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Nutritive value and acceptability of bread fortified with moringa seed powder

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ABSTRACT

Bread is a common staple food in developing countries and many other regions of the world. It is an energy dense food with low micronutrient content. Micronutrient deficiency is increasing among children and pregnant women in Africa and other developing countries. In this study, bread was fortified with moringa seed powder at varying proportions (0–20%). The proximate, mineral, vitamin A content and sensory attributes of the moringa fortified bread samples were evaluated. Results of the proximate analysis showed that moringa seed powder addition significantly ($p < 0.05$) increased the protein (8.55–13.46%), ash (0.63–1.76%), fat (7.31–15.75%) and fibre content (0.08–0.62%) of the bread samples, while the moisture (22.90–20.01%) and carbohydrates content (57.68–46.73%) of the bread decreases. The mineral contents (Phosphorus, potassium, calcium and Iron) of the moringa fortified bread also increased significantly. Vitamin A contents of the bread samples increased by 50–74%, as the proportion of moringa seed powder increases in the flour blends. Results of the sensory evaluation indicated that the 5% moringa fortified bread was not significantly different from the bread produced from 100% wheat flour in terms of most of the quality atributes evaluated in this study. In conclusion, fortification of bread with moringa seed powder increased both the micro and macronutrient of conventional bread. In addition, the moringa fortified bread was rich in Vitamin A and also acceptable to consumers at 5% fortification level.
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1. Introduction

Bread is one of the most important staple foods and the most widely consumed non-indigenous food in Nigeria (Shittu et al., 2007). It is the favorites of children and adults, regardless of their socioeconomic class. Bread may be served in various forms; it could be eaten as a snack, or used as an ingredient in other culinary preparations.

Bread is a baked product produced from wheat flour. There are different varieties of bread depending on shape, weight, crust hardness, crumb cell structure, softness and colour (Collins, 1995). Bread is a high energy food, rich in carbohydrate and fat (Ameh et al., 2013) but low in other nutrients such as protein, minerals and vitamin (Young, 2001). In order to increase the nutritional composition of bread, many studies have investigated the potentials of substituting wheat flour with other flour (Olaoye et al., 2006; Oyeku et al., 2008; Ade-Omowaye et al., 2008; Adeleke and Odedeji, 2010; Sanful and Darko, 2010; Abdelghafor et al., 2011; Onuegbu et al., 2013; Udofia et al., 2013; Igbabul et al., 2014; Nwosu et al., 2014). Bread has been produced from blends of wheat, maize and orange fleshed sweet potato (Igbabul et al., 2014), wheat and un-defatted rice bran (Ameh et al., 2013), wheat and tilapia fish (Adeleke and Odedeji, 2010), wheat, plantain and soybean flour (Olaoye et al., 2006), and wheat and tigernut flour (Ade-Omowaye et al., 2008).

Moringa oleifera also called "miracle plant" is one of the most recently cultivated plants in West African regions. The plant is entirely edible from leaves to roots. Moringa seeds contain significant sources of minerals (calcium, phosphorus and iron) and vitamins (A, B and C). It is rich in protein but low in fat and carbohydrates (Price, 2000; Olushola, 2006). It is not only rich in nutritional content but also has some medicinal properties (Price, 2000; Olushola, 2006). The use of moringa leave powder for food fortification has been reported by many studies (Arise et al., 2014; Haneen, 2015; Abioye and Aka, 2015; Nour and Ibrahim,

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2016). However, the protein, fat and mineral (especially magnesium) content of moringa seed has been reported to be significantly higher than that of moringa leave (Gopalakrishnanb et al., 2016). Thus, fortification of wheat flour with moringa seed powder could therefore significantly improve the nutritional quality of wheat-moringa composite flour. Thus, the objective of this study is to determine the effect of moringa seed powder fortification on the proximate, mineral and vitamin A content of bread.

2. Materials and methods

2.1. Sample procurement

Wheat flour and baking ingredients (sugar, salt, yeast, and butter) were obtained from Wazobia market, while matured moringa seeds were purchased from Arada market in Ogbomoso, Oyo state, Southwest, Nigeria.

2.2. Production of Moringa seed powder

Matured moringa seeds were manually removed from the seed kernels and dried using cabinet drier (60 °C; 5 days). The dried seeds were ground in a clean Marlex blender. The moringa seed powder was sieved using a sieve of 500 μm mesh size, to obtain a fine powder. The flow chart for the production of moringa seed powder is shown in Fig. 1.

2.3. Formulations of Wheat-Moringa dough

Wheat flour was mixed with moringa seed powder at varying proportions (0:100; 95:5; 90:10; 85:15; 80:20). The wheat-moringa flour blends were mixed with other ingredients (as presented in Table 1) for bread dough formulation.

2.4. Production of moringa fortified bread

The wheat-moringa dough was kneaded, scaled, molded and placed in greased baking pans. The dough was left to proof for 55 min at 30 °C in a proofing cabinet at a relative humidity of about 40%. The proofed dough was baked in an oven (220–230 °C; 15 min) and cooled at ambient temperature.

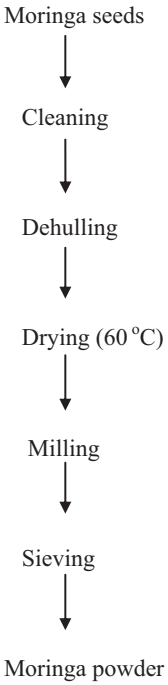


Fig. 1. Flow chart for the production of moringa powder.

2.5. Chemical analysis of the moringa fortified bread

2.5.1. Proximate composition

The moisture, crude protein, crude fibre, ash, fat and carbohydrate of the moringa fortified bread samples and 100% wheat bread (control) were determined using standard analytical method. The moisture, crude protein, crude fibre, fat and ash were determined by using AOAC (2000). Carbohydrate was determined by difference (i.e. 100 -% Protein, % Moisture, % Fibre, % Fat, % Ash).

2.6. Mineral content

The bread sample (5 g) was ashed, and the mineral content (phosphorus, potassium, calcium zinc and iron) were determined using Atomic Absorption Spectrophotometer (AAS).

2.7. Vitamin A content

Vitamin A content of the bread samples were determined using the procedure described by Singh et al. (2015). The bread sample (5 g) was crushed in 10 ml acetone and a few crystals of anhydrous sodium sulphate were added and the mixture was allowed to settle (This process was repeated twice). The supernatant was decanted into a beaker and transferred to a separator funnel. Petroleum ether (10 ml) was added to the supernatant, mix thoroughly and allowed to separate into two layers. The lower layer was discarded and the upper layer was collected in a 100 ml volumetric flask, and the volume was make up to 100 ml with petroleum ether. The optical density (OD) of the solution was determined at 452 nm, using petroleum ether as blank.

Calculations:

$$\beta\text{-carotene} = \frac{OD \times 13.9 \times 10000 \times 100}{\text{Wt of sample} \times 560 \times 1000}$$

where OD = Optical density of the solution at 452 nm

$$\text{Vitamin-A} = \frac{\textit{beta-carotene}\ (\mu g/100)}{0.6}.$$

2.8. Sensory evaluation

The moringa bread samples were coded and served to twenty (20) randomly selected judges. The judges were asked to score the bread samples for colour, shape, texture, sweetness, flavor, mouth feel and overall acceptability, using a seven (7) point's hedonic scale, where 1 to 7 represented dislike extremely and like extremely, respectively. Bread produced from 100% wheat flour (conventional bread) was used as control.

2.9. Statistical analyses

Data generated from the chemical analysis were in triplicate, and subjected to analysis of variance (ANOVA). Means were tested for significances by Duncan's Multiple Range Test (a method of comparisons in which the group means are ranked from smallest to largest and then the number of steps that two means are apart in this ranking is used to compute a range statistic for each comparison). Significance was accepted at $p < 0.05$. The sensory data was subjected to ANOVA and Duncan Multiple range test was used for means separation.

Table 1
Formulation of wheat – moringa dough.

Sample code	Moringa seed powder (%)	Wheat flour (g)	Yeast (g)	Margarine (g)	Salt (g)	Sugar (g)	Water (ml)
A	0	100	2.0	10	1.0	12	60
B	5	95	2.0	10	1.0	12	60
C	10	90	2.0	10	1.0	12	60
D	15	85	2.0	10	1.0	12	60
E	20	80	2.0	10	1.0	12	60

3. Results

3.1. Proximate composition of moringa fortified bread

The proximate content of the *moringa* fortified the bread samples are presented on Table 2.

The moisture content of the fortified bread decreases (20.01–22.89%) as the substitution levels of *moringa* seed powder increases in the flour blends. The protein content of the moringa fortified bread increases significantly ($p < 0.05$) as the substitution level of moringa seed powder increases in the flour blends. Bread sample fortified with 20% moringa powder had the highest (13.5%) protein content while the un-fortified bread had the least (8.6%) protein.

The ash content of the moringa fortified bread samples also increased with progressive increase in the proportion of *moringa* powder in the wheat – moringa flour blends (Table 2).

Significant increment (25–54%) was observed in the fat content of the moringa fortified bread samples. However, the carbohydrate contents of the moringa fortified bread decreases (60.5–48.4%) as the proportion of moringa seed powder increases in the wheat-moringa flour mixes.

3.2. Mineral and vitamin A content of the moringa fortified bread

Generally, the mineral contents of the moringa fortified bread increases as the substitution level of moringa seed powder increases in the flour blend, except in the case of zinc which decreases as the level of moringa seed powder increases in the flour blends (Table 3). Vitamin A contents of the fortified bread was significantly ($p < 0.05$) higher than the vitamin A content of the un-fortified bread (Fig. 2).

3.3. Sensory attributes of the moringa fortified bread

The mean sensory scores of the moringa fortified bread are presented in Table 4. The scores of almost all the sensory attributes of the un-fortified bread was not significantly ($p > 0.05$) different from the mean sensory scores of the wheat bread fortified with 5% moringa seed powder. However, significant differences existed in the sensory attributes of the un-fortified bread and the bread samples fortified with higher proportions (>5%) of moringa seed powder.

4. Discussion

4.1. Proximate composition of moringa fortified bread

4.1.1. Moisture content

The relatively low moisture contents (20.01–22.89%) of the fortified bread compared to the 100% wheat bread (22.90%) indicates that the bread samples fortified with high proportions (15–20%) of moringa will not be as soft as the un-fortified moringa bread (100% wheat bread). However, the moringa fortified bread would have longer shelf life compared to the un-fortified bread due to its relatively low moisture content.

The moisture content of the moringa fortified bread (20.01–22.89%) is close to the moisture content (29.6%) of bread fortified with green tea (Abd El-Megeid et al., 2009), but lower than the moisture content of soy supplemented whole wheat bread (34.1–35.6%) reported by Olaoye et al. (2006). The variation in the moisture contents of the bread samples could be due to variations in the chemical composition of the fortificants.

4.1.2. Protein content

The increment in the protein content of the fortified bread could be due to the high protein content of moringa seed used as fortificant. Moringa seed flour and moringa cake flour has been reported to contain 28% and 50.8% crude protein, respectively (Abiodun et al., 2012). The increased in the protein content of the moringa seed fortified bread (8.6–13.5%) reported in this study is in line with previous report on the fortification of bread with moringa. According to a review by Oyeyinka and Oyeyinka (2018), bread samples fortified with moringa leaf powder showed a 17–88% increased in protein content.

The protein content (10.3–13.5%) of the moringa fortified bread produced in this study is within the range of protein content (10.6–18%) of bread fortified with (5–20%) tilapia fish flour (Adeleke and Odedeji, 2010), but lower than the protein content (14–21%) of potato bread fortified with (30–70%) whole soy flour (Natal et al., 2013). The protein content of the moringa fortified bread reported in this study is lower than that of the potato bread fortified with soy flour probably due to variations in the dough formulation and in the substitution level of the fortificants.

4.1.3. Ash content

Ash is an index of the mineral content of food. The increment (56–64%) in the ash content of the bread samples could probably

Table 2
Proximate analysis of moringa fortified bread.

Sample code	Moisture (%)	Protein (%)	Ash (%)	Fat (%)	Crude fibre (%)	Carbohydrate (%)
A	22.90 ± 0.11^{c}	8.55 ± 0.23^{a}	0.63 ± 0.64^{a}	7.31 ± 0.15^{a}	0.08 ± 0.09^{a}	60.53 ± 0.33^{c}
B	22.89 ± 0.50^{c}	10.27 ± 0.23^{b}	1.43 ± 0.08^{b}	9.69 ± 0.27^{b}	0.18 ± 0.03^{a}	55.54 ± 0.46^{c}
C	20.58 ± 0.23^{b}	12.07 ± 0.00^{c}	1.57 ± 0.17^{c}	11.80 ± 1.68^{c}	0.35 ± 0.12^{b}	53.63 ± 1.55^{b}
D	20.13 ± 0.21^{a}	12.31 ± 0.12^{c}	1.57 ± 0.19^{c}	13.31 ± 0.46^{c}	0.44 ± 0.17^{b}	52.24 ± 0.17^{b}
E	20.01 ± 0.26^{a}	13.46 ± 0.61^{d}	1.76 ± 0.21^{d}	15.75 ± 0.37^{d}	0.62 ± 0.08^{d}	48.40 ± 0.52^{a}

Values are expressed as mean ± standard deviation of triplicate determination. Means with the same letters along the same column are not significantly different ($p > 0.05$). A: 100% Wheat flour; B: 95% Wheat flour + 5% Moringa powder; C: 90% Wheat flour + 10% Moringa powder; D: 85% Wheat flour + 15% Moringa powder; E: 80% Wheat flour + 20% Moringa powder.

Table 3
Mineral content of moringa fortified bread samples.

Sample	Phosphorus (mg/100)	Potassium (mg/100 g)	Calcium (mg/100 g)	Zinc (mg/100 g)	Iron (mg/100 g)
A	14.4 ± 0.07[a]	224 ± 0.07[a]	334 ± 0.07[a]	0.41 ± 0.07[d]	13.9 ± 0.07[a]
B	23.5 ± 0.07[b]	272 ± 0.07[b]	563 ± 0.07[b]	0.33 ± 0.07[c]	19.4 ± 0.07[b]
C	30.3 ± 0.07[e]	293 ± 0.07[c]	680 ± 0.07[c]	0.31 ± 0.07[c]	22.1 ± 0.07[c]
D	27.0 ± 0.07[c]	306 ± 0.07[d]	799 ± 0.07[d]	0.29 ± 0.07[b]	23.7 ± 0.07[d]
E	28.9 ± 0.07[d]	327 ± 0.07[e]	826 ± 0.07[e]	0.22 ± 0.07[a]	26.4 ± 0.07[e]

Values are expressed as mean ± standard deviation of triplicate determination. Means with the same letters along the same column are not significantly different ($p > 0.05$). A: 100% Wheat flour; B: 95% Wheat flour + 5% Moringa powder; C: 90% Wheat flour + 10% Moringa powder; D: 85% Wheat flour + 15% Moringa powder; E: 80% Wheat flour + 20% Moringa powder.

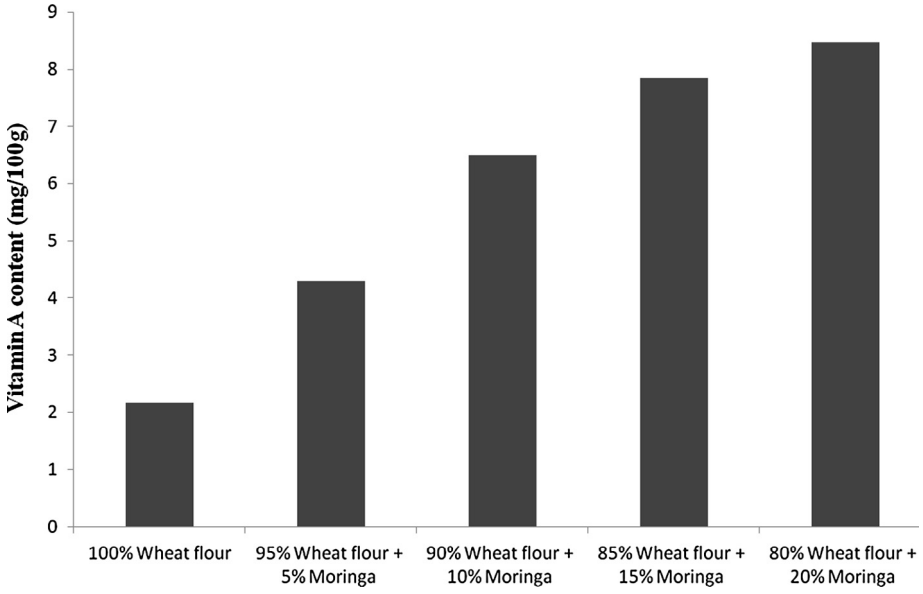


Fig. 2. Vitamin A content of moringa fortified bread.

Table 4
Sensory attributes of moringa fortified bread.

Sample code	Colour	Shape	Texture	Sweetness	Flavor	Mouthfeel	Overall acceptability
A	6.30 ± 0.95[c]	6.50 ± 0.85[d]	6.80 ± 0.42[c]	6.33 ± 0.68[d]	6.90 ± 0.5[c]	6.10 ± 0.57[d]	6.40 ± 0.69[d]
B	5.90 ± 1.14[c]	5.70 ± 0.82[c]	5.90 ± 0.99[c]	5.40 ± 1.17[d]	5.50 ± 1.18[b]	5.60 ± 1.17[d]	5.90 ± 1.10[d]
C	5.20 ± 1.03[b]	4.80 ± 0.92[b]	4.10 ± 0.88[b]	4.50 ± 1.08[c]	4.70 ± 0.95[b]	4.70 ± 0.17[c]	4.90 ± 0.74[c]
D	3.10 ± 0.88[a]	3.50 ± 0.83[a]	2.60 ± 1.17[a]	2.50 ± 1.08[b]	2.30 ± 1.16[a]	2.70 ± 0.95[b]	2.70 ± 0.94[b]
E	3.10 ± 0.88[a]	3.50 ± 0.71[a]	2.50 ± 1.16[a]	1.40 ± 0.69[a]	1.50 ± 0.85[a]	1.80 ± 1.28[a]	1.60 ± 0.52[a]

Values are expressed as mean ± standard deviation of triplicate determination. Means with the same letters along the same column are not significantly different ($p > 0.05$). A: 100% Wheat flour; B: 95% Wheat flour + 5% Moringa powder; C: 90% Wheat flour + 10% Moringa powder; D: 85% Wheat flour + 15% Moringa powder; E: 80% Wheat flour + 20% Moringa powder.

be due to the higher ash content (4.1%) of moringa seed powder (Abiodun et al., 2012). The ash content (0.63–1.8%) obtained in this study is in line with the ash content (2.85–2.88%) of maize powder substituted with 20% soy powder (Edema et al., 2005) and the ash content (1.7–2.6%) of cookies fortified with dried moringa leaves (Haneen, 2015).

4.1.4. Fat content

The relatively high fat content (7.3–15.8%) of the moringa fortified bread indicates that the bread will be more palatable than the un-fortified bread, since fat increases food palatability. Bread fortified with highest level of moringa seed powder (20%) had the highest fat content (15.8%). The fat content (7.3–15.8%) of the moringa fortified bread samples reported in this study is higher than the fat content (3.52–5.50%) of composite bread produced from wheat, maize and orange fleshed sweet potato flour (Igbabul et al., 2014).

4.1.5. Crude fibre content

The crude fibre content (0.08–0.62%) of the bread samples also increased significantly ($p < 0.05$) due to fortification of wheat flour with moringa seed powder in the bread formulation. Olaoye et al. (2006) reported crude fiber content of 0.03–0.14% for bread produced from composite flour of wheat, plantain, and soy beans.

4.1.6. Carbohydrate content

The carbohydrate content (60.5–48.4%) of the moringa fortified bread samples decreases as the substitution of moringa seed powder increases in the blend. Un-fortified bread had the highest carbohydrate content (60.5%) while 20% moringa fortified bread had the least carbohydrate content (48.4%). This observation was in line with other studies that also reported low level of carbohydrate content of bread from wheat and soy flour blends. Sanful and Darko (2010) reported decrease of 36–39% in the carbohydrate

content of bread produced from wheat and soy flour blends. The carbohydrate content (60.5–48.4%) of the moringa fortified bread samples produced in this study is within the range of the carbohydrate content (43.7–53.4%) of bread samples produced from composite flour of wheat, maize and sweet potato flour blends.

4.2. Mineral content of the moringa fortified bread

The relatively high level of minerals in the fortified bread compared to the un-fortified bread could be due to the high contents of essential minerals in moringa plant. Moringa leaves and powder has been reported to be rich in minerals that are essential for human development and growth (Khawaja Tahir Mahmood, 2010). The calcium content of moringa powder is more than two times that of milk, and its iron content is more than that of spinach (Gopalakrishnanb et al., 2016). Low level of zinc recorded for the fortified bread could be as a result of low content of zinc in moringa seed. Although moringa leaves was reported to 25.5–31.3 mg of zinc/kg (Barminas et al., 1998).

The calcium content (563–826 mg/100 g) of the moringa fortified bread reported in this study is higher than the calcium content (54–84 mg/100 g) of potato bread fortified with soybeans flour (Natal et al., 2013). The iron content (19.4–26.4 mg/100 g) of the breads was also higher than the iron content (1.99–3.38 mg/100 g) of composite bread produced from wheat, maize and orange fleshed sweet potato flour (Igbabul et al., 2014).

Potassium and phosphorus are important component of cell and body fluids that help control heart beat rate and blood pressure. The potassium content (272.5–327 mg/100 g) of the moringa fortified bread reported in this study is higher than the potassium content (110.4–188.2 mg/100 g) of wheat bread supplemented with stabilized un-deffated rice bran (Ameh et al., 2013). The phosphorus content (23.5–28.9 mg/100 g) of the moringa fortified bread was higher than that of the un-fortified bread (14.4 mg/100 g).

4.3. Vitamin A content of the moringa fortified bread

Vitamin A is an essential vitamin in human diet. It helps in sight brightness and proper vision, in addition to other metabolic functions in the body. Vitamin A deficiency is a leading cause of high morbidity and mortality among preschool children, pregnant women and lactating mothers in developing countries (Uchendu et al., 2012). The vitamin A content (4.3–8.5 mg/100 g) of the fortified bread samples were significantly ($p < 0.05$) higher than the vitamin A (2.2 mg/100 g) content of the un-fortified bread sample (Fig. 2). The high content of vitamin A in the fortified bread compared to the un-fortified bread could be due to the high content of vitamin A in moringa plant (Khawaja Tahir Mahmood, 2010). Moringa leaves have been reported to contain four times (fresh leaves) to ten times (dried leaves) vitamin A content of carrots (Khawaja Tahir Mahmood, 2010).

Vitamin A content (4.3–8.5 mg/100 g) of the moringa fortified bread produced in this study is higher than vitamin A content of wheat bread improved with ascorbic acid (3.43 mg/100 g) and that of the wheat bread improved with egg (3.42 mg/100 g) (Umelo et al., 2014).

4.4. Sensory attributes of the moringa fortified bread

Results of the sensory evaluation revealed that bread from pure wheat flour (un-fortified bread) and those from fortified wheat flour with 5% moriga seed powder was rated alike in almost all the quality attributes evaluated. This, indicate the feasibility of adding moringa seed powder to bread. This result suggests the potential of using moringa seed powder as food fortifcant.

5. Conclusion

Fortification of bread with moringa seed powder resulted in increased proximate, mineral and vitamin A contents of the fortified bread. Bread produced from 5% moringa seed powder and 95% wheat powder had the best sensory attributes. This study shows that fortification of wheat bread with moringa seed powder resulted in notable increase in protein content of the bread, which could be of great nutritional advantage to developing countries, where many can hardly afford high animal protein foods because of its cost. The high content of vitamin A in the fortified bread indicates that the moringa fortified bread could help in reducing vitamin A deficiency in developing countries.

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