**Functional and Physicochemical Properties of Bread Produced from Composite Flour of Wheat, Soybean and Moringa Leaf.**

## ABSTRACT

The study evaluated the quality characteristics of bread produced from wheat, soybean, and moringa leaf flour. Four samples from individual flours were formulated as follows; 100:0:0, 90:5:5, 80:15:5, 70:25:5 for wheat flour, soybean and moringa leaf flour, respectively. The samples were labeled samples A, B, C, and D and analysed using standard procedures. The functional properties of the flours ranged thus respectively; bulk density (0.81-0.86 g/mL), swelling capacity (3.46-6.40%), WAC (3.55-4.70 mL/g), OAC (3.85-4.10 mL/g). In addition to the carbohydrate content, all other approximate parameters of the bread samples increased significantly among the samples. The mineral composition of the samples ranged from the following: Calcium (283.64-494.24 mg/100g), potassium (434.33-761.36 mg/100g), iron (6.74-15.14 mg/100g) and zinc (3.97-6.64 mg/100g). The vitamin composition of the samples was as follows: provitamin A (6.80-32.32µg/100g), vitamin B1 (0.42-1.45 mg/100g), vitamin B2 (1.31-3.88 mg/100g), vitamin C (21.53-36.79 mg/100g). The antinutrient composition ranged thus: phytates (1.77-3.97 mg/100g), saponins (0.14-1.18 mg/100g), oxalate (0.34-1.58 mg/100g). The results of the sensory evaluation showed that all the bread samples were generally accepted by the panelists. The composite flour produced here demonstrates great potential for its use in the development of bread given its great nutrients and improved functional characteristics, as seen with the formulated samples.

Keywords: Moringa leaf, composite flour, soybean, functional properties

## Introduction

Bread is the most common among all wheat baked products. It is consumed and enjoyed by both children and adults of different socioeconomic status in Nigeria, which leads to its high daily demand (Inyang and Asuquo, 2016). It contains a rich source of energy, protein, vitamins, especially B vitamins, minerals, and dietary fiber, making it highly nutritive. Recent developments for over 20 years have focused on healthy eating, enhancing the utilization of indigenous produce such as whole wheat, local cereals, and legumes in baking industries.

Bread is generally made by baking dough that has wheat flour, water, yeast, and salt as its main ingredient (Okoye and Ezeugwu, 2019). These ingredients undergo a series of processes involving weighing, mixing, kneading, shaping, proofing, and baking before the product is ready-to-eat.

Other ingredients that can be added include flour from other cereals, fat, malt flour, soy flour, emulsifiers, milk, sugar, and fruits, among others. Nutritionally, bread contains a high percentage of carbohydrates and fat, both of which are needed for energy (Ameh et al.,2013), while vitamins, minerals, protein and other nutrients are relatively small portions.

Ayoade et al*.* (2020) defined composite flour as blends of various cereals, legumes, and tuber flour, rich in starch, protein, and other nutrients integrated with or without wheat flour. Replacement or incorporation of wheat flour with indigenous raw materials is growing as a result of the high demand for baked products and pastries. The use of composite flour in developing countries has been used at different levels of substitutions which have achieved varying levels of success.

Composite flour is an innovative flour that has attracted much attention in research as well as in the development of food products (Hasmadi et al., 2014), it is a mixture of flour obtained from tubers that is rich in starch such as cassava, yam, potato, legumes that are rich in protein such as soybean and protein rich flour and cereals, with or without wheat flour that is created to satisfy specific functional characteristics and nutritional composition.

According to Ayoade et al. (2020), wheat is the most important stable food crop for more than a third of the world's population and contributes more calories and proteins to the world's diet than any other cereal crop. Wheat grains are generally oval-shaped, although different wheats have grains that range from almost spherical to long, narrow and flattened shapes (Zuzana et al*.,* 2019), the grain is usually between 5 and 9 mm in length, weighs between 35 and 50 mg and has a crease down one side where it was originally connected to the wheat flower. The wheat grain contains 2-3 % germ, 13-17 % bran, and 80-85 % mealy endosperm (all constituents converted to a dry matter basis).

It is nutritious, easy to store and transport and can be processed into various types of food. Wheat is considered a good source of protein, minerals, B-group vitamins, and dietary fiber although environmental conditions can affect the nutritional composition of wheat grains with its essential coating of bran, vitamins, and minerals; it is an excellent health-building food. Wheat flour is used to prepare bread, produce biscuits, confectionary products, noodles, and vital wheat gluten or seitan. Wheat germ and wheat bran can be a good source of dietary fiber that helps to prevent and treat some digestive disorders.

Soybean (*Glycine max*) has recently become popular in the West African subregion due to its high protein content. It is an annual leguminous crop and is grown to provide food for humans, feeds for animals, and raw materials for industries. Soybean is an excellent source of protein (35-40%). The soy bean seed is the richest in food value of all plant foods consumed in the world. It is used in the production of bread as a composite flour (Ogbemudia *et al.,* 2017). The soy bean is used by leading infant food manufacturers in the country due to its high nutritional value. Soy beans are a widely used, inexpensive, and nutritional source of dietary protein. Its protein content (40%) is higher and more economical than that of beef (19%), chicken (20%), fish (18%) and groundnut (23%). It is also rich in minerals and vitamins such as iron, zinc, copper, thiamine, riboflavin, niacin, and pantothenic acid, most of these minerals and vitamins are well known hematinic and are essential in the formation of red blood cells (Eshun, 2012). Soy bean is of particular interest as a vegetable protein source because of its cholesterol-lowering abilities in patients with type II hyperlipoproteinamia.

*Moringa oleifera* is an important fast growing tree species that can grow up to 6-7 m in a year under low rainfall of at least 400 mm / year, known for its resistance to drought and diseases, as well as its adaptation to harsh growing conditions (Moshibudi et al. 2017).

The nutrient concentration of *M. oleifera* leaves is notable, as they contain all essential amino acids, including arginine and histidine, which are important for infant development, as well as high concentrations of vitamins and minerals. *M. oleifera* contains more than 90 important nutrients that have synergic effects and high bioavailability, protein is the most prominent nutrient (25% of dry matter) in all *M. oleifera* parts, while the lipid content is higher in seeds (30% of dry matter) and lower in fruit, leaves, and pods. *Leaves of*

*M. oleifera* contain all essential amino acids and important biological proteins, including globulin, albumin, glutein, and prolamin (Ashfaq et al*.,* 2012).

## 2. Materials and Methods

### 2.1 Source of raw materials

Soybean was purchased at the seed store in the BNARDA office in Makurdi. Moringa leaves were collected from the Federal University of Agriculture, Makurdi farm. Wheat flour was purchased from the modern market in the town of Makurdi in Benue State, Nigeria.

### 2.2. Preparation of Soya Flour

Soybean flour was produced using the modified method of Verem et al. (2021). Soybeans were sorted by hand picking chaff and stones. The sorted soya bean grains were washed with water to remove the adhering dirt and poured into heated 100 ° C water to boil for 30 minutes to remove antinutritional factors and the taste of beany. The boiled soy beans were dehulled and washed properly. The grains were dried in an oven (Pax 2 and Pax 3 2.0 vented oven lid) at 60 C for 24 - 48 h to reduce the moisture content to approximately 10%. The dried grains were milled using an Attrition milling machine and the flour was sieved into fine flour of uniform particle size by passing it through a 0.5 mm mesh sieve and packaged in polyethylene bags and kept at room temperature for later use. The flow chart for the production of soy flour is shown in Figure 1.

### 2.3. Preparation of moringa leaf powder

Moringa leaf powder was produced using the method of Verem et al. (2021). The Moringa leaves were removed by hand from the stems and washed in water to remove dirt and other contaminants. The leaves were removed from the water using plastic baskets and allowed to drain for 30 minutes. The leaves were spread in clean sacks and dried under ambient conditions for 25 days. The leaves were pounded in a mortar and later milled or grinded to pass through a 0.5 mm sieve mesh size, and the moringa leaves powder was packaged in airtight containers for later use. The flow chart to produce moringa is shown in Figure 2.

Soybean grains

↓

Sorting

↓

Washing

↓

Boiling (100 $^{\circ}C$ for 30 min)

↓

Dehulling

↓

Oven drying (60 $^{0}C$, 24 h)

↓

Milling (attrition milling machine)

↓

Sieving (0.5mm)

↓

Soybean flour

Figure 1: Flow chart for the production of soybean flour
**Source:** Akubor et al. (2013) modified

Moringa leaf

↓

Washing

↓

Drainage in basket

↓

Drying (at ambient conditions, 25 days)

↓

Milling (attrition mill)

↓

Sieving (0.5 mm mesh)

↓

Moringa leaf powder

Figure 2: Flow chart for the production of moringa leaf powder
**Source: (**Verem et al. 2021)

## 2.4. Mix Formulation

A composite flour of wheat, soybean, and moringa leaf samples was prepared. The four (4) blends were formulated as follows. 100 percent wheat flour (100%) was the control designated as sample A. Sample B consisted of 90 % wheat, 5 % soybean and 5 % moringa leaf powder. Sample C consisted of 80 % wheat, 15% soybean, and 5 % moringa leaf powder and sample D was 70 % wheat, 25% soybean, and 5 % moringa leaf powder. The mixtures were thoroughly mixed using a Kenwood blender (BLG 450 Blender/Grinder) to achieve a uniform mixing and the ratio of the formulation in w/w is shown in Table 1 and Table 2.

## 2.5. Preparation of Bread

Bread samples were produced from wheat, soybeans and moringa using the method described by Olaoye et al. (2006) with slight modification as shown in Figure 3. The unit operations in the production of bread include dough mixing, fermentation, proofing, and cooling (at ambient conditions) for 1 h.

**Table 1: Formulation of blends**

| Samples | Wheat % | Soybeans % | Moringa % |
|---|---|---|---|
| A | 100 | - | - |
| B | 90 | 5 | 5 |
| C | 80 | 15 | 5 |
| D | 70 | 25 | 5 |

**Table 2: Recipe Formulation**

| Recipe | Percentage (%) |
|---|---|
| Water | 36 |
| Yeast | 1 |
| Salt | 1.5 |
| Sugar | 2 |
| Fat | 5 |

Source**:** Ihekoronye (1998)

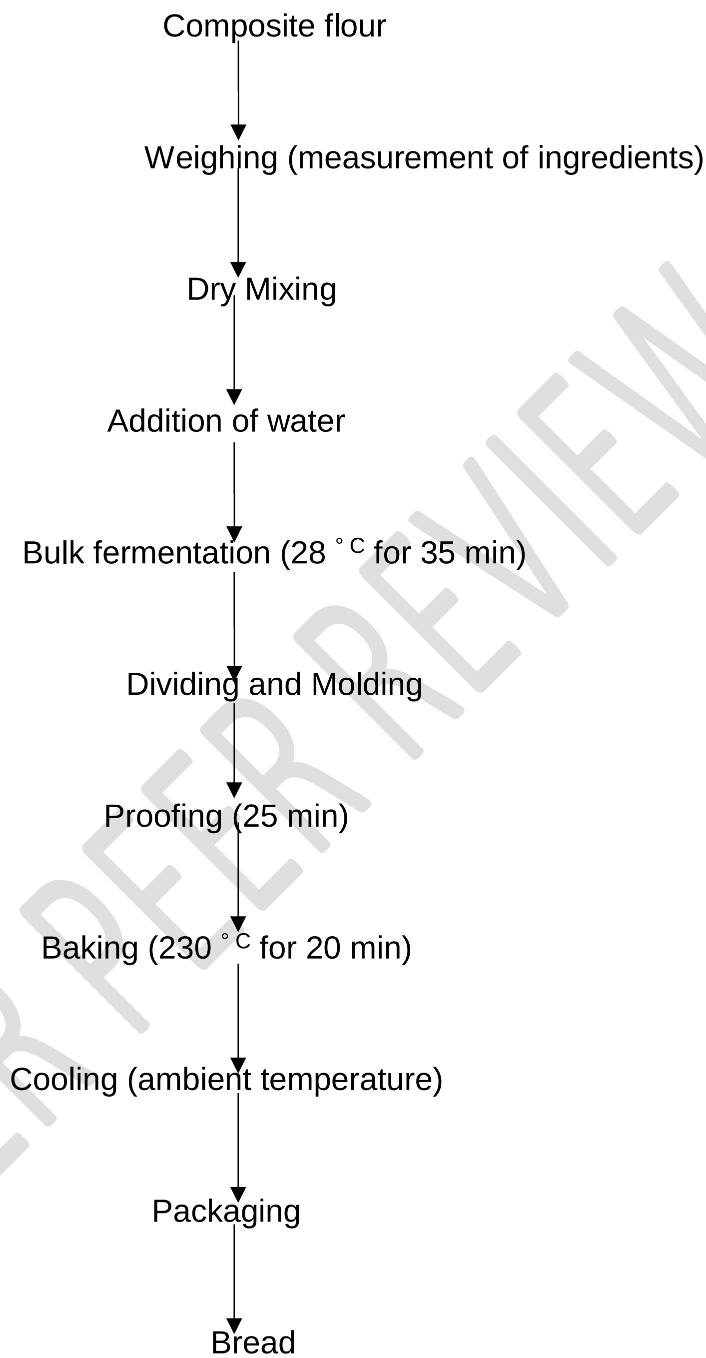


Figure 3: Flow chart for production of bread from wheat, soybean flour and moringa powder.

**Source:** (Olaoye et al., 2006) Modified.

## 2.6. Analytical Methods

### 2.6.1 Determination of the functional properties of wheat bread, soybeans, and moringa leaf powder

Functional properties such as bulk density, water absorption capacity, foaming capacity, oil absorption capacity, swelling capacity, gelatinization temperature and least gelation concentration of the flours and their blends were determined according to the method described by Onwuka, (2005)**.**

### 2.6.2. Determination of Physical Properties of the Bread Produced

The physical properties of loaf weight, loaf volume, specific volume, and loaf height were determined as described by Giami et al. (2004).

#### 2.6.3. Determination of the proximate composition of biscuits of wheat, soybean and OFSP flour

The approximate parameters were determined using the standard method of the Association of Official Analytical Chemists (AOAC, 2012).

### 2.6.4. Determination of Mineral Content of Biscuit Samples

The mineral content of the formulated samples was evaluated using the method described by (Bongjo et al., 2023). A gram of dried samples will be digested with 2.5 ml of 0.03N hydrochloric acid (HCl). The digest will be boiled for 5 min, allowed to cool to room temperature, and transferred to a 50 ml volumetric flask and made to the mark with diluted water. The resulting digest was filtered with ashless Whatman No. 1 filter paper. The filtration of each sample will then be analyzed for mineral (calcium, phosphorus, magnesium, iron, sodium, potassium) contents using an atomic absorption spectrometer using standard wavelengths. The real values were extrapolated from the respective standard curves. The values obtained will be adjusted for the HCl-extractability for the respective ions. All determinations were made in triplicate.

### 2.6.5. Determination of the vitamin content of biscuit samples

The method of AOAC (2010) using the colorimeter will be adopted. Vitamins A, B1, B2, B3, and C were determined.

### 2.6.6. Evaluation of sensory quality attributes of biscuit samples

A panel of 30 individuals was used for this study, where a 9-point hedonic scale was used; with 9 representing like extremely and 1 representing dislike extremely.

## 2.7. STATISTICAL ANALYSES

Data were generated in triplicate and subjected to analysis of variance (ANOVA). Means were tested for significant differences using Duncan's multiple range test (DMRT). Significance was accepted at $p < 0.05$. (Ihekoronye and Ngoddy, 1985).

**3. RESULTS AND DISCUSSIONS**

### 3.1 Functional properties of flours from blends of wheat, soybean, and moringa leaf flour

The functional properties of the flours produced are presented in Table 3. Bulk density, swelling capacity, water absorption capacity, oil absorption capacity, and foam capacity were the functional attributes that were evaluated. These properties of foods enable food processors to forecast and accurately assess how different nutrients or biomolecules in foods can affect or how these nutrients may behave in certain food systems (Awuchi et al., 2019).

The water absorption capacity of the flours differed significantly, with sample A having the least (3.55 mL/g) and the highest recorded in sample D (4.70 mL/g). The results obtained exceeded those obtained by Ahemen et al. (2018), where they obtained results in the range of 1.40-1.63 mL/g. The ability of a product to bind with water in situations where water is scarce is known as its water absorption capability. The high water absorption capacity of the food material may be caused by the presence of hydrophilic ingredients (polar amino acids) (Lawal & Adebowale, 2004). The notable increase in the fiber content of composite flours may also be the cause of this (Amandikwa et al., 2015). This is a result of the strong affinity of the fiber for water in low-aqueous environments.

**Table 3: Functional Properties of the Flour Blends from Wheat, Soy, and Moringa Leaf**

| SAMPLE | WAC (ml/g) | OAC (%) | FC (%) | BD (g/ml) | SC (%) |
|---|---|---|---|---|---|
| **A** | 3.55$^{a}$±0.05 | 3.85$^{a}$±0.05 | 7.75$^{d}$±0.25 | 0.81$^{b}$±0.02 | 6.40$^{d}$±0.30 |
| **B** | 3.95$^{b}$±0.05 | 3.90$^{b}$±0.10 | 6.93$^{c}$±0.08 | 0.77$^{a}$±0.02 | 5.20$^{c}$±0.00 |
| **C** | 3.85$^{b}$±0.15 | 3.95$^{c}$±0.15 | 5.84$^{b}$±0.16 | 0.85$^{c}$±0.02 | 3.83$_{b}$±0.03 |
| **D** | 4.70$^{c}$±0.20 | 4.10$^{d}$±0.10 | 5.41$^{a}$±0.01 | 0.86$^{c}$±0.01 | 3.46$^{a}$±0.07 |

Values are means±standard deviation of triplicate determinations. Values in the same column with different superscripts are significantly different at $p<0.05$
Key
A = 100% wheat flour
B=90% Wheat: 5% Soybean flour: 5% Moringa leaf powder
C = 80% wheat flour: 15% soybean flour: 5% Moringa leaf powder
D = 70% wheat flour: 25% Soybean flour: 5% Moringa leaf powder

**Table 4. Physical Properties of Bread Produced from the Flour Blends**

| Sample | Loaf Weight (g) | Loaf Volume ($cm^3$) | Specific Volume ($cm^3/g$) | Loaf Height (cm) |
|---|---|---|---|---|
| **A** | $229.98^b \pm 2.14$ | $883.70^d \pm 0.02$ | $3.84^d \pm 0.03$ | $7.35^d \pm 0.05$ |
| **B** | $229.30^b \pm 5.30$ | $809.83^c \pm 0.02$ | $3.53^c \pm 0.08$ | $7.00^c \pm 0.00$ |
| **C** | $230.74^a \pm 6.79$ | $728.40^b \pm 0.02$ | $3.30^b \pm 0.10$ | $6.50^b \pm 0.00$ |
| **D** | $232.08^b \pm 0.12$ | $726.15^a \pm 0.02$ | $3.13^a \pm 0.00$ | $6.40^a \pm 0.00$ |

Values are means±standard deviation of triplicate determinations. Values in the same column with different superscripts are significantly different at $p<0.05$

The high water absorption capacity of composite flours suggests that they can be used to make bread, biscuits, sausage, dough and processed cheese, among other items (Amandikwa et al., 2015).

Oil absorption capacity measures the ability of food material to absorb oil (Godswill et al., 2016). Iwe et al. (2016) stated that oil absorption capacity is the flavour-retaining capacity of flour, which is very important in food formulations. As the amount of soy and moringa leaf flour in the blends increased, the results showed a significant ($p<0.05$) increase ($p <0.05$) in the ability of the flour samples to absorb oil. Sample D had the highest value of 4.10 g / ml, while sample A, the control sample, had the lowest value of 3.85 g / ml. Since protein in the diet affects fat absorption, the flour samples' capacities to absorb oil were likely enhanced by an increase in protein content. The hydrophobic protein composition of the flour samples contributes to their high oil absorption ability. Because protein increases hydrophobicity and exposes more nonpolar amino acids to fat, more oil is absorbed by the flour. The findings of this study are higher, but agree with the oil absorption capacity of 1.98 - 2.59 g / g reported in biscuits produced from wheat and sweet potatoes enriched with African yam bean flour (Oluwamukomi et al., 2011).

The highest foam capacity was observed for the control sample (sample A) with 7.75 and the lowest value for sample D with 5.41. There was a significant difference between the samples as soybean and moringa leaf flour increased. The foaming capacity of flour is a measure of the amount of interfacial area created by whipping the flour. Protein is mainly responsible for foaming. Foaming capacity and stability generally depend on the interfacial film formed by the proteins (Mauer, 2003). The foaming capacity of the samples showed a decreasing trend with an increase in soybean and moringa leaf flour blends. This could be because an excess of proteins, especially those with strong intermolecular forces like gluten proteins, can lead to a decrease in the ability of proteins to effectively cover and stabilize air bubbles; as well as to the fact that more proteins mean increased viscosity in the flour-water mixture. Elevated viscosity can impede the incorporation of air into the system, making it more difficult to create and stabilize foam. However, the foaming capacity in this study is still higher than that reported in some previous studies and is affirmed to be suitable for the production of various foods such as cakes, muffins, *akara*, and cookies (Akubor, 2016). The highest bulk density was observed for sample D (0.86 g / ml) and the lowest for sample B (0.77 g / ml). All samples were significantly different (p<0.05) from each other. This variation may be due to the difference in the particle size of the flour blends. It could also be due to the high protein content of soybeans. The reported results are higher than those reported by Ahemen et al. (2018) and lower than those recorded by Akubor & Owuse (2020) with a bulky density between 0.85g for tomato peel flour and 0.68g for wheat flour. Generally, high BD is desirable due to its great ease of dispensability and reduction in paste thickness, which is an important factor in convalescent child feeding, while, in contrast, low BD would be an advantage in the formation of complementary foods (Adegunwa et al., 2017).

The swelling capacity of the flour samples decreased significantly (p<0.05) decreased with the level of soybean and moringa leaf flour inclusion in the blends. Sample A had the highest swelling capacity (6.40), while sample D had the lowest (3.46). The observed decreasing trend could be due to an increase in protein content which could have affected the swelling index of the flours. The study findings are in agreement with the report by Bello et al. (2008) whose swelling index decreased in the range of 1.11 to 1.33 (ml / g) in the mixes of yellow yam, unripe plantains and pumpkin seed flour.

**Table 5: Proximate composition (%) of bread from wheat, soybean, and moringa leaf flour blends**

| Sample | Moisture | Ash | Fat | Fibre | Protein | Carbohydrate |
|---|---|---|---|---|---|---|
| **A** | $32.43^{a}\pm0.03$ | $2.53^{b}\pm0.01$ | $4.88^{a}\pm0.03$ | $0.08^{a}\pm0.01$ | $9.67^{a}\pm0.38$ | $50.46^{d}\pm0.33$ |
| **B** | $32.93^{b}\pm0.03$ | $2.74^{d}\pm0.14$ | $5.22^{b}\pm0.04$ | $1.48^{b}\pm0.04$ | $13.37^{b}\pm0.03$ | $44.25^{c}\pm0.17$ |
| **C** | $34.55^{c}\pm0.00$ | $2.57^{c}\pm0.00$ | $5.38^{c}\pm0.00$ | $2.31^{c}\pm0.04$ | $15.35^{c}\pm0.21$ | $39.70^{b}\pm0.00$ |
| **D** | $39.53^{d}\pm0.03$ | $2.31^{a}\pm0.00$ | $5.56^{d}\pm0.00$ | $2.87^{d}\pm0.01$ | $18.55^{d}\pm0.11$ | $31.19^{a}\pm0.10$ |

Values are means±standard deviation of triplicate determinations. Values in the same column with different superscripts are significantly different at p<0.05

**Table 6: Mineral content mg/100g of wheat, soybean and moringa leaf flour mixtures**

| Sample | K | Ca | Zn | Fe |
|---|---|---|---|---|
| **A** | 434.33$^{a}$±0.02 | 283.64$^{a}$±0.02 | 3.97$^{a}$±0.02 | 6.74$^{a}$±0.02 |
| **B** | 615.38$^{b}$±0.02 | 469.04$^{b}$±0.02 | 5.97$^{b}$±0.02 | 12.56$^{b}$±0.02 |
| **C** | 622.47$^{c}$±0.02 | 494.24$^{c}$±0.02 | 6.23$^{c}$±0.02 | 13.37$^{c}$±0.02 |
| **D** | 761.36$^{d}$±0.02 | 482.24$^{d}$±0.02 | 6.64$^{d}$±0.02 | 15.14$^{d}$±0.02 |

Values are means±standard deviation of triplicate determinations. Values in the same column with different superscripts are significantly different at $p<0.05$

**Table 7: Vitamin content of bread from wheat, soybeans, and moringa leaf flour blends**

| Sample | µg/100g | mg/100g | | |
|---|---|---|---|---|
| | A | B1 | B2 | C |
| **A** | 6.80$^{a}$±0.02 | 0.42$^{a}$±0.02 | 1.31$^{a}$±0.00 | 21.53$^{a}$±0.02 |
| **B** | 23.88$^{b}$±0.02 | 1.22$^{b}$±0.02 | 3.14$^{b}$±0.02 | 31.75$^{b}$±0.02 |
| **C** | 28.66$^{c}$±0.02 | 1.44$^{c}$±0.02 | 3.54$^{c}$±0.02 | 33.67$^{c}$±0.02 |
| **D** | 32.32$^{d}$±0.01 | 1.45$^{c}$±0.02 | 3.88$^{d}$±0.02 | 36.79$^{d}$±0.02 |

Values are means±standard deviation of triplicate determinations. Values in the same column with different superscripts are significantly different at $p<0.05$

Table 8: Sensory quality attributes of bread from wheat, soybeans and moringa leaf flour blends

| Sample | Crust Appearance | Crumb Appearance | Aroma | Taste | Overall Acceptance |
|---|---|---|---|---|---|
| **A** | $8.30^{b}\pm0.73$ | $8.30^{b}\pm0.73$ | $7.65^{b}\pm1.04$ | $7.90^{b}\pm0.79$ | $8.30^{b}\pm0.80$ |
| **B** | $6.80^{a}\pm1.11$ | $7.00^{a}\pm0.92$ | $6.40^{a}\pm1.39$ | $6.65^{a}\pm1.35$ | $6.65^{a}\pm1.46$ |
| **C** | $6.80\pm^{a}1.54$ | $6.90^{a}\pm1.25$ | $6.75^{a}\pm1.37$ | $6.95^{a}\pm1.40$ | $6.95^{a}\pm1.20$ |
| **D** | $7.00^{a}\pm0.73$ | $6.70^{a}\pm0.87$ | $6.55^{a}\pm1.76$ | $6.80^{a}\pm1.28$ | $7.00^{a}\pm1.30$ |

Values are means±standard deviation of triplicate determinations. Values in the same column with different superscripts are significantly different at $p<0.05$

**3.2. Physical Properties of Bread Made from wheat, soybean and Moringa Leaf Flour Mix**

As shown in Table 4, the loaf height decreased from sample A (7.35 cm) to sample D (6.40 cm). There was a significant decrease ($p<0.05$) as the incorporation of soybean and moringa leaf flour increased. Similar results were obtained for moringa-base bread (Sengev et al., 2013). This could be due to the reduction in gluten content as the percentage of replacement with soybean and moringa leaf flour increased.

The loaf weight ranged from 229.30-232.08 g. Sample A had the lowest value, while sample D had the highest value. There was no significant difference ($p<0.05$) between the samples as the level of soybean and moringa incorporation increased. The values obtained in this study differ from those reported by Dooshima et al. (2014) and Onoja et al. (2011); who reported (199.50-213.00 g) and (166-134 g), respectively.

The loaf volume ranged from 883.70-726.15 $cm^3$. Sample A had the highest value, while sample D had the lowest value. Volume score scores were significantly different ($p<0.05$) between all samples. The volume of the grain decreased with an increase in the proportion of soybean and moringa leaf flour. The values obtained in this study are higher than the values (296-322 $cm^3$) reported by Peluola-Adeyemi et al. (2012) who recorded a decrease in volume as the level of avocado incorporation in wheat bread increased. The volume of the loaf is also extremely important for consumers because they want breads that appear to be light and not so dense (Sengev et al., 2013).

The values for a specific volume ranged from 3.13 to 3.84 cm3 / g. Sample A had the highest value, while sample D had the lowest value, and all samples were significantly different from each other. According to

Ragaee & Abel-Aal, (2006), the specific volume could probably be affected by the protein content of the flour, as well as other factors such as the proofing time, temperature, and the differences in the rate of gas retention. The values obtained in this research are higher compared to those (2.40-3.33 cm3/g) reported by Hussein, (2021) and similar to those reported (3.35-3.90 cm3/g) Peluola-Adeyemi et al., (2016). The reduction in gas production and the retention ability of bread carbon dioxide as soybean incorporation increased could have led to the decrease observed in a specific volume of the samples.

### 3.3. Proximate composition of bread made from wheat, soybean, and moringa leaf flour blend

The approximate composition of the bread produced is shown in Table 5. As observed, the moisture content of the samples ranged from 32.43 % to 39.53 %. The highest value was recorded in sample D, while the lowest value was recorded in sample A. The approximate composition of the bread samples showed that all the samples were within the normal moisture content of the white bread, which should not exceed 40%. All samples were significantly different from each other as the moisture content increased with an increase in the percentage of substitution of soybean and moringa leaf flour. The results obtained in this study are significantly ($p < 0.05$) higher than the values (27.65-35.20 %) reported by Sengev et al. (2013), as well as (30.50-33.97) reported by Olusegun Olaoye & Onilude, (2008). This moisture content affects the physical and chemical properties of food and food products by becoming an important factor in determining spoilage level, shelf life, processing, and packaging conditions (Akua, 2012). The high moisture values recorded in this study could be a result of the increased protein content of the flour mixes, which correlates with the high water absorption capacity.

The crude protein content ranged from 9.67 % to 18.55%. The crude protein of all bread samples was significantly different ($p<0.05$) from each other as the percentage level of incorporation of soy and moringa leaf flour increased. Ameh et al. (2013) recorded a protein content of 11.04-12.01 % for wheat bread and stabilized unfatted rice bran. The increase in bread protein content could be due to protein content in soybean and moringa leaf flour (Eshun, 2012).

The fat content of the bread samples increased with increasing level of soybean flour substitution with values ranging from 4.88 in sample A to 5.56 in sample D. The fat content of all bread samples was significantly different ($p<0.05$) from each other as the level of soybean and moringa leaf flour increased. This could be as a result of the soybean which is rich in fat (Eshun, 2012). These findings are in disagreement with those recorded by **Hussien, (2021)** who recorded a decrease in fat content in cookies, cake and bread samples, respectively. Sample A would be a better choice for weight watchers who are only interested in reducing fat but still want to maintain other nutrients, such as protein and ash content.

From the results obtained, it was observed that sample A had the lowest value (2.31) for ash content, while sample D had the highest value (2.74). The ash content of each sample was significantly different (p<0.05) from the other as the substitution with soybean and moringa leaf flour increased. The ash content of bread is simply a measure of its mineral content (Mudau et al., 2021). Similar results in ash content was reported by some authors  (Olaoye & Onilude, 2008) during the production of bread.

The crude fiber of the bread samples ranged from 0.08 to 2.87 %. Sample A had the lowest value, while sample D had the highest value. There were significant differences (p<0.05) among all samples. The crude fiber increased with an increase in the level of soybean and moringa flour. The increased fiber content of bread samples could be attributed to the high fiber content in soybeans as reported by Eshun (2012) and Etiosa (2018). This shows that soybeans are a good source of fiber that could help digest food in the intestinal tract and has good potential in the bakery industry Etiosa (2018); (Boshra & Tajul, 2013).

The carbohydrate content ranged from 31.19 % to -50.46%. Sample A had the highest value, while sample D had the lowest value. Carbohydrate content decreased with increasing replacement of soybean and moringa flour. All samples were significantly different (p<0.05) from each other.  The values obtained are lower than the values (66.32-62% and 52.25-60.58%) reported by Ayoade et al. (2020) and Olusegun Olaoye & Onilude, (2008) respectively.

**3.4. Mineral composition of bread made from wheat, soybean and moringa leaf flour blend**

The mineral content of the bread samples produced is shown in Table 6. The values for calcium content ranged from 283.64 mg / 100g-494.24 mg / 100g, with sample A having the least calcium content while sample D had the highest. There was a significant increase (p<0.05) in calcium content as the level of incorporation of the soybean and moringa leaf flour increased. The values obtained in this study are higher than those reported for soybean-based chinchin (Ndife et al., 2020). Sengev et al. (2013) and Ameh et al. (2013) also reported lower calcium values in a study on bread supplemented with moringa leaf powder (3.67 to 6.07 mg/100g) and stabilized undefatted rice bran (81.31 mg/100g to 130.70 mg/100g).

There was a significant increase ($p<0.05$) for potassium content in the bread samples produced as the level of incorporation of the soybean and moringa leaf flour. The values ranged from 434.33-761.36 mg/100g with sample A having the least value, while sample D had the highest value. The results of this study are higher than those reported for soybean-based chinchin (Ndife et al., 2020). Ameh et al. (2013) also reported potassium contents for bread supplemented with stabilized undefatted rice bran ranging from 80.74 mg/100g to 188.20 mg/100g.

The zinc content of the samples varied significantly ($p<0.05$) from 3.97-6.64 mg/100g with sample A having the lowest value, while sample D had the highest zinc value.

The results in this study are in disagreement with reports by those who witnessed a decrease in the zinc content of whole wheat bread and unripe plantains (Inyang & Asuquo, 2016). Zinc helps with hormone production, growth and repair; improves immunity, and facilitates digestion. Zinc also has a great impact on hormonal balance, so zinc deficiency can lead to an increased risk of infertility or diabetes. Zinc is an effective therapy for diarrhea and will decrease diarrhea morbidity and mortality. The zinc content reported in this study was below the RDA of 11mg/day (United State Department of Agriculture, 2018).

Iron plays a role in the electron-transferring reactions of mitochondria. It is an important component of hemoglobin, which is an oxygen–carrying pigment in the blood (Olayinka & Etejere, 2018). The findings of this study 6.74-15.14 mg/100g) showed an increase in iron content with the level of soybeans and the inclusion of moringa leaf flour in the flour blends bread. This could be due to the effect of supplementing wheat flour with soybeans and moringa leaf flour probably high in micronutrients. This disagrees with reports by Sengev et al. (2013) who recorded a decreasing trend in iron content for moringa leaf powder-based bread. The iron content of the control and flour blends biscuit samples was below the RDA of 18 mg/day (United State Department of Agriculture, 2018).

**3.5. Vitamin composition of bread made from wheat, soybean and moringa leaf flour blend**

The vitamin content of the bread produced is presented in Table 7. The vitamin A (b-carotene) content ranged from 6.80-32.32 µg/100g with a significant increase ($p<0.05$) as the level of incorporation of the soybean and moringa leaf flour increased. This could be because both soybeans and moringa are rich in these micronutrients (Eshun, 2012; Etiosa, 2018). The results in this study are higher than those (0.76 to 1.27 µg/100g) reported by Sengev et al. (2013).

The results also showed that the content of thiamine or vitamin B1 ranged from 0.42 mg/100g to 1.45 mg/100 g. Sample D had the highest value (1.45 mg/100g) which was significantly different ($p < 0.05$) from Sample A and Sample B, but not significantly different ($p<0.05$) from Sample C. Sample A had the lowest values (0.42 mg/100g). These results obtained are higher than those recorded by Ajayi et al., (2020). These results are also higher than those (0.15 mg/100g to 0.47 mg/100g) reported by Ameh et al. (2013). The observed increase in the thiamine content could be as a result of an increase in the soybean flour content. The riboflavin or vitamin $B_2$ content ranged from 1.31 mg/100g to 3.88 mg/100g. Sample A had the lowest value (1.31 mg/100 g) while sample D had the highest value (3.88 mg/100g). The value of vitamin B2 increased as the level of incorporation of the soybean and moringa leaf flour increased in the bread samples. There was a significant difference ($p < 0.05$) between all bread samples of the bread and the result revealed that the samples with more soybean flour were very rich in riboflavin due to the fact that soybean has appreciable amounts of vitamin. These results agree with those recorded by Ajayi et al., (2020) where the vitamin B2 content of bread and biscuits increased significantly with increasing pigeon-pea flour addition.

The content of ascorbic acid or Vitamin C varied from 21.53 mg/100g to 36.79 mg/100g. All samples were significantly different from each other at ($p< 0.05$). Sample A had the lowest value (21.53 mg/100 g) and sample D had the highest value (36.79 mg/100g). The value of vitamin C in the samples increased as the level of incorporation with the soybean and moringa leaf increased. These results agree with those reported by Ajayi et al., (2020) where the vitamin C content of bread and biscuits increased significantly with increasing addition of pigeon pea flour addition; but are lower than 420 mg/100g for Rosehip powder-based bread (Vatolomei, 2021). The result revealed that the samples with more soybean flour were rich in ascorbic acid compared to other samples.

**3.6. Sensory quality attributes of biscuits from wheat, soybeans, and moringa leaf flour blends**

As seen in Table 8, sensory attributes such as crust appearance, crumb appearance, flavor, texture, and overall acceptability were determined for the bread samples produced. The sensory quality attributes presented showed that the inclusion of soybeans and moringa leaf flour led to a significant difference ($p<0.05$) between sample A (control) and the test samples (B, C, and D). There was however no significant difference in the sensory attributes between samples B, C, and D. All samples were generally acceptable, which affirms the use of these flours in the development of food products. Other works confirming the use of soy and moringa leaf flour have been reported for the production of acceptable bread and other related food products (Inyang & Asuquo, 2016; Sengev et al., 2013; Ndife et al., 2020).

## 4. CONCLUSION

The results obtained from this research work showed that substitution of wheat flour for soybean flour and moringa leaf powder led to an increase in the nutritional value of bread. The results showed an increase in the ash, fiber, fats, and protein content of the bread as the level of incorporation of soybean flour and moringa leaf powder increased. The B vitamin content and provitamin A content of the bread also improved with the increase in soybean and moringa leaf powder. The addition of soybean flour and moringa leaf powder had a positive effect on the physical properties of the bread, such as the loaf weight, loaf volume, specific volume and loaf height. Additionally, mineral analysis showed that they are not only present but can be absorbed by the body owing to bioavailability since the antinutrient content of the samples was quite low.

The substitution of wheat with soybean flour and moringa leaf powder produced nutritious bread with desirable organoleptic qualities. All breads produced were generally acceptable, but sample C was the most acceptable among the test samples.

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