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Evaluation of Nutritional, Anti-Nutritional and Functional Properties of *Musa Paradisiacal* and *Avena Sativa* Flour Blend for Food Formulation

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ABSTRACT
The increased demand for gluten-free food alternatives has encouraged development of composite flour from locally available plant sources. In this study, the proximate composition, functional properties and mineral composition of *Musa paradisiacal* (plantain) and *Avena sativa* flour (oat) flour blend were determined. The moisture content, ash, fibre, fat protein and carbohydrate were determined to be in the range of 5.94–7.36 %, 1.13–1.91 %, 1.13–1.74 %, 0.46–0.64 %, 5.71–13.33 % and 76.91–84.24 % respectively. Mineral analysis gave concentrations in mg/100g as K (412.25–1077.67), Na (21.87–78.54), Ca (1.99–12.46), Fe (0.24–0.98) and Mg (55.76–107.34). The vitamin content of the plantain–oat blend in (mg/100g) was vitamin A (0.07–1.60) vitamin C (0.06–0.08) and vitamin E (0.12–0.35). The range of composition of anti nutrients (%) were phytate (0.4 – 1.0), oxalate (0.60 –1.65) and tannins (0.27–0.30). The determined functional properties were foaming stability, swelling power, water absorption capacity, oil absorption capacity and bulk density. The result of the analysis showed that the foaming capacity was 6.66– 20.00 %, swelling power 0.86–0.97 g/g, water absorption capacity 1.16–1.42 g/g, oil absorption capacity 3.27–3.39 g/g and bulk density was 0.59–0.65 g/cm^3. The composite flour produced has enhanced nutritional and functional properties. Therefore, it is suitable for good food formulations.

Keywords:
Nutritional,
Functional properties,
Flour blend,
Formulation,
Mineral analysis.

INTRODUCTION

In current era, the demand for gluten-free alternatives has soared, driven by the growing number of individuals with gluten sensitivities, celiac disease, or those simply embracing a gluten-free lifestyle. This has led many to seek alternatives to traditional wheat flour from various available substitutes such as potatoes, maize, cassava, banana etc (Banu *et al*., 2012; Adeyeye *et al*., 2023). The development of gluten-free flour-blends has become increasingly important in response to rising health awareness, dietary restrictions (Zannini *et al*., 2022; Hasmadi *et al*., 2020), and the growing prevalence of celiac disease and gluten intolerance. Traditional wheat-based flours, which contain gluten—a protein complex responsible for the structure and elasticity in many baked goods—must be replaced in gluten-free diets with alternative flours that mimic these functional properties while meeting nutritional needs. As a result, gluten-free flour blends often incorporate a variety of sources, including rice, corn, sorghum, millet, legumes, tubers (such as cassava or sweet potato), and seeds (like chia or flaxseed).

These flour blends not only allow for the creation of structurally sound and palatable gluten-free products but also offer enhanced nutritional profiles (Udeh *et al*., 2023; Hager *et al*., 2021). Many gluten-free flours are rich in dietary fibre, high-quality plant proteins, essential fatty acids, and bioactive compounds with antioxidant properties. Furthermore, combining different gluten-free flours can improve the amino acid balance, increase micronutrient diversity, and compensate for the deficiencies often found in single-source gluten-free flours (Oladipo *et al*., 2022).

Functionally, the formulation of gluten-free flour blends requires careful selection and balancing to replicate the viscoelastic properties of gluten. Factors such as water absorption capacity, gelatinization behaviour, and emulsifying ability are critical for ensuring desirable texture, volume, and mouth-feel in the final product. Breakthrough in food science and ingredient technology have enabled the optimization of these blends for variety of gluten-free applications, including bread, cakes, cookies, pasta, and snack foods (Kaur *et al*., 2023).

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As consumer demand continues to grow for nutritious and high-quality gluten-free options, the role of carefully designed flour blends in food formulation becomes increasingly vital (Ajala *et al*., 2022). By harnessing the natural qualities of plantain and the fiber-packed goodness of oat flour, it is possible to have a variety of flavuorful, gluten-free dishes that meet both dietary and taste needs (Nnamani *et al*., 2023).

MATERIALS AND METHODS

Sample collection

The samples (plantain and oat) were bought from Wurukum market in Makurdi Benue State and taken to chemistry laboratory, Benue State University and stored at 4 ^{o}C. The dry oat (*Avena Sativa*) grains were sorted to remove the unwanted material like stones, pebbles and other foreign seeds. The seeds were then washed with tap water, allowed to drain, and dried in an oven at 60 ^{o}C for 24 h constant weight. The dried grain were milled and sieved through 600 µm mesh size sieve. The floor obtained was collected and stored in polythene bags for analysis (Onyeke *et al*., 2025). The plantains were washed to eliminate sand and other unwanted particles. It was then cut into smaller pieces of 2 cm thickness. These pieces were dried in an oven at 60^{o}C for 24 h. The already dried samples were milled to powder. The floor was sieved through a 250 µm sieve (Onyeke *et al*., 2025).

Blending of plantain and oat flours

The blends of plantain and oat flours were made in different ratios and labelled as follows: samples A(1:1), B(4:1), C(3:2) and D(2:3). This was done by measuring respective amounts of plantain and oat flours separately using digital balance and mixing them together to form the blend. The blends were sealed in separate polyethylene bags prior to analyses

Determination of moisture content

The procedure outlined by AOAC (2005) was followed. Crucibles were thoroughly cleaned and dried in an air oven at 110 °C for approximately 10 minutes until a constant weight was achieved. After cooling in a desiccator for 30 minutes, the empty crucibles were weighed (W_1). A 2.0 g portion of the sample was then carefully added to each crucible, and the combined weight was recorded (W_2). The crucibles with the samples were placed in an oven at 110 °C for 14 hours. After drying, they were cooled in a desiccator at room temperature and weighed again (W_3). The moisture content of the sample was then determined using the following formula:

$$\% \text{ Moisture} = \frac{\text{Weight loss}}{\text{Sample weight}} \times 100\ \% \quad (1)$$

$$\% \text{ Moisture} = \frac{W_2 - W_3}{W_2 - W_1} \times 100\ \% \quad (2)$$

Where W_1 = weight of dish only, W_2 = weight of dish and sample before drying, W_3 = weight of dish and sample after drying W_2-W_3 = weight of sample after drying W_2-W_1 = weight of original sample before drying sample.

Determination of ash content:

The ash content was determined following the AOAC (2005) procedure. Porcelain crucibles were first cleaned and dried in an oven at 100 °C for 10 minutes until a constant weight was achieved. After cooling in a desiccator, the crucibles were weighed (W_1). Accurately, 2.0 g of each sample was placed into the weighed crucibles, and the combined weight was recorded (W_2). The crucibles with the samples were then placed in a furnace set at 550 °C for 8 hours to ensure complete ashing. After cooling in a desiccator, the crucibles were weighed again (W_3). The ash content was expressed as a percentage using the appropriate calculation formula.

Percentage ash content

$$= \frac{\text{Weight of crucible +ash} - \text{weight of empty}}{\text{Weight of sample}} \times 100\ \% \quad (3)$$

$$\text{Percentage ash content} = \frac{W_3 - W_1}{W_2 - W_1} \times 100\ \% \quad (4)$$

Where W_1 = weight of crucible only, W_2 = weight of crucible + sample, W_3 = weight of crucible + ash, W_3-W_1 = weight of ash, W_2-W_1 = weight of sample

Determination of crude fibre

The procedure outlined by AOAC (2005) was followed. Precisely 2.0 g of the sample was placed in a round-bottom flask and 200 cm³ of 1.25 M sulfuric acid was added. The mixture was then boiled under reflux for 2 hours. After heating, the solution was rapidly filtered using suction and the residue was washed repeatedly with hot water until no acid remained. The residue was subsequently transferred back into the flask, 100 cm³ of hot 0.3 M sodium hydroxide was added, and the mixture was boiled under reflux for 1 hour. The mixture was again quickly filtered under suction, and the insoluble residue was washed with hot water until free of base. The residue was dried in an oven at 100 °C for 2 hours, cooled in a desiccator, and weighed (W_1). The dried residue was then incinerated and weighed again (W_2). The crude fiber content was determined as a percentage based on the difference in weight.

$$\text{Percentage crude fibre} = \frac{W_2 - W_1}{\text{Weight of sample}} \times 100\ \% \quad (5)$$

Determination of crude fat content

Crude fat content was determined by the Soxhlet extraction method as outlined by AOAC (2012) method. Five grams of dried samples will be weighed into preconditioned and weighed (Wo) extraction thimble and placed in the soxhlet extraction apparatus. Fat of the samples will be extracted using organic solvent (petroleum ether) and boiled under reflux for 6 hours. The

extraction thimbles will be removed and dried in an oven at 105°C for 30 min. then cooled and weighed (W_1). Percentage of fat content will be calculated using the following formula:

$$\% \text{ crude fat} = \frac{\text{weight of fat content in sample}}{\text{weight of dry sample}} \times 100 \quad (6)$$

$$= \frac{W_o - W_1}{\text{Weight of dry sample}} \times 100\ \% \quad (7)$$

Determination of protein content

The protein content of the sample was measured using the total Kjeldahl nitrogen (TKN) method as described by AOAC (2012). A 1 g portion of the sample was digested with concentrated sulphuric acid (H_2SO_4) in the presence of a Kjeldahl digestion tablet. After digestion, the mixture was neutralized with 40 % sodium hydroxide (NaOH) and subjected to distillation. The distilled solution will then be titrated with 0.1 N hydrochloric acid (HCl) using a mixed indicator of methyl red and bromocresol green. The nitrogen content (%) will subsequently be determined using the corresponding calculation formula.

$$\% \text{ nitrogen} = (S - B) \times N. \times 0.014 \times D \times \frac{100}{w} \times V \quad (8)$$

Where: D = dilution factor, T = titre value = (S-B),
W = weight of sample,
Crude protein will be obtained by multiplying the corresponding total nitrogen content by a conventional factor of 6.25.

Thus: Crude protein (%) = % N × 6.25. (9)

Determination of total carbohydrates

The total carbohydrate content will be estimated by the difference as described by (Osuala *et al*., 2021) according to the following equation

$$\text{Carbohydrate} = 100\ \% - (\%\ \text{moisture} + \%\ \text{protein} + \%\ \text{Ash} + \%\ \text{Fibre} + \%\ \text{fat}) \quad (10)$$

Determination of phytate content

The phytate content in the samples was assessed using the procedure outlined by AOAC (2012). Initially, phytate was extracted by treating the sample with 0.5 mol/dm³ HNO_3 and subsequently digested with 0.5 ml of perchloric acid ($HClO_4$). The resulting digested solution was diluted to a final volume of 25 ml with distilled water in a standard volumetric flask. From this solution, a 2.5 ml aliquot will be combined with an equal volume of nitric acid, followed by the addition of 2.5 ml of vanadium-molybdate reagent, which reacts with phytic phosphorus to form a yellow-orange complex. The optical density of this complex was recorded at 460 nm using a P7 UV/Vis spectrophotometer. Phytate content was then be determined by comparison with a 2 mg phytic acid standard, while a reagent blank processed in the same way will serve as a control.

$$\text{phytate}\left(\frac{\text{mg}}{100}\text{g}\right) = \frac{\text{Sample absorbance x standad concentration}}{\text{Standard absorbance x weight of sample}} \times 100 \quad (11)$$

Determination oxalate content

Oxalate levels in the samples were measured following the official AOAC method (AOAC, 2005). In brief, 1.0 g of the sample was mixed with 75 cm³ of 3.0 mol/dm³ H_2SO_4 and stirred thoroughly for one hour. The mixture was then filtered using Whatman No. 1 filter paper. A 25 mL portion of the filtrate was titrated with 0.1 mol/dm³ $KMnO_4$ solution, heated to 80–90 °C, until a faint pink colour persisted for at least 30 seconds. The oxalate content was calculated using the conversion factor that 1.0 cm³ of 0.1 mol/dm³ $KMnO_4$ is equivalent to 0.006303 g of oxalate.

Determination of tannins content

Tannin levels were assessed following the AOAC (2012) method. Briefly, 5 g of the sample was mixed with 50 cm³ of distilled water and shaken thoroughly. The mixture was left to stand at 28 °C for 30 minutes before being filtered through Whatman No. 4 filter paper. An aliquot of 2 ml of the filtrate was transferred into a 50 ml volumetric flask. In a similar manner, 2 ml of a standard tannic acid solution (0.1 mg/ml) and 2 ml of distilled water were placed in a separate 50 ml volumetric flask to serve as the standard. To each flask, 2.5 ml of saturated sodium carbonate (Na_2CO_3) solution and 1 ml of Folin–Ciocalteu reagent were added, and the volume was adjusted to 50 ml with distilled water and mixed thoroughly. The solutions were allowed to react for 1.5 hours, then filtered through Whatman No. 4 filter paper, and the absorbance was recorded at 760 nm using a spectrophotometer against a reagent blank. The tannin content was calculated from Equation 13.

$$\text{Tanning}\left(\frac{\text{mg}}{100}\text{g}\right) = \frac{\text{standard concentration} \times \text{sample absorbance}}{\text{standard absorbance} \times \text{weight of sample}} \times 100 \quad (12)$$

Determination of foam stability

Foam stability was assessed following a slightly modified version of the method described by Narayana and Narasinga (1982). A 1.0 g portion of the flour sample was mixed with 50 cm³ of distilled water at 30 °C in a graduated cylinder. The mixture was vigorously shaken for 5 minutes to generate foam. After one hour, the foam volume was measured and the stability was calculated as a percentage of the original foam volume.

$$\text{Foam stability (\%)} = \frac{\text{Volume of foam after whipping} - \text{volume of foam before whipping}}{Volume\ of\ foam\ before\ whipping} \times 100\ \% \quad (13)$$

Determination of bulk density

A 50 g flour sample was measured into a 100 cm^3 measuring cylinder. The cylinder was tapped continuously until a constant volume was obtained. The bulk density (g/cm^3) was calculated as weight of flour (g) divided by flour volume (cm^3) (WHO, 2019; Das *et al*., 2019)

$$\text{Bulk density } (g/cm^3)\ (\%) = \frac{\text{Weight of sample}}{\text{Volume of sample after tapping}} \quad (14)$$

Determination swelling power

Swelling power and solubility index were assessed following the procedure of Abdualrahman et al. (2019) with slight modifications. One gram of the sample was placed into a 50 cm^3 centrifuge tube, and 50 cm^3 of distilled water was added. The mixture was gently stirred to form a uniform slurry, which was then heated in a water bath at 80 °C for 15 minutes, with occasional gentle stirring to prevent clumping. After heating, the tube was centrifuged at 3000 rpm for 10 minutes. The supernatant was carefully removed, and the weight of the sediment was recorded. The moisture content of the sediment gel was measured to determine the dry matter, which was used to calculate the swelling power. The moisture content of the sediments gel was therefore determined to get the dry matter content of the gel.

$$\text{Swelling power} = \frac{\text{Weight of wet mass sediment}}{\text{Weight of dry matter in the gel}} \quad (15)$$

Determination water absorption capacity

The water absorption capacity of the flour was determined by the method of Takashi and Sieb, (1988). About 10 cm^3 of distilled water was added to exactly 1.0 g of the flour. This mixture was left undisturbed for 30 mins at 25 ºC. This mixture was centrifuged at 3000 rpm for 40 mins. The clear supernatant liquid was collected by decantation. Water absorption was expressed as percent water bound per gram flour.

Determination oil absorption capacity

Oil absorption capacity was evaluated according to Abdualrahman *et al*. (2019). One gram of flour was mixed with 10 ml of oil and allowed to stand at room temperature (~25 °C) for 30 minutes. The mixture was centrifuged at 3000 rpm for 30 minutes, and the supernatant was carefully removed. The amount of oil bound per gram of flour was calculated and expressed as a percentage.

RESULTS AND DISCUSSION

Table 1: Proximate composition of plantain –oat blend

Sample	A	B	C	D	WHO/FAO
Moisture (%)	5.94 ±0.001	7.03 ± 0.25	7.36 ± 0.21	5.96 ± 0.49	<3
Ash (%)	1.45 ± 0.00	1.13 ± 0.00	1.84 ± 0.01	1.91 ± 0.00	<3
Fibre (%)	1.74 ± 0.00	1.44 ± 0.01	1.45 ± 0.15	1.13 ± 0.01	<5
Fat (%)	0.64 ± 0.04	0.46 ± 0.11	0.56 ± 0.35	0.52 ± 0.43	10-25
Protein (%)	13.33 ±0.01	5.71 ± 0.13	11.57 ± 0.01	11.77 ± 0.01	16
Carbohydrates (%)	76.91 ± 0.05	84.24 ± 0.29	77.23 ± 0.71	78.73 ± 0.93	60-75

Table 2: Mineral content of plantain –oat blend (mg/100 g)

Sample	A	B	C	D	Codex
K	1077.67 ± 0.01	412.54 ± 0.01	645.82 ± 0.01	815.68 ± 0.01	516
Na	78.54 ± 0.01	21.87 ± 0.01	37.92 ± 0.01	53.13 ± 0.01	120-600
Ca	12.46 ± 0.01	1.99 ± 0.01	2.68 ± 0.01	5.37 ± 0.01	250
Fe	0.98 ± 0.01	0.24 ± 0.01	0.67 ± 0.01	0.76 ± 0.01	11.6-40
Mg	107.34 ± 0.01	55.76 ± 0.01	81.15 ± 0.00	83.72 ± 0.01	100-150

Table 3: Vitamin content of plantain –oat blend (mg/100 g)

Sample	A	B	C	D	Codex
Vitamin A	0.16 ± 0.00	0.07 ± 0.00	0.12 ± 0.00	0.14 ± 0.00	0.8-1
Vitamin C	0.08 ± 0.00	0.06 ± 0.00	0.06 ± 0.00	0.06 ± 0.00	80-22
Vitamin E	0.35 ± 0.00	0.12 ± 0.00	0.32 ± 0.00	0.35 ± 0.00	0.05

Table 4: Anti-nutrient content of plantain –oat blend

Samples	A	B	C	D	
Phytate (%)	0.40 ± 0.00	1.00 ± 0.00	0.55 ± 0.00	0.50 ± 0.00	
Oxalate (%)	0.06 ± 0.00	1.65 ± 0.07	0.85 ± 0.07	0.65 ± 0.07	
Tannins (%)	0.28 ± 0.00	0.30 ± 0.00	0.27 ± 0.00	0.28 ± 0.00	

Table 5: Functional properties of plantain –oat blend

Samples	A	B	C	D	
Foaming ability (%)	20.00 ±0.00	6.66 ± 0.00	6.68 ± 0.03	6.72 ± 0.08	
Swelling power (%)	0.94 ± 0.05	0.86 ± 0.00	0.95 ± 0.04	0.97 ± 0.05	
Water absorption capacity (%)	1.42 ± 0.08	1.16 ± 0.13	1.37 ± 0.14	1.22 ± 0.20	
Oil absorption capacity (%)	3.39 ± 0.22	3.27 ± 0.13	3.36 ± 0.17	3.38 ± 0.07	
Bulk density (g/cm^3)	0.63 ± 0.00	0.65 ± 0.00	0.65 ± 0.00	0.59 ± 0.00	

The proximate analyses, mineral and vitamin contents and functional properties plantain-oat flour blend were determined and the results are presented Tables 1-4. Moisture content determines the water content of a sample and indirectly, its dry matter content. It also gives an ideal of the shelf life/ stability of a sample (Diningsih *et al*., 2024). Moisture levels above 14 % make substances susceptible to microbial growth and thus have a lower stability (Onyeke *et al.,* 2024). The moisture content of the blends was between 5.94 -7.36 %. This means that blends will have a long shelf life. The moisture contents of all the formulated composite food samples reported in this study were within the recommended moisture contents for dried foods. Similar ranges of result were obtained by of Orlu *et* al., 2022 and Hu *et al.* (2014). The ash content gives an idea of the mineral content present in the food. The value of ash contents of the blend was in the range 1.13-1.91 % and it agreements with that obtained by Damak *et al*., 2022. According to Diningsih *et al*., 2024 increase in ash content in cookies can be increased by the presence of oats. Also, during ashing, incomplete oxidation of organic substances may occur. The crude fibre contents of the blends were in the range 1.13- 1.74 %. Research has shown that fibres can help solve some common health issues. It has been established that dietary fibre prevents indigestion in the small intestine (Sengupta *et al.,* 2023). It also maintains the internal distention in intestinal tract as its physiological effect (Adegbanke *et al*., 2023). Consuming diets containing good amount of fibre give protection against colon cancer (Okpewho *et al*., 2025). Fibres also maintain blood lipids and hence reduce risk of cardiovascular and coronary heart diseases. Fibres in foods prevent the constipation and diverticular diseases. Some fibres can also slow D-glucose absorption and reduce insulin secretion, which is of great importance for non- diabetics as well (Agu *et al*., 2022; Shi *et al*., 2023).

The crude fat content of the blends was in the range 0.464 -0.64 % According to Salawu *et al.* (2023), a sample is classified oily if it contains at least 20 % fat. These low values are low because the blends were made from non-oil/fat samples. Fats are important in diet because they are high energy nutrients and encourage absorption of fat soluble vitamins (Chinma *et al*., 2022). The crude protein content of these blends were high in the range 5.71-13.33 %. This result is within the range to the obtained by Obasi and Askepnde, 2023 from flours prepared from wheat, unripe plantain and pigeon pea. This high protein content shows that the plants contain reasonable amount of protein and can therefore serve as alternative source of protein in the diet and supplements. The carbohydrate contents of the blends were very high (76.91-84.24 %). This high carbohydrate content proved that the blends are rich in energy. The energy is enough to take care of daily energy need in children and adults (Umaru *et al*., 2023).

The minerals Fe, K, Na, Ca and Mg were also analyzed and presented on Table 2. The other of increasing amounts of the minerals was Fe, Ca, Na, Mg, and K. The results showed that all the determined minerals did exceed the recommended codex values hence safe for consumption. K helps in the proper functioning of the body, Na helps to balance the amount and distribution of water in the body. They maintain blood pressure, control nerve and for muscle functioning. K and Na maintain body fluids; regulate pH, muscles and nerve signals (Adeyemo *et al*., 2022). Mg regulates the level of blood sugar and also helps to regulate Zn level in the body. Potassium is an essential nutrient needed for maintenance of total body fluid volume, acid and electrolyte balance, and normal cell function (Abdullahi *et al*., 2023; Ezeocha *et al*., 2024). Ca is mostly known for bones formation, blood clothing. It also controls heart beat and contraction of muscles and prevents type 2 diabetes (Adeyemo *et al*., 2022). Iron is known for boosting of immune system and prevention of anaemia (Olagunju *et al*., 2022).

The vitamins A, C and E contents of the blends were determined and presented on Table 3. The results showed that all the blends contained the high amount of vitamin

E and vitamin A. Vitamins help the body to fight infections, wounding healing of wounds, strengthen of bones and regulation of body hormones (Okonkwo *et al*., 2022; Ezeocha *et al*., 2023). Vitamin A is responsible for proper vision, bone formation, cell division and differentiation (Okereke *et al*., 2021). It produces white blood cells which fights infectious bacteria and viruses. By so doing, the immune system is enhanced. Vitamin C is used for collagen production, which gives shape/structure to muscles, vascular tissues, bone and cartilage for the healthy teeth and gums and also assist in iron absorption (Okereke *et al*., 2021; Babarinde *et al*., 2020). The results obtained from the anti-nutrient analysis are presented in Table 4. Three anti-nutrients analysed were phytate tannins and oxalate. Anti-nutrients are known to decrease bioavailability of mineral elements in monogastric animals (Nwachukwu *et al.*, 2024). Oxalates compounds in food can induce irritation of the tissues lining the mouth. Oxalate also reduce the bioavailability of certain cations especially calcium. This is because they bind with calcium to form insole salts thus prevents its abortion. Consequently, the availability of calcium is diminished, limiting its contributions to essential physiological and biochemical roles. Calcium is known for strong skeletal formation, dental health, enzyme activation, neuronal communication and clot formation in blood (Ibrahim *et al*., 2023). Additionally, excessive oxalate consumption may cause and abnormal increase in oxalate excretion in urine. This condition thus increases the risk of kidney stone formation (Ibrahim *et al*., 2023).

The functional properties such as forming capacity (FC), swelling capacity (SC), water absorption capacity (WAC), oil absorption capacity (OAC) and bulk density (BD) of the plantain-out blend were also determined with the results presented on Table 5. Functional properties are used to determine the requirements and appropriateness of a flour blend for specific application. The range of the foaming capacity of the blended flour was 6.66 -20.00 %. Foaming capacity refers to how effectively flour can generate and sterilize the air-liquid interface when it is whipped. It improves the visual appeal and the texture of foods. The FC of flours depends on its protein and carbohydrates content (Maboh *et al*., 2023). It also depends on the distribution of gas bubbles in semisolid or liquid phase. (Awuchi, 2019). The capacity of flour to form and maintain form is key functional property required for its effective application in backed products such as cakes, muffins and cookies (Awuchi *et al*., 2019). The swelling property of flour blends is described by its starch content. Flour swelling capacity is affected by multiple factors including ingredient composition and processing methods (Chandra and Samsher, 2013, Otegbayo *et al.*, 2020). The swelling power of the flours varied from 0.86 - 0.97 g/g, where the lowest value was obtained for 4:1 blend and the highest was 2:3 blends. These results agree with that obtained by Ajala *et al*., 2022 from wheat, mushroom (*Pleurotus ostreatus*) and unripe llantain (*Musa paradisiaca*) flour. WAC gives idea of the quantity of water absorbed or retained by flour. (Henry- Unaeze and Okoye, 2022). The water absorption capacity was highest for 1:1 flour (1.42 g/g) and lowest for 2:3 flour with value of 1.22 g/g. Higher water absorption values were attributed to the higher content of starch and fibre. Obasi *et al*. (2023) also stated that "higher protein contents tend to increase water absorption". Water absorption capacity depends on the amount of the hydrophilic constituents and to some extent on pH and nature of protein (Awuchi *et al*., 2019; Li-Chan *et al*, 2006). From the study, 1:1 ratio flour blend exhibited the highest oil absorption capacity (3.39 g/g), being suitable for retaining the flavour and enhance the mouth feel when used in foods (Ikegwu *et al*., 2010). The water and oil absorption capacity depends on the type of protein, amino acid composition, protein polarity and hydrophobicity (Iheanacho *et al*., 2021). Bulk density of flour blends is related to its weight (Ekpa and Okoye, 2023). Blends 4:1 and 3:2 gave higher bulk while 2:3 blend was low. Variation in bulk densities of flour is due to nonuniform distribution of the particles (Aliyu and Mohammed 2022).

CONCLUSION

In this research, the nutritional quality, anti- nutritional constituents and functional attributes of *M. paradisiacal-A. sativa* flour blend. The flour blends were prepared in varying ratios of mixing. Results of the proximate analysis showed that the blends were rich in carbohydrates, contained moderate proteins and low fats and crude fibre. The moisture contents were within the acceptable limit suggesting good storage stability. Mineral analysis proved that the flour blends contained important macro and trace elements such as Fe, K, Ca, Mg and Na. Vitamin evaluation showed the presence of vitamins A, C and E thus enhancing their nutritional value. Anti-nutrients such as phytates, oxalate and tannis were detected in very low concentrations to affect nutrient utilization. The functional characteristics indicated that the flour blends has favourable processing qualities to be used in diverse food products. On overall, these results demonstrate that plantain-oat flour blends are nutritionally beneficial, functionally efficient for consumption.

The results showed considerable enhanced amounts of nutritional properties such as proteins, vitamins, minerals as well as functional properties. This will be nutritionally advantageous to most populace in Nigeria as a gluten-free alternative.

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