and right order of protein molecule that are globular in nature (Sanni *et al*., 2019)

In the same manner, foaming stability is the ability of foam formed to remain stable for a specific length of time. Lawal et al. (2021) had reported that foam stability with the occurrence of protein-protein interaction on the air-water surface of the samples enhances the stability of samples. Similarly, the formation of a high level visco-elastic multiple layers films could encourage a kind of resistance to the bubbles being formed on the surface, thereby maintaining the stability of the foams. In this study, the trend of the foam capacity was similar when compared with that of foam stability, in that samples that had highest form capacity was also seen having the highest foam stability. This pattern may be due to the fact that the high content of sample E that contained protein hydrolysate helps to maintain a strong elastic pattern on the air-water surface, leading to strong foam stability. Similar trend of results had been reported by Barretto *et al.* (2022) and Anaemene (2020).

Emulsion properties is a two-way process that involves the formation of emulsion as well as the stability of emulsion. According to Abulude et al. (2018), the nature and the characteristics of protein on the surface are determinants for emulsion capacity. The extent to which dietary protein would mix with oil and become stable is simply referred to as emulsion properties. Generally, emulsion formed in foods are not stable under the influence of heat and also immiscible liquids formed between water and oil interface (Chen *et. al*., 2007; Lee et al., 2005). Sample D had the highest value for emulsion capacity and stability while the least value was obtained in sample A that contained only wheat flour. The ability of the emulsion formed to remain for a specific length of time without significant reduction is known as emulsion stability. The high protein content of protein isolates as contained in sample D, coupled with its ability to maintain immiscible solution on the surface may have been responsible for the high value in sample D. The high emulsion properties suggest that the components of the composite could be useful in salad dressing, dessert and in the making of mayonnaise (Zhang *et al.,* 2023; Honfo *et al*., 2022).

***Table 6: Functional Properties of Wheat, Soybean and Moriche Palm Fruit Flour Blends***

| | **WAC (g/g)** | **OAC (g/g)** | **BD (g/ml)** | **FC (g/g)** | **FS (%)** | **EC (g/m$^2$)** | **ES (%)** |
|---|---|---|---|---|---|---|---|
| **A** | $1.7^{e}$ ±0.43 | $1.53^{e}$ ±0.09 | $0.54^{d}$ ±0.04 | $0.74^{e}$ ±0.12 | $21.55^{e}$ ±0.92 | $1.03^{d}$ ±0.02 | $32.15^{e}$ ±0.09 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **B** | $1.95^{d}$ ±0.09 | $2.11^{d}$ ±0.04 | $0.75^{a}$ ±0.09 | $1.23^{d}$ ±0.09 | $35.95^{d}$ ±1.02 | $2.09^{c}$ ±0.07 | $48.25^{d}$ ±1.02 |
| **C** | $2.3^{c}$ 1±0.08 | $2.34^{c}$ ±0.09 | $0.71^{b}$ ±0.03 | $1.56^{c}$ ±0.03 | $45.25^{c}$ ±1.11 | $2.18^{b}$ ±0.08 | $55.83^{b}$ ±1.08 |
| **D** | $2.68^{b}$ ±0.13 | $2.63^{b}$ ±0.13 | $0.63^{c}$ ±0.09 | $1.85^{b}$ ±0.07 | $55.93^{b}$ ±1.09 | $2.34^{a}$ ±0.06 | $62.35^{a}$ ±0.88 |
| **E** | $2.71^{a}$ ±0.17 | $2.95^{a}$ ±0.19 | $0.59^{d}$ ±0.02 | $2.19^{a}$ ±0.12 | $58.35^{a}$ ±1.23 | $2.17^{b}$ ±0.11 | $53.45^{c}$ ±1.09 |

**Note: Values with superscripts along the columns are significantly different ($p<0.05$) from one another**

**KEY:**

*A = 100% Wheat flour (Control); B = 80% Wheat flour + 10% Soy flour + 10% Moriche Palm fruit whole flour; C= 80% Wheat flour + 10% Soy flour + 10%Moriche palm fruit protein concentrate; D = 80% Wheat flour + 10% Soy flour + 10% Moriche palm fruit protein isolate; E= 80% Wheat flour + 10% Soy flour + 10% Moriche palm fruit protein hydrolysate.*

## 5.0 CONCLUSION

a. The Flour blends produced from wheat, soybean and moriche palm fruit whole flour were of good quality as they contained reasonable amount of proteins, fats, fibres, ash and mineral elements as well as vitamin C and A making them better source of nutrients compared to wheat Flour alone.

b. Though the flour blends containing higher percentage of proteins had higher moisture content they were still below the maximum limit of moisture content for flours which is 15.5%.

c. The wheat, soybean and moriche palm fruit whole flour blends had high water absorption capacity which is an indication that such flours will be useful in the formulation of foods such as bread and other bakery products.

d. Replacement of moriche palm fruit whole flour with the protein concentrate, isolate and hydrolysate enhanced protein content but led to significant decrease ($p<0.05$) in the mineral content, reduced the fibre and fat content of flour blends produced but were still of better quality compared to wheat flour only.

e. The purer the protein present in the flour blend, the higher the concentration of amino acids which are building blocks of life making the flour blends of better quality than wheat flour alone.

f. The flour blends that contained protein isolate and hydrolysate also recorded higher concentrations of essential amino acids, sulphur containing amino acids, hydrophobic amino acids, positively charged and negatively charged amino acids that suggests that the flour blends would be good antioxidants.

g. The concentration of antinutrients in the flour blends were within safe limits due to the processing method used for both the soybean and moriche palm fruit flours.

h. The Functional properties of flour blends showed that a shelf stable and nutritious bakery product such as cookies and bread could be made from the composite flours.

**REFERENCES**

AACC. (2001). *Approved methods of the Association of Cereal Chemist* (11th ed., Method 61-02.01. Determination of the pasting properties of rice with the rapid visco analyzer). St. Paul, MN: Author.

Abulude, F. O., Ndamitso, M. M., Akinnusotu, A., Elisha, J. J., & Makinde, O. E. (2018). Proximate Composition, Mineral Contents and the effects of Sodium Sulphate Salts on Emulsion Capacity and Stability of Mushroom Species obtained from Nigeria. *Iraqi Journal of Science*, 986-997.

Abulude, F.O., Ndamitso, M.M. and Yusuf, A. (2013). Food functional properties: A review. In Srivasta, Y. (Ed.). Advances in Food Science and Nutrition, p. 1- 12. Nigeria: Science and Education Development Institute.

Adejo,Sylvester and Igbua Francis (2020)Antinutrients and Bioavaibility of Nutrients in maize, Cassava and Soybean Composite Flour. Asian Food Science Journal16(2), Pp. 5-12.

Akinyede, A. I., Fagbemi, T. N., Osundahunsi, O. F., & Aluko, R. E. (2021). Amino acid composition and antioxidant properties of the enzymatic hydrolysate of calabash nutmeg (Monodora myristica) and its membrane ultrafiltration peptide fractions. *Journal of Food Biochemistry*, *45*(3), e13437.

Akoja, S. S., & Coker, O. J. (2018). Physicochemical, functional, pasting and sensory properties of wheat flour biscuit incorporated with Okra powder. *International Journal of Food Science and Nutrition*, *3*(5), 64-70.

Akubor, P. I., Shabu, S. A. P., Okereke, G. O., & Damak, A. M. A. (2023). Quality properties of bread from blends of wheat flour and sweet orange seed protein concentrate. *Research Journal of Food Science and Nutrition*, *8*(3), 48-62.

Alain, M.M.M.; Israel, M.P. and Rene, M.S. (2007). Improving the Nutritional Quality of cowpea and bambara Bean flours use in infant feeding. *Pakistan Journal of Nutrition*, 6: 660-664.

Al-Attar, A. M. (2020). Therapeutic influences of almond oil on male rats exposed to a sublethal concentration of lead. *Saudi journal of biological sciences*, *27*(2), 581-587.

Al-Attar, A.M. and Zari, T.A. (2007). Modulatory effects of ginger and clove oils on physiological responses in streptozotocin-induced diabetic rats. *International Journal of Pharmacology,* 3, 34–40.

Aleem, Z. M. D.; Gentha, T. R. and Syed, I. H.(2012). Effects of defatted soy flour incorporation on physical, sensorial and nutritional properties of biscuits. J*ournal Food Processing and Technology*, 3:100-149.

Anaemene, D. I. (2020). *Utritional, Physico-Chemical And Microbiological Evaluation Of Cereal-Based Complementary Foods Fortified With Pigeon Pea (Cajanus cajan) FLOUR* (Doctoral dissertation).

AOAC (2005). Official methods of Analysis, 17th Edn Association of Official Analytical Chemists. Washington D.C, U.S.A.

AOAC (2015). Association of official analytical chemist. *Official methods of Analysis (*20th edth). Chemist press. Pp 234-289

Association of Official Analytical Chemists – AOAC. (2000). *Official methods of analysis of the Association of Official Analytical Chemists:* 17th ed. Washington DC.

Barretto, R., Buenavista, R. M., Pandiselvam, R., & Siliveru, K. (2022). Influence of milling methods on the flow properties of ivory teff flour. *Journal of Texture Studies*, *53*(6), 820-833.

Bergmann, S. M., Cieslak, M., Fichtner, D., Dabels, J., Monaghan, S. J., Wang, Q., ... & Kempter, J. (2016). Is there any species specificity in infections with aquatic animal herpesviruses. *The Koi Herpesvirus (KHV): An Alloherpesvirus Model. Fish Aquac J*, *7*(169), 2.

Bolarinwa IF, Olaniyan SA, Adebayo LO, Ademola AA. (2015). Malted sorghum- soy composite flour: Preparation, chemical and physico-chemical properties. Journal of Food Process Technology.6: 467.

Bonkoungou, S., Dagno, K., Basso, A., Ekanao, T., Atehnkeng, J., Agbetiameh, D., ... & Ortega-Beltran, A. (2024). Mitigation of aflatoxin contamination of maize, groundnut, and sorghum by commercial biocontrol products in farmers' fields across Burkina Faso, Mali, Niger, and Togo. *CABI Agriculture and Bioscience*, *5*(1), 106.

Brunner, J. H. (1984). Direct spectrophotometer determination of saponin, Animal Chemistry, 34: 1324-1326

Carazo, A., Macáková, K., Matoušová, K., Krčmová, L. K., Protti, M., & Mladěnka, P. (2021). Vitamin A update: forms, sources, kinetics, detection, function, deficiency, therapeutic use and toxicity. *Nutrients*, *13*(5), 1703.

Chen, Y., Sun, Y., Ding, Y., Ding, Y., Liu, S., Zhou, X., ... & Lu, B. (2024). Recent progress in fish oil-based emulsions by various food-grade stabilizers: Fabrication strategy, interfacial stability mechanism and potential application. *Critical Reviews in Food Science and Nutrition*, *64*(6), 1677-1700.

Dabels N., Igbabul B. D., Amove J. and Iorliam B.(2016).Nutritional Composition, Physical and Sensory Properties of Cookies from Wheat, Acha and Mung Bean Composite Flours. *International Journal of Nutrition and Food Sciences.* Vol. 5, No. 6, pp. 401-406.

Ekeanyanwu, R. C., Njoku, O. & Ononogbu, I. C. (2010). The phytochemical composistion and some bichemical effects of Nigerian tiger nut tuber. *Pakistan Journal of Nutrition*, 9(7): 709-715.

Esan, A., Okunola, O. J., & Adebowale, K. (2017). The role of mineral elements in human nutrition: Impacts on health and disease. *Journal of Nutritional Science*, *12*(3), 145-150. https://doi.org/10.1017/jns.2017.001

Famuwagun, A. A., & Gbadamosi, S. O. (2021). Nutritional Properties, Antioxidant and Enzyme Inhibitory Activities of Bread Sweetened with Date Fruit. *Turkish Journal of Agriculture-Food Science and Technology*, *9*(1), 114-123.

Felhi, S., Hajlaoui, H., Ncir, M., Bakari, S., Ktari, N., Saoudi, M., ... & Kadri, A. (2016). Nutritional, phytochemical and antioxidant evaluation and FT-IR analysis of freeze dried extracts of Ecballium elaterium fruit juice from three localities. *Food Science and Technology*, *36*, 646-655.

Gbadamosi, S. O., Abiose, S. H. and Aluko, R. E. (2012). Amino acid profile, protein digestibility, thermal and functional properties of Conophor nut (*Tetracarpidium conophorum*) defatted flour, protein concentrate and isolates. *International Journal of Food Science and Technology,* 47: 731-739.

Gbadamosi, S. O., Abiose, S. H., & Aluko, R. E. (2012). Amino acid profile, protein digestibility, thermal and functional properties of Conophor nut (Tetracarpidium conophorum) defatted flour, protein concentrate and isolates. *International journal of food science & technology*, *47*(4), 731-739.

Hasan, M. Z. (2020). *Proximate and Mineral Analysis Of Most Widely Used Mushroom Cultivated In Chattogram And Developed Mushroom Biscuits* (Doctoral dissertation, Chattogram Veterinary & Animal| Sciences University).

Honfo, F. G., Togbe, E. C., Dekker, M., Akissoe, N., & Ahohuendo, B. C. (2022). Nutritional and functional characterisation of flour from six plantain (Musa spp.) cultivars grown in Benin. *International Food Research Journal*, *29*(5), 1101-1109.

Idris HW, Hassan AD, Babiker EE, ElTinay AH. (2020). Effect of malt pretreatment on antinutritional factors and HCl extractability of minerals of sorghum cultivars. *Pakistan Journal of Nutrition*.; 4:396-401.

Jiru, N. A., Fekadu Gemede, H., & Keyata, E. O. (2023). Nutritional composition and antioxidant properties of selected underutilized wild edible fruits in East Wollega zone, Western Ethiopia. *International Journal of Fruit Science*, *23*(1), 34-45.

Kaur, L., Lamsar, H., López, I. F., Filippi, M., Ong Shu Min, D., Ah-Sing, K., & Singh, J. (2021). Physico-chemical characteristics and in vitro gastro-small intestinal digestion of New Zealand ryegrass proteins. *Foods*, *10*(2), 331.

Köhn, C.R., Fontoura, A.M., Kempka, A.P., Demiate, I.M., Kubota, E.H. and Prestes, R.C. (2015). Assessment of different methods for determining the capacity of water absorption of ingredients and additives used in the meat industry. *International Food Research Journal,* 22(1), 356-362.

Lawal, S. O., Idowu, A. O., Malomo, S. A., Badejo, A. A., & Fagbemi, T. N. (2021). Effect of toasting on the chemical composition, functional and antioxidative properties of full fat and defatted sesame (Sesamum indicum L) seed flours. *Journal of Culinary Science & Technology*, *19*(1), 18-34.

Lee, M. H., Do Kim, H., & Jang, Y. J. (2024). Delivery systems designed to enhance stability and suitability of lipophilic bioactive compounds in food processing: A review. *Food Chemistry*, *437*, 137910.

Liang, L., Alorbu, C., McDonald, A. G., & Cai, L. (2024). Phytic Acid for Dual wood Protection Against Fungi and fire. *Wood and Fiber Science*, *56*(2), 72-82.

Lyu, H., Chen, O. I. F., Hanikel, N., Hossain, M. I., Flaig, R. W., Pei, X., ... & Yaghi, O. M. (2022). Carbon dioxide capture chemistry of amino acid functionalized metal–organic frameworks in humid flue gas. *Journal of the American Chemical Society*, *144*(5), 2387-2396.

Martín-Mateos, M. J., Ortiz, A., Curbelo, P., Barraso, C., León, L., López-Parra, M. M., ... & García-Torres, S. (2022). New beef burger formulation with added cherry (pico negro variety) as a potential functional ingredient. *Applied Food Research*, *2*(2), 100132.

Mashayekh, S., Pourahmad, R., Akbari-Adergani, B., & Eshaghi, M. R. (2024). Evaluation of physicochemical, textural, and microbial characteristics of probiotic soy cheese during storage: Generation and isolation of bioactive peptides. *Food Science and Technology International*, 10820132231226257.

Masrul, M., & Nindrea, R. D. (2019). Dietary fibre protective against colorectal cancer patients in Asia: a meta-analysis. *Open access Macedonian journal of medical sciences*, *7*(10), 1723.

Mathew A.A. and Panonnummal R. (2021): 'Magnesium'-the mastercation-as a drug—possibilities and evidence. Biometals (2021) 34:955–986 https://doi.org/10.1007/s10534-021-00328-7

Msugh C. T.1, Adah C. A., and Asemave K. (2024). Quality Evaluation of Composite Flour From Wheat, Soybean And Sunflower Seeds For Bread Making. *African Journal of Agriculture and Food Science* ***Vol.*** 7 (3) pp. 265-283

Norhaizan ME, Norfaizadatul AA. (2009). Determination of phytate, iron, zinc, calcium contents and their molar ratios in commonly consumed raw and prepared food in Malaysia. Malnutrition Journal of Nutrition. Vol. 15: Pp. 213-222.

of *Mauritia flexuosa* L.f, from the Peruvian Amazon *Journal* of Grasas Y Aceites, 61 (4), Pp. 390-397.

Ojinnaka, M. C. and Okudu, H. O. (2017). *Production Agriculture and Technology Prints,* Vol. 13, No.1 Pp 74 – 79.

Onipe, O. O., Beswa, D., Jideani, V. A., & Jideani, A. I. O. (2018). Optimization of processing conditions for oil reduction of magwinya (a deep-fried cereal dough). *African Journal of Science, Technology, Innovation and Development*, *10*(2), 209-218.

Onoja US, Akubor PI, Gernar DI, Chinmma CE. (2014). Evaluation of complementary food formulated from local staples and fortified with calcium, iron and zinc. *Journal of Nutrition and Food Sciences*. 4(6).

Onuh, J. O., Girgih, A. T., Aluko, R. E., & Aliani, M. (2013). Inhibitions of renin and angiotensin converting enzyme activities by enzymatic chicken skin protein hydrolysates. *Food Research International,* 53:260–267

Onuh, J. O., Girgih, A. T., Malomo, S. A., Aluko, R. E., & Aliani, M. (2015). Kinetics of in vitro renin and angiotensin converting enzyme inhibition by chicken skin protein hydrolysates and their blood pressure lowering effects in spontaneously hypertensive rats. *Journal of Functional Foods*, *14*, 133-143.

Oskar, S., Mook, J., Smith, M. K., Huang, X., & McDonald, J. A. (2024). Temporal trends in phthalate metabolite exposure of girls in the United States across sociodemographic factors and intersectional social identities: National Health and Nutrition Examination Survey (NHANES) 2001–2018. *Environmental Research*, *260*, 119755.

Pongpichaiudom, A., Songsermpong, S., Tang, J., & Sablani, S. (2018). Modeling of dielectric and thermal properties of protein-enriched instant noodles as a function of food chemical composition. *International Journal of Food Engineering*, *14*(5-6), 20170205.

Sanni, T. A., Ogunbusola, E. M., Alabi, O. O., Jaiyeoba, C. N., Oni, K. O., Adubiaro, H. O., & Gbadamosi, S. O. (2019). Evaluation of chemical and functional properties of protein isolates from Basella alba and Senecio biafrae leaves. *FUW Trends in Science & Technology Journal*, *4*(1), 001-007.

Sanni, T. A., Ogunbusola, E. M., Jaiyeoba, C. N and Araoye, K. T. (2020). Nutritional and Sensory Characteristics of Bread Produced from Wheat and Cassava Flour, Fortified with Sorrel Seed Protein Isolate. FUOYE Journal of Engineering and Technology (FUOYEJET), 5(1): 25790617.http://dx.doi.org/10.46792/fuoyejet.v5i1.445.

Shar F.M, Igbabul B. D., Ikya J.; and Dabels N. (2016). Quality Evaluation of *Soy-mumu Supplemented with M*oringa Leaf Powder. *Journal of Food and Nutrition Sciences. Vol. 4, No. 5, pp. 131-135.*

Shuluwa, E. M., Famuwagun, A. A., Ahure, D., Ukeyima, M., Aluko, R. E., Gbenyi, D. I., & Girgih, A. T. (2021). Amino acid profiles and in vitro antioxidant properties of cereal-legume flour blends. *Journal of Food Bioactives*, *14*.

Singh, A. S., Alagbe, J. O., Sharma, S., Oluwafemi, R. A., & Agubosi, O. C. P. (2021). Effect of dietary supplementation of melon (Citrallus lanatus) seed oil on the growth performance and antioxidant status of growing rabbits. *Indonesian Journal of Innovation and Applied Sciences (IJIAS)*, *1*(2), 134-143.

Suresh, C. and Samsher., S. (2013). Assessment of functional properties of different flours. *African Journal of Agricultural Research,* 8(38), 4849-4852.

Tamilselvan, T., & Kushwaha, A. (2020). Effect of traditional processing methods on the nutritional composition of sorghum (Sorghum bicolour L. Moench) flour. *European Journal of Nutrition & Food Safety*, *12*(7), 69-77.

Gemede, H. F. (2020). Nutritional and antinutritional evaluation of complementary foods formulated from maize, pea, and anchote flours. *Food Science & Nutrition*, *8*(4), 2156-2164.

Vásquez-Ocmín, Pedro G. Luis Freitas Alvarado, Víctor Sotero Solís, Rosángela Paván Torres, and Jorge Mancini-Filho (2010). Chemical characterization and oxidative stability of the oils from three morphotypes of aguaje (*Mauritia flexuosa).*

Zhang, L., Peng, Q., & Chen, J. (2024). Effect of dry-and moist-heat treatment processes on the structure, solubility, and in vitro digestion of macadamia protein isolate. *Journal of Food Science*, *89*(8), 4671-4687.

Zhang, M., Wang, O., Cai, S., Zhao, L., & Zhao, L. (2023). Composition, functional properties, health benefits and applications of oilseed proteins: A systematic review. *Food Research International*, *171*, 113061.

Zhang, Q., Cheng, Z., Wang, Y., & Fu, L. (2021). Dietary protein-phenolic interactions: Characterization, biochemical-physiological consequences, and potential food applications. *Critical Reviews in Food Science and Nutrition*, *61*(21), 3589-3615.