PROXIMATE, MINERAL AND FUNCTIONAL PROPERTIES OF MORINGA SEEDS AND PEARL MILLET FLOUR BLENDS

Ezinne Prisca Obinwa, Patricia Etuna Mbah, & Umeh-Idika Adaku Sandra
Department of Home Science,
Michael Okpara University of Agriculture Umudike. Abia State, Nigeria
*Correspondence: ezinneobinwa@gmail.com. Tel: 08039198473

Abstract
Moringa seeds and millet grains were processed into flour using different processing methods. The different flour were blended to produce composite flour at different ratios 90:10, 80:20, 70:30 and 100:0 wheat flour (control). Proximate, mineral composition and functional properties of the composite flour blends were determined. Results were analyzed statistically by the analysis of variance. Result for proximate composition of the flour samples shows significant increase (P < 0.05) in the ash content (0.83% – 1.83%), Fat (1.16% – 12.66%), protein, (2.01% - 5.60%) and fiber; (0.77% - 1.83%). Mineral composition of the flour samples revealed that the control had highest sodium, potassium and iron content, (38.40% - 46.40%, 165.85% - 181.29% and 5.31% - 6.53%) respectively while the composite flour had highest magnesium, calcium and zinc, 47.61% - 56.44%, 82.77% - 92.62% and 2.69% - 3.59% respectively. Water absorption, foam stability, gelation capacity and swelling index were found maximum in the composite flour blends while oil absorption and foam capacity were maximum in wheat flour. There is need to utilized moringa seeds and pearl millet in diverse form to enhance household menus and improve the nutritional quality of pearl millet flour.

Key words: Proximate, Mineral, Functional Properties, Moringa and Millet

Introduction
The COVID 19 pandemic repercussions are much more extensive than that of other viral illness that must have infected the global community and it poses a risk to undermine the years of painstaking human development. Prior to the COVID 19 outbreak, Nigeria had serious issues with food insecurity and malnutrition. The pandemic worsened the situation and caused a significant challenge on food and health system, which threatened nutrition of the populace. Emphasis has been made on dietary modifications and the need to overcome micronutrient malnutrition characterized as under-nutrition which negatively impact mostly poor households, although in varied contexts (FAO, IFAD & WFP, 2015). Malnutrition, comprising undernourishment, micronutrient deficiency and over nutrition seems to be a major barrier to inclusive growth. (Lukett, Declerck, Fanzo, Mundorf & Rose, 2015). When crisis emerges, be it an epidemic or economic crisis, the first type of malnutrition to surface is hidden hunger due to the fact that more expensive and nutritious foods will be entirely removed from household meal plans.

Fortifying our local food crops can be an important approach to provide added nutrient to those at risk of nutrient deficiencies (Boateng, Norley, Ohemeng, Asante & Steiner-Asiedu, 2019). In order to tackle micronutrient deficiencies and minimized their occurrences in human population, food fortification is a crucial intervention strategy (Rowe, 2020).

Recently the food and agricultural organization have been facilitating the utilization of underutilized crops that is readily available, accessible and much cost effective to prevent and control micronutrient deficiencies. However, the use and incorporation of the underutilized plants into our daily diet still remain a challenge. Hence there is need to focus more on the implementation of these food based approaches to achieve a healthy living. Moringa is known to be a vegetable plant that is believed to be one of the world’s most useful trees, as virtually every part of the moringa tree can be used for food, medication, and industrial purposes (Mbah, Salami, Azubiike & Apugo, 2015).Moringa oleifera seeds have significant levels of monounsaturated fatty acids /saturated fatty acids (MUFA/SFA) sterols and tocopherols, as well as proteins with a high sulfated amino acid content, making them interesting resources for both food and non-food uses. (Leon, Spada, Battezzati, Schirald, Aristil & Bertoli, 2016). According to Bolarinwa, Aruna and Raji (2019), Substantial amounts of minerals (calcium, phosphorus, and iron) and vitamins (A, B and C) are present in moringa oleifera seeds.
Pearl millet (*Pennisetum glaucum*) is among the most popular drought-resistant crop and the 6th cereal crop after wheat, rice, maize, barley, and sorghum, in terms of world agricultural production (Bora, Ragae & Marcone, 2019). Pearl millet can be grown in locations with drought, poor soil fertility, high salt, low pH, or high temperatures, unlike maize or wheat, which cannot be grown in arid climates (Djanaguiraman, Perumal, Clampitti, Gupta, & Prasad, 2017). Elevated quantities of protein, vitamins, critical amino acids, antioxidants, and vital minerals give pearl millet great nutritional value (Saleh, Zhang, Chen & Shen, 2013). According to reports, it contains phenolic compounds, ascorbic acid, and has a significant antioxidant action (Kaur, Purewal, Sandhu, Kaur & Salar, 2019). Incorporating millet and millet-based foods into daily diets on a regular basis may help households maintain their health and improve their immunity. The goal of the study was to expand the use of composite flour blends based on cereal as a viable strategy of alleviating micronutrient malnutrition, analyze the nutrient value of the flour mixes and their functional characteristics.

**Methodology**

**Materials**

Moringa (*Moringa Oleifera*) seeds were harvested from the matured tree of moringa in a home garden in Umudike Abia State. Pearl millet grains (*Pennisetum glaucum*) and the control flour (wheat flour) were purchased from a local market (Orieugba market) Umuahia, Abia state. The chemical used for the chemical analysis were obtained from Food Science Laboratory, College of Applied Food Science and Tourism Michael Okpara University of Agriculture Umudike, where the study was carried out.

**Sample preparation**

Moringa (*Moringa Oleifera*) seeds were dehusked and cleaned. The cleaned seeds were dehulled manually by boiling for 15 minutes, washed to remove the shell, dried in an oven at 60°C for 5 hours, processed into flour, and then packaged in a closed container for further examination.

Pearl millet grains (*Pennisetum glaucum*) were cleaned, and then washed in tap water, the washed seeds were oven dried at 60°C for 5 hours, milled using commercial milling machine. The flour obtained was sieved using 0.4mm sieve and kept in a sealed bag at room temperature for further investigation.

**Sample formulation**

Composite flour were formulated from processed seeds of Moringa and Pearl millet grains using the following ratios

- Wheat flour 100% (control)
- 90% Moringa seed and 10% Pearl millet: 9:1
- 80% Moringa seed and 20% Pearl millet: 4:1
- 70% Moringa seed and 30% Pearl millet: 7:3

**Proximate Analysis**

The proximate analysis of the flour samples was carried out in triplicate with the exception of the carbohydrate contents, which was measured by difference. The chemical makeup of the samples was ascertained using the accepted procedure outlined in the Association of Official Analytical Chemist (A.O.A.C.) 2006 standard method.

**Mineral content Determination**

The mineral content of the flour samples were analyzed according to the method of AOAC (2006). 1 g of sample was digested with a 9:2:1 mixture of nitric perchloric acid which was filtered in a 5ml volumetric flask. An atomic absorption spectrophotometer was loaded with the filtered solution (model 703; Perkin elmes, Norwalk, CT). Each mineral (calcium, magnesium, iron, and zinc) standard curve was prepared from known standards and the mineral value of samples measured against that of the standard curve. Values of sodium and potassium was determined using a flame photometer (Sherwood flame photometer 410; Sherwood scientific ltd, Cambridge, U.K) using Nacl and Kcl as the standard (AOAC 2006).

**Functional Properties Determination**

The functional properties that were analyzed include bulk density, water absorption capacity, swelling capacity, foaming properties and oil absorption capacity. The method described by Onwuka (2005) was used to determine the bulk density, water absorption capacity and swelling capacity, Foaming properties was determined by the method described by Coffman and Gracia (1977) while the oil absorption capacity was determined using the method described by Sosuiski, Grarrat & Slimkard (1976).
Results and Discussion

Table 1: proximate composition of composite blends and wheat flour

<table>
<thead>
<tr>
<th>Samples</th>
<th>Moisture (%)</th>
<th>Ash (%)</th>
<th>Fat (%)</th>
<th>Crude Protein (%)</th>
<th>Crude Fiber (%)</th>
<th>Carbohydrate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample A WTA</td>
<td>13.18± 0.32</td>
<td>0.83± 0.13</td>
<td>1.16± 0.03</td>
<td>2.01± 0.08</td>
<td>0.77± 0.29</td>
<td>82.05± 1.10</td>
</tr>
<tr>
<td>Sample B PMB</td>
<td>11.32± 0.13</td>
<td>1.04± 0.06</td>
<td>7.27± 0.01</td>
<td>4.91± 0.11</td>
<td>1.17± 0.30</td>
<td>74.30± 1.46</td>
</tr>
<tr>
<td>Sample C PMC</td>
<td>9.62± 0.30</td>
<td>1.83± 0.11</td>
<td>10.24± 0.10</td>
<td>5.11± 0.02</td>
<td>1.83± 0.11</td>
<td>71.77± 0.62</td>
</tr>
<tr>
<td>Sample D PMD</td>
<td>9.91± 0.67</td>
<td>1.36± 0.11</td>
<td>12.66± 0.11</td>
<td>5.61± 0.04</td>
<td>1.50± 0.11</td>
<td>68.98± 0.97</td>
</tr>
</tbody>
</table>

Means of data of duplicate determination. Values with the same superscript in the same column are not significantly different (P ≥ 0.05).

Key: WTA= 100% Wheat flour, PMB= 90% Pearl millet flour 10% moringa seed flour, PMC = 70% Pearl millet flour 20% moringa seed flour, PMD = 80% Pearl millet flour 30% moringa seed flour.

Proximate composition of moringa seed and pearl millet flour blends was presented in Table 1. The values of the measured parameters of all the flour blend samples were significantly different from each other (P < 0.05). The moisture content of wheat flour (WTA) had the highest value (13.18%) followed by 90% pearl millet and 10% moringa seed (PMB) (11.32%) while the flour blends from 80% pearl millet and 20% moringa seed (PMC) had the least moisture content (9.62%). This means that formulations with lower 9.62% moisture content will be having longer shelf life than that with 13.18% since high moisture content encourages microbial growth; however the moisture content of WTA which was high is still within the recommended limit below the maximum limit of 15% (world food programme, 2012). The ash content of the flour samples varied significantly (P < 0.05) from 0.83% to 1.83% with flour from 100% wheat flour (WTA) having the least value while the highest value was recorded in the flour blends from 80% pearl millet and 20% moringa seed (PMC). The observed high ash could be associated with the increase ratio of moringa seeds in those formulations and implies the availability of higher mineral contents in those formulations (Abiodun, Adegbite, and Omolola, 2012). The fat content of the formulated flour blends were significantly (P < 0.05) higher than the wheat flour (WTA), fat content of the formulated samples ranged from (7.27 – 12.66%) and wheat flour (WTA) had the lowest value of (1.16%). The result shows that the higher the inclusion of moringa seed flour the higher the fat content. The observed results also agreed with the study done by Aluko, Brail and Adelore (2013) for maize moringa seed flour blends. The protein contents were significantly different between the formulated flour blends and wheat flour. Sample PMD had the highest protein (5.61%) and sample WTA had lowest protein content (2.01%). The result confirmed an increase in the protein level of the samples as the ratio of moringa seed increased in the formulations. This could be attributed to the fact that moringa seed is high in protein which agreed with the report by (Chinma, Gbadamosi, Ogunshin, Oloyede, and Salami, 2014). The fibre content of the formulated flour samples increased...
significantly (P < 0.05) from 1.17% to 1.83%, sample PMC (80% pearl millet - 20% moringa) had the highest value while sample WTA (100% wheat flour) had the lowest value (0.08%). Carbohydrate values for the formulated flour samples ranged from 74.30% to 68.98% while sample WTA (100% wheat) had the least value of 68.98%. The result shows that as the ratio of moringa increases, the carbohydrate value also reduced. This was because moringa is a vegetable plant which is rich in protein and fat (Aluko et al, 2013). The percentage of carbohydrate content of these samples indicates that the flour samples could serve as an excellent source of energy needed for body metabolism.

Table 2: Mineral composition of the composite flour blends and wheat flour

<table>
<thead>
<tr>
<th>Samples</th>
<th>Magnesium (mg/100g)</th>
<th>Sodium (mg/100g)</th>
<th>Calcium (mg/100g)</th>
<th>Potassium (mg/100g)</th>
<th>Iron (mg/100g)</th>
<th>Zinc (mg/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WTA</td>
<td>47.61±0.01</td>
<td>46.40±0.03</td>
<td>90.72±0.14</td>
<td>181.29±0.01</td>
<td>6.53±0.11</td>
<td>3.54±0.08</td>
</tr>
<tr>
<td>PMB</td>
<td>48.48±0.03</td>
<td>38.40±0.03</td>
<td>85.80±0.13</td>
<td>165.83±0.11</td>
<td>5.51±0.13</td>
<td>2.77±0.02</td>
</tr>
<tr>
<td>PMC</td>
<td>52.39±0.09</td>
<td>43.04±0.07</td>
<td>92.62±0.31</td>
<td>173.87±0.04</td>
<td>5.79±0.04</td>
<td>3.59±0.01</td>
</tr>
<tr>
<td>PMD</td>
<td>56.44±0.08</td>
<td>45.73±0.08</td>
<td>82.77±0.04</td>
<td>170.73±0.16</td>
<td>6.17±0.05</td>
<td>2.69±0.01</td>
</tr>
</tbody>
</table>

Values are means of data of duplicate determination. Values with the same superscript in the column are not significantly different (P ≥ 0.05).

Key: WTA = 100% Wheat flour, PMB = 90% Pearl millet flour 10% moringa seed flour, PMC = 80% Pearl millet flour 20% moringa seed flour, PMD = 70% Pearl millet flour 30% moringa seed flour.

The mineral elements examined increased with the inclusion of moringa seeds. The composite flour was high in magnesium, followed by calcium and then zinc while the control was high in sodium, potassium and iron. The potassium content ranged from 165.83 in PMB to 181.29mg/100g in WTA. While calcium content of the samples ranged from 82.77 in PMB to 92.62mg/100g in PMC and magnesium content of samples ranged from 47.61 in WTA to 56.44mg/100g in PMD. The potassium, calcium, and magnesium content of the flour samples was found to be higher than the results of Wakil and Alao (2013) in legume-fortified millet based weaning blends with moringa leaves. Potassium is needed to keep osmotic balance of the body fluids, the PH of the body, regulate muscle and nerve irritability, control glucose absorption and enhances proper retention of protein during growth (Omoba, Obilance, Martin, Madzvanuse, and many, 2013). Calcium plays a key role in blood clothing, muscle contraction and in certain enzymes in metabolic processes and magnesium have been identified in regulation of blood glucose levels and aid in building up energy and protein (Ayo, Adeleji and Okpasu 2018). The sodium content of the flour samples ranged from 38.40m PMB to 46.40mg/100g in WTA. The sodium content of the flour samples was higher than the value (26.63mg/100g) reported by Oladeji, Taiwo, Ishola and Oladeji (2017) for Maize Ogi flour enriched with moringa seed. The iron content of the flour samples ranged from 5.51 in PMB to 6.53mg/100g in WTA Iron is required for blood hemoglobin formation (Ogungbenle and Onoge, 2014). The zinc content of the flour blends were 2.69, 2.77, 3.54 and 3.59mg/100g for samples PMD, PMB, WTA and PMC respectively. There were significant variations among the samples. Zinc aids the growth and repair of tissues, boosts ones immune system and plays a crucial role in sperm survival. WHO recommends zinc intake of 15 and 10mg/day for adults and children, respectively (Ogungbenle and Onoge, 2014).
Functional Properties of the composite flour blends

Functional properties determine the application of food material for various food products. The functional properties of the formulated samples and conventional wheat flour are represented in Table 3 above. The Bulk density of the flour blends were not significantly different (P > 0.05) from each other. Sample PMB and PMD had the highest (0.74 ± 0.01 g/ml) while the least was sample WTA (0.72 ± 0.01 g/ml). This study’s bulk density was higher than the values (0.61 to 0.64) reported by Ijarotimi, Adeoti and Ariyo (2013) for raw, germinated and fermented moringa seed flour. Bulk density is generally affected by the particle size of the flour and initial moisture contents which play a crucial role in the determination of requirements for packaging, material handling and wet processing application in food industrial sector (Adebowale, Sanni and Oladapo, 2008).

The water absorption capacities of the flour samples ranged from 1.10 to 1.31 g/ml. There was a significant different (P < 0.05) in the oil absorption capacity of the flour samples. Sample WTA had the highest value (1.31 g/ml). The oil absorption capacity can act as a flavor retainer, which means that it can be added in food to improve taste. Good oil absorption capacity of flour samples shows that they may be useful in preparing food that has to do with oil mixing as in bakery products, where oil is an important ingredient. (Oloyede et al., 2016). The foaming capacity of the flour blends significantly (P < 0.05) increased as the inclusion of moringa seed increased. The foaming capacity value ranged from 5.64 to 39.59 in samples PMB and WTA respectively. While the foaming stability ranged from 63.59% in sample WTA to 96.29. The foaming properties recorded in this study are higher than that recorded by Oloyede et al., (2016). There was a significant (P < 0.05) difference between the control

### Table 3: Functional properties of the composite flour blends and wheat flour

<table>
<thead>
<tr>
<th>Sample</th>
<th>Bulk density (g/ml)</th>
<th>Water absorption capacity (g/ml)</th>
<th>Oil absorption capacity (g/ml)</th>
<th>Foam capacity (g/ml)</th>
<th>Foam stability (g/ml)</th>
<th>Gelation capacity (g/ml)</th>
<th>Swelling Index (g/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WTA</td>
<td>0.74±0.01</td>
<td>0.93±0.11</td>
<td>1.31±0.02</td>
<td>39.59±0.24</td>
<td>63.60±1.56</td>
<td>2.00±0.00</td>
<td>0.68±0.08</td>
</tr>
<tr>
<td>PMB</td>
<td>0.74±0.01</td>
<td>1.20±0.00</td>
<td>1.19±0.06</td>
<td>5.64±0.35</td>
<td>95.64±0.27</td>
<td>2.00±0.00</td>
<td>0.86±0.08</td>
</tr>
<tr>
<td>PMC</td>
<td>0.73±0.01</td>
<td>1.18±0.04</td>
<td>1.14±0.00</td>
<td>6.62±0.35</td>
<td>96.29±0.20</td>
<td>3.00±0.41</td>
<td>0.96±0.00</td>
</tr>
<tr>
<td>PMD</td>
<td>0.74±0.01</td>
<td>1.14±0.06</td>
<td>1.10±0.06</td>
<td>8.58±0.35</td>
<td>95.67±0.19</td>
<td>2.00±0.00</td>
<td>0.96±0.08</td>
</tr>
</tbody>
</table>

Values are means of data of duplicate determination. Values with the same superscript in the same column are not significantly different (P ≥0.05).

Key: WTA = 100% Wheat flour PMB = 90% Pearl millet flour 10% moringa seed flour, PMC = 80% Pearl millet flour 20% moringa seed flour, PMD = 70% Pearl millet flour 30% moringa seed flour.
sample and the composite samples. Form capacity improves the textural consistency of foods. Good foam capacity is a desirable attribute for flour in the food system due to its high percentage of porosity intended for the production of a variety of baked products such as ice cream, cakes, muffins and akara. (Yusufu and Ejeh, 2018).

The gelation capacity of the flour samples ranged from 2.00% to 3.00% although there was no significant different (P > 0.05) between sample PMB, PMD and WTA. The gelation capacity measures the minimum amount of water (Ezeocha and Onwuneme, 2016). It changes from flour to flour based on the relative ratios of their structural constituents like protein, carbohydrates and lipids (Amandikwa et al, 2015). The greater the gelation concentration, the greater will be the flour quantity required to form a gel. On the contrary gelation capacity that is low will have a better ability of the flour to form a gel. Values for the swelling index of samples ranged from 0.68% in WTA to 0.96% in PMD. The values increased with increase in moringa seeds flour. The swelling power is related to the water absorption index of the starch-based flour during heating.

**Conclusion**

Micronutrient deficiency is a public health concerns. A food-based intervention such as fortification of millet flour with moringa seeds flour could improve the nutritional status of individuals. The results presented in this study depicted that the composite samples had a higher ash content, fiber, crude protein and crude fat than the wheat flour. The mineral content of the flour samples showed that wheat flour had higher values in terms of sodium, calcium, potassium and iron while the composite flour blends had a higher magnesium and zinc content. Inclusion of moringa seed increases the mineral content of the composite flour blends. The functional properties revealed that the flour blends may find application in food formulations. This study has demonstrated that millet flour can be improved with moringa seed flour to boost the body’s nutritional value and health advantages. However, further research needs to be conducted in order to improve the mineral content of the flour blends.

**Recommendations**

Based on the findings of this study, the following recommendations were made.

- Utilization of local crops such as moringa seeds and pearl millet flour in food fortification should be encouraged so that communities can have access to nutritious foods that are locally cultivated, readily available and affordable.
- The flour blends can be used to develop food products in order to establish the acceptable level of the flour blends.

**References**


Proximate, Mineral and Functional Properties of Moringa Seeds and Pearl Millet Flour Blends


Institute of food science and Technology. Journal of food science and Technology. 9:66-69.

