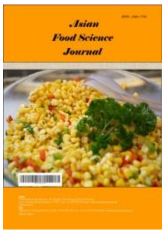

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Proximate Composition, Phytochemical, Mineral and Sensory Analyses of *Moringa oleifera* Enriched Bread

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim/background: The study investigated the effect of *Moringa oleifera* powder on enriched bread samples produced at various levels. Wheat flour and moringa powder were formulated at different percent ratio (1%, 2%, 3% and 4%) to determine the best enrichment ratio.
Methods: Proximate, phytochemical, mineral content and sensory evaluation of the bread samples were determined using bread made from 100% wheat flour which served as control.
Results: Result for proximate composition showed a progressive drop ($p<0.05$) in the fibre content of the enriched bread samples with decreasing level of enrichment. The energy value of the bread samples ranged from 392.73 to 394.32 Kcal. For crude protein, sample with 4% moringa enrichment recorded the high protein content which recorded a value of 12.89 %, which was significantly different ($p<0.05$) from other samples. The sample with 4% moringa enrichment recorded the highest ash content value of 2.67 % and was significantly different ($p<0.05$) from the other samples. Result of sensory evaluation using a nine-point Hedonic scale showed that enriched bread samples recorded 5.10 to 7.65 for appearance, 5.45 to 6.85 (aroma), 5.35 to 7.75 (texture), 5.55 to 7.70 (mouth feel) and 5.55 to 7.60 (general acceptability).
Conclusion: The enrichment of bread products could be best achieved at moringa levels of 2 % and 4%.

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Keywords: Bread; enrichment; Moringa oleifera; proximate and sensory analysis.

1. INTRODUCTION

Food enrichment is a process of adding vitamins or minerals to a processed food at levels specified by the law. 'Enriched' denotes the extra nutrients that have been added to the food. These nutrients are added to replace the original vitamins and minerals that were lost during refining process [1]. Enrichment is also carried out to act as public health measure, to ensure appropriate vitamins and mineral composition of foods are adequate for special dietary purposes, and also prevent nutritional associated ailments. *Moringa oleifera* is a rapidly growing food plant from the family *moringaceae* native to the sub-Himalayan area of India and Pakistan [2]. The plant which is highly nutritious is considered a complete food as all parts of the tree are useful and contains all the essential amino acids required for a healthy body. *Moringa oleifera* leaves have been used as an alternative food source to combat malnutrition, especially among children and infants [3]. It is a significant source of fats, proteins, beta-carotenes, vitamin C, Iron, potassium etc [4]. *Moringa oleifera* leaves can be eaten fresh, cooked or stored as dried powder for many months without refrigeration and reportedly without loss of nutritional value [3]. It is especially promising as a food source in the tropic because the tree is in full leaf at all seasons i.e. it is readily available. In African countries like Ghana and Nigeria, both fresh and dried leaves are included in meals. The dried leaves are processed into powder and added in food systems such as weaning food which can be cereal gruel (*Ogi*), soups, cake, yoghurt and cheese, biscuits and other pastry product [5]. This research focuses on the enrichment of bread using processed *Moringa oleifera* leaves in bid to improve the functionality of breads produced in Nigeria. The enrichment became necessary due to the fact that bread which is an important staple in the country has as its main dietary principle starch, with little or no other nutrient to make it a nutritionally balanced food product. Therefore the use of *Moringa oleifera* as an enrichment agent will significantly improve the nutritional quality of the food product as well as enhance its functionality in prevention and management of some chronic health conditions. In other words, the dynamic product of this research will combine the nutritional characteristics and biological activities of *Moringa oleifera* to deliver optimum result as a functional food. The use of *Moringa oleifera* in the enrichment of bread is borne out of the need to create a product capable of improving the nutritional and well-being of a greater number of Nigerians that consume bread daily, by utilizing the nutritional characteristics and biological activities of the well-known food plant *Moringa oleifera.* The objective of this study was to produce bread enriched with various percentages of processed *Moringa oleifera* leaves powder, and to determine the best enrichment ratio.

2. MATERIALS AND METHODS

This study was undertaken between the months of February and October 2020 in the Dry Food Workshop of the Food Technology Department Akanu Ibiam Federal Polytechnic Unwana, Afikpo, Ebonyi State; Biochemistry Laboratory of the National Root Crops Research Institute Umudike, and the Michael Okpara University Umudike both in Abia State. Nigeria. The materials used for the production of bread samples namely wheat flour, margarine, yeast, sugar, salt, nutmeg and improver, were procured from Eke market, Afikpo, Ebonyi State.

2.1 Collection of Plant Material and Processing of *Moringa oleifera* leaves

The leaves of *Moringa oleifera* were collected from the botanical gardens of Michael Okpara University Umudike, Umuahia, Abia State. Plant material was authenticated at Michael Okpara University Umudike, Umuahia, Department of Botany in Abia State. The *Moringa oleifera* leaves were first sorted to remove dirt and other foreign materials. The leaflets were striped and washed properly with clean portable water and then spread on a wooden tray to drip dry. The leaflets were further blanched at 100°C using steam for about 15 seconds. The leaves were then dried in a drying cabinet maintained at a temperature of 50°C. The dried *Moringa oleifera* leave samples were then milled and sieved at least two times using 0.5mm sized mesh screen till fine flour was obtained.

2.2 Production of Bread Enriched with Processed *Moringa oleifera* Leaves Powder

Production of bread samples enriched with various percentages of processed *Moringa oleifera* leaves was carried out at the Dry Food Workshop of the Food Technology Department

Akanu Ibiam Federal Polytechnic Unwana. The raw materials namely wheat flour, margarine, yeast, sugar, salt, nutmeg, processed *Moringa oleifera leaves* powder, bread improver and water were all measured as shown in Table 1 and mixed. For the production of 1% *Moringa oleifera* bread sample, 2.5g of *Moringa oleifera* leaves powder, to 247.5g of wheat flour was used to produced enriched bread, while for 2%, 3% and 4% enriched bread samples, 5g, 7.5g and 10g of *Moringa* leaves powder to 245g, 242.5g and 240g respectively were used. The other raw materials were left constant for each of the bread samples as indicated in Table 1. The no time dough method [6] was employed, in preparing the various doughs. The dough was then baked in an oven reheated at 200ºC for 15minutes and afterwards maintained at a temperature of 160ºC. The total baking time was 1 hour, 15 minutes. The bread produced was allowed to cool, packaged and labelled.

2.3 Proximate Analysis

Moisture content was determined by direct oven drying method; the loss in weight after oven-drying was expressed as % moisture content. The method of AOAC [7] was used. Crude protein was estimated from the total nitrogen (TN) determined by the micro-Kjeldahl method by multiplying the TN by a factor of 6.25, the method of AOAC [7] was adopted for determination of protein. Crude fat was determined by using the soxhlet extraction method using petroleum ether as the solvent, the method described by [7] was adopted. Ash was measured gravimetrically after ashing in a muffle furnace at 550ºC for 3 hours to constant weight. Crude fibre was determined on the bread samples by adopting the method of [7]. The dry matter content (in %) of bread samples was determined by subtracting the moisture content from 100 %. The method for carbohydrate determination was carried out as described by [8]. The difference was calculated as the Nitrogen Free Extract (NFE). The dry matter content (in %) of bread samples was determined by subtracting the moisture content from 100 %.

2.4 Mineral Analysis

The calcium content was determined by using the atomic absorption spectrophotometric method as described by Pearson [9]. The magnesium content was determined on 1g of the sample digested in 20 ml of acid mixture of 650 ml concentrated nitric acid (HNO_3); 80 ml protocatechuic acid (PCA) and 20 ml concentrated sulphuric acid H_2SO_4) using the atomic absorption spectrophotometric method described by Onwuka [10]. Potassium content was determined by adopting the method of [11]. Sodium content was determined by photometry method of AOAC [11]. Phosphorus content was determined on 0.5ml of mineral digest using the molybdate method described by Onwuka [10]. The iron content was using spectrophotometric method described by Onwuka [10]. Zinc content was determined on 1g of digested sample in 20 ml of acid mixture (650 ml concentrated HNO_3; 80ml PCA and 20ml concentrated H_2SO_4) using spectrophotometric method described by [10].

2.5 Phytochemical Analysis

Phytate content of the bread samples was determined by adopting the method of Pearson [9]. Tannin content was determined on 1g of sample using the Folin Denis spectrophotometric method as described by Pearson [9]. The flavonoid content was carried out using the acid hydrolysis gravimetric method as described by Onwuka [10]. The saponin content was determined on 5g of bread sample using the method described by [11]. Oxalate content was determined by using the method adopted by Onwuka [10]. Hydrogen cyanide content was determined on 5g of bread sample using a method adopted by Onwuka [10].

2.6 Sensory Evaluation

Sensory evaluation of coded bread samples namely A, B, C, D and E with various levels of enrichment (except sample E which was unenriched) was carried out using 20 semi trained panelists drawn from staff of National Roots Crop Research Institute Umudike. Parameters evaluated include Appearance, Aroma, Texture, Mouth feel and General acceptability. A nine-point hedonic scale ranging from 9 =extremely liked to 1= extremely disliked was used for the scoring.

2.7 Statistical Analysis

Replicate determinations were carried out on every parameter and the results presented as mean and standard error of mean. The mean scores were subjected to Analysis of variance (ANOVA) and mean separated using Turkey test at 95% confidence level.

Table 1. Level of enrichment of bread sample

Level of Enrichment	Wheat flour	*Moringa* powder	Yeast	Margarine	Sugar	Salt	Nutmeg	Improver	Water
5%	247.5g	2.5g	5g	12g	25g	0.5g	0.3g	0.5g	275ml
10%	245.0g	5.0g	5g	12g	25g	0.5g	0.3g	0.5g	275ml
15%	242.5g	7.5g	5g	12g	25g	0.5g	0.3g	0.5g	275ml
20%	240.0g	10.0g	5g	12g	25g	0.5g	0.3g	0.5g	275ml

3. RESULTS AND DISCUSSION

3.1 Moringa Oleifera Powder

The processing of moringa leaves produced a fine powder with a dark green colour attributed to the blanching carried out on the leaflets. While preparing the bread dough containing different moringa concentrations for baking, they exhibited some satisfactory characteristics such as shape retention and proofing. Also the different dough during baking gave appreciable baking properties comparable to the unenriched dough such as formation of bread crust, and development of characteristic bread aroma. The textures of enriched bread samples were slightly spongy with increasing level of moringa enrichment. This was attributed to the method employed in mixing and kneading the dough.

3.2 Proximate Composition Data

The result of the proximate analysis of the bread samples enriched with moringa is presented in Table 2. Dry matter of bread samples ranged between 87.28 and 88.05%. Bread sample with 4% moringa powder recorded the highest at 88.05% and was significantly different (P<0.05) from the other samples. The dry matter of the samples showed a progressive drop (P<0.05) with decreasing level of enrichment. However the unenriched bread sample (0% moringa) had the lowest dry matter at 87.28. The dry matter of any food product provides a measure of the amount of the particular food that is required to supply a given amount of nutrients. Increase or decrease in the value of dry matter is directly proportional to the availability of nutrients. The moisture content of the bread samples ranged between 11.95 and 12.72%. The unenriched bread sample (0% moringa) had significant high moisture content than the other samples. The result was within the values considered acceptable for dried foods and other dried samples which is in accordance with the findings of [12,5]. The moisture content of food sample is an index of stability and the result obeserved in the moisture content may be due to the difference in the processing method. Results obtained from the crude protein of the bread samples showed that the 4% moringa enriched sample recorded 12.89% of protein, which was significantly different (p<0.05) from the other samples. This indicates that this level of moringa powder can be used in food formulation. The unenriched (0% moringa) bread sample recorded the lowest protein at 12.52%. The result was in accordance with the findings of [12,5]. The unenriched (0% moringa) bread sample recorded the highest value interms of fat content recorded at 12.16% and was significantly different (p<0.05) from the enriched samples. The fat content of the enriched bread samples showed a progressive drop (p<0.05) with increasing level of enrichment leading to speculations that increasing levels of moringa powder in the bread samples lowered their fat content. High fat content in meals promotes high plasma cholesterol concentration which increases the risk of thrombosis [13]. How ever the levels obtained in the research was within acceptable safe limits. There was significant difference (p<0.05) in the crude fibre content of the bread samples. The result showed a progressive drop (p<0.05) in the fibre content of enriched bread samples with decreasing level of enrichment. The unenriched (0% moringa) bread sample had the lowest crude fibre content of 1.68%. The consumption of dietary fibre such as those contained in moringa may aid in reducing blood cholesterol which in turn reduces the risk of coronary heart disease [13].

The ash content of the samples showed that the 4% moringa enriched bread sample recorded the highest ash content of 2.67% and was significantly different (p<0.05) from the other samples.The result showed a progressive drop (p<0.05) with decreasing level of enrichment and were within reported values. The result showed there was no significant (p<0.05) difference in the carbohydrate content of the bread samples and was within reported values [13].

3.3 Phytochemical Content

The phytochemicals content of bread sample is shown in Table 4.

3.3.1 Phytate

The phytate content of bread samples varied between 0.02 and 1.15 mg/100g. The result indicated that there was a progressive drop (P<0.05) in the phytate content of the sample with decreasing level of moringa enrichment. The 4% moringa enriched bread sample at 1.15mg/100g was significantly different (P<0.05) from the other samples. There was no significant difference (P<0.05) in the phytate content of bread samples containing 1% and 0% (unenriched) moringa enrichment. Phytate in food products are well known for the metalthelation which affects their bioavailability [14]. However the values obtained in this study were within acceptable limits
[14].

3.3.2 Tannin

Result of the tannin content of bread samples showed a progressive drop (P<0.05) from the other samples. The unenriched sample (0% moringa) at 0.03 mg/100g recorded the lowest tannin content. Tannins in food are often responsible for colour changes which accounted for the dark brown coloration during processing of bread samples with high level of moringa enrichment. Also tannin is a good antioxidant and may inhibit carcinogen activation and cancer promotion [15].

3.3.3 Flavonoids

The flavonoid content of the bread samples varied between 0.02 and 0.03mg/100g. The 4% moringa enriched sample at 0.13mg/100g recorded the highest value and was significantly different (P<0.05) from the other samples. There was no significant different (P<0.05) in the flavonoid content of bread samples containing 1%, 2%, and 0% (unenriched) moringa enrichment. The result showed that the moringa enriched bread samples are good source of flavonoid which performs several important functions in the body such as antioxidants, scavenging carcinogens, inhibiting cell proliferation and binding to nitrates in the stomach, thereby preventing their conversion to nitrosamines [15].

3.3.4 Saponin

The saponin content of bread samples showed a progressive drop (P<0.05) with decreasing level of moringa enrichment. However there was no significant difference (P<0.05) between bread samples with 1% and 0% (unenriched) moringa enrichment. It was reported that saponins may prevent cancer cells from multiplying by interfering with DNA replication and also stimulate immune response [13].

3.3.5 Oxalate

The result obtained from the oxalate content of bread samples indicated that the 4% moringa enriched sample recorded the highest value at 0.19mg/100g and was significantly different (P<0.05). There was no significant different (P<0.05) between bread samples containing 2% and 3% moringa on one hand and bread sample containing 1% and 0% (unenriched) moringa on the other hand. Oxalates in food tend to bind minerals affecting their bioavailability [15].

3.3.5 Hydrogen cyanide (HCN)

The hydrogen cyanide content of bread samples ranged between 0.2 and 0.5. The result showed no significant difference (P<0.05) between the bread samples. The values obtained for the bread samples were within FAO acceptable safe limits [16].

3.3.6 Mineral content

The mineral content is shown in Table 3. Calcium content of the bread samples ranged between 33.02% and 34.01%. Bread sample with 1% moringa enrichment recorded the highest value at 34.01 and was significantly different (P<0.05) from the other samples. Also the calcium content of the bread samples showed a progressive drop (P<0.05) with increasing level of moringa enrichment with the exception of bread sample containing 0% moringa enrichment which was unenriched recorded the lowest calcium content at 33.02%. The result showed that the bread sample is a good source of calcium which is necessary in the body for normal development, maintenance of bones and teeth, clothing of blood, nerve irritability and protection against osteoporosis [14].

Result obtained for magnesium content of bread samples showed a progressive drop (P<0.05) with corresponding increase in the level of moringa enrichment. Bread sample with 1% moringa recorded the highest calcium value of 18.67mg/100g and was significantly different ($P<0.05$) from the other samples. The unenriched bread sample (0% moringa) recorded the lowest magnesium 18.01 mg/100g. The enriched bread is a good source of magnesium which could be employed in the treatment and management of hypomagnesaemia in individuals with prolonged diarrhea or malabsorption [13].

Bread sample with 4% moringa enrichment recorded the highest value of 23.29 for phosphorus and was significantly different ($p<0.05$) from other samples. The result showed a progressive drop ($p<0.05$) in their phosphorous content with decreasing levels of moringa enrichment. The unenriched sample (0% moringa) recorded the lowest phosphorus content at 22.84mg/100g. Phosphorus in food is needed for normal development and maintenance of bones and teeth, normal muscle activity, carbohydrate and fat metabolism and also prevention and management of phosphorus related deficiency ailments such as retarded growth, poor teeth and bone formation, ricket, weakness, anorexia and pain in the bones [14].

Result of the potassium content of bread samples showed a progressive drop ($p<0.05$) with increasing level of moringa enrichment. Bread sample with 1% moringa enrichment recorded the highest potassium value of 101.74mg/100g and was significantly different ($p<0.05$) from the other samples. The unenriched bread sample (0% moringa) at 101.22 mg/100g recorded the lowest potassium value. These values were lower than the values reported by [5]. Potassium is an essential mineral needed by the body for regulation of nerve impulse, regular heart beat rhythm, fluid balance and cell metabolism [14]. An increased potassium diet may help individuals with hypokalaemia i.e individuals with low plasma potassium [13].

The sodium content of bread samples ranged between 1.18 and 1.52 mg/100g. The unenriched (0% moringa) recorder the highest content of sodium at 1.52 mg/100g and was significantly different ($P>0.05$) from the enriched samples. The result also showed a progress drop ($P<0.05$) in the sodium content of enriched bread samples with increase in the level of enrichment. The result in the sodium content may be due to the different recipes used in the preparation of the bread samples. However the sodium levels recorded for the samples were within the FAO recommended dietary allowance.

There was a progressive drop ($P<0.05$) in the iron content of bread samples with decreasing level of moringa enrichment. Bread sample with 4% moringa powder recorded the highest iron content of 10.76 and was significantly different ($P>0.05$) from the other samples. The unenriched (0% moringa) sample at 1.85mg was significantly lower ($P>0.05$) than the enriched samples in terms of iron content. The result showed that moringa enriched bread is a good source of iron which is essential for formation of haemoglobin of the red blood cells and prevention and management of iron associated deficiency anaemia [14]. The result obtained is accordance with the findings of [5].

The result of zinc content of bread samples showed a progressive drop ($P<0.05$) with decreasing level of moringa enrichment. The 4% moringa enriched bread sample recorded at 6.41mg/100g was significantly different ($P<0.05$) from the other samples. The 0% moringa (unenriched) sample recorded the lowest value of 4.98. The result indicated that the enriched bread sample are good source of zinc which is essential in the body as a component of insulin and aid in enzyme wound healing and also in the prevention and management of the related deficiency anaemia [14].

3.3.7 Sensory evaluation

The result of the sensory evaluation of bread samples is shown in Table 5. From the table it was seen that the appearance of freshly baked bread samples ranged from 5.10 to 7.65. Sample E (unenriched bread) scored highest at 7.65 and was significantly different ($p<0.05$) from the other samples. This could be attributed to the presence of Moringa powder which tainted the bright colour of the wheat flour during baking. In terms of aroma, the samples were all accepted and were not significantly different ($p<0.05$). Analysis of texture indicated that the samples were fairly accepted with scores ranging from 5.35 to 7.75. However sample E (unenriched bread) which scored highest at 7.75, was different ($p<0.05$) from the other samples. The texture of the enriched bread samples looked a bit spongy which may be as a result of the method employed in mixing the bread dough. Evaluation of mouth feel, indicated significant difference ($p<0.05$) among the bread samples with sample E (unenriched bread) recording the highest score at 7.70. Also sample E (unenriched bread) was significantly different (p<0.05) from the other sample. The result on the general acceptability showed that the bread samples were fairly acceptable to the panelists as shown by their scores. Sample E scored highest at 7.60 and was significantly different (p<0.05) from other samples. Also bread samples A and C containing 1% and 3% moringa enrichment respectively were slightly different (p<0.05) in their acceptability from samples B and D, containing 2 % and 4% moringa enrichment. This result shows that with little improvement in the method of preparation, the enriched bread samples can compete favourably with their commercial counterparts.

Table 2. Proximate data of enriched bread samples

Parameter %			Samples		
	A(1% moringa)	**B(2% moringa)**	**C(3% moringa)**	**D(4% moringa)**	**E(control)**
DM	87.67 ± 0.01^{d}	87.79 ± 0.01^{c}	87.93 ± 0.01^{b}	88.05±01^{a}	87.28 ± 0.02^{e}
MC	12.33 ± 0.01^{b}	12.21 ± 0.01^{c}	12.07 ± 0.01^{d}	11.95 ± 0.01^{e}	12.72 ± 0.02^{a}
CP	12.62 ± 0.01^{d}	12.68 ± 0.01^{c}	12.74 ± 0.01^{b}	12.89 ± 0.01^{a}	12.52 ± 0.01^{e}
FAT	12.09 ± 0.01^{b}	12.05 ± 0.01^{c}	11.96 ± 0.01^{d}	11.90 ± 0.01^{e}	12.16 ± 0.02^{a}
CF	1.77 ± 0.01^{d}	1.84 ± 0.01^{c}	1.91 ± 0.01^{b}	2.01 ± 0.01^{a}	1.68 ± 0.02^{e}
ASH	2.32 ± 0.01^{d}	2.41 ± 0.01^{c}	2.53 ± 0.01^{b}	2.67 ± 0.01^{a}	2.22 ± 0.02^{e}
CHO	58.87 ± 0.01^{a}	58.81 ± 0.01^{a}	58.79 ± 0.01^{a}	58.58 ± 0.01^{a}	56.19 ± 2.49^{a}
EV	394.73 ± 0.13^{a}	394.41 ± 0.09^{b}	393.76 ± 0.01^{c}	392.98 ± 0.01^{d}	394.32±0.02^{a}

Mean scores with the same super scripts in the same row are not significantly different (p<0.05)
DM: Dry matter, MC: Moisture content, CP: Crude protein, F: Fat, CF: Crude Fibre, CHO;Carbohydrate, EV: Energy value.

Table 3. Mineral content of enriched bread samples

Parameter %			Samples		
A (1% moringa)	**B (2% moringa)**	**C (3% moringa)**	**D (4% moringa)**	**E (control)**	
Ca	34.01 ± 0.01^{a}	33.92 ± 0.01^{b}	33.84 ± 0.01^{c}	33.72 ± 0.01^{d}	33.02 ± 0.01^{e}
Mg	18.67 ± 0.02^{a}	18.51 ± 0.02^{b}	18.46 ± 0.01^{c}	18.37 ± 0.02^{d}	18.01 ± 0.01^{e}
P	22.91 ± 0.01^{d}	23.01 ± 0.01^{c}	23.15 ± 0.01^{b}	23.29 ± 0.01^{a}	22.84 ± 0.01^{e}
K	101.74 ± 0.01^{a}	101.66 ± 0.02^{b}	101.53 ± 0.02^{c}	101.42 ± 0.02^{d}	101.22± 0.01^{e}
Na	1.47 ± 0.01^{b}	1.36 ± 0.01^{c}	1.26 ± 0.02^{d}	1.18 ± 0.01^{e}	1.52 ± 0.01^{a}
Fe	10.42 ± 0.01^{d}	10.56 ± 0.01^{c}	10.67 ± 0.02^{b}	10.76 ± 0.02^{a}	1.85± 0.01^{e}
Zn	6.11 ± 0.02^{d}	6.24 ± 0.01^{c}	6.32 ± 0.02^{b}	6.41 ± 0.01^{a}	4.98 ± 0.01^{e}

Mean scores with the same super scripts in the same row are not significantly different (p<0.05)
Ca: calcium, Mg: Magnesium, P: Phosphorus, K: Potassium, Na: Sodium, Fe: Iron, Zn: Zinc

Table 4. Phytochemical content of enriched bread samples

Parameter %			Samples		
	A (1% moringa)	**B (2% moringa)**	**C (3% moringa)**	**D (4% moringa)**	**E(control)**
Phytate	0.03 ± 0.01^{d}	0.07 ± 0.01^{c}	0.11 ± 0.01^{b}	0.15 ± 0.01^{a}	0.02 ± 0.01^{e}
Tan	0.07 ± 0.01^{d}	0.10 ± 0.01^{c}	0.15 ± 0.01^{b}	0.19 ± 0.01^{a}	0.03 ± 0.01^{e}
Fla	0.03 ± 0.01^{c}	0.04 ± 0.02^{c}	0.09 ± 0.01^{b}	0.13 ± 0.01^{a}	0.02 ± 0.01^{c}
Sap	0.38 ± 0.01^{d}	0.42 ± 0.01^{c}	0.47 ± 0.01^{b}	0.51 ± 0.01^{a}	0.36 ± 0.01^{e}
Ox	0.09 ± 0.01^{c}	0.13 ± 0.01^{b}	0.14 ± 0.02^{b}	0.19 ± 0.01^{a}	0.08 ± 0.01^{e}
HCN	0.02 ± 0.01^{a}	0.02 ± 0.01^{a}	0.04 ± 0.01^{a}	0.05 ± 0.01^{a}	0.02 ± 0.01^{a}

Mean scores with the same super scripts in the same row are not significantly different (p<0.05)
Key: Phytate; Tan=Tannin; Fla=Flavonoid; Sap=Saponin; Ox=Oxalate; HCN=Hydogen cyanide. All measured as mg/100g

Table 5. Sensory mean scores of enriched bread samples

Sample	**Appearance**	**Aroma**	**Texture**	**Mouth feel**	**General Acceptability**
A (1% moringa)	6.60 ± 1.43^{ab}	6.65 ±1.31^{a}	6.00 ± 1.65^{b}	5.60 ± 1.76^{b}	6.75 ± 1.33^{ab}
B (2% moringa)	6.10 ± 1.80^{b}	5.95 ± 1.57^{a}	5.35 ± 1.42^{b}	5.25 ± 2.05^{b}	5.70 ± 1.30^{b}
C (3% moringa)	5.60 ± 1.67^{b}	6.10 ± 171^{a}	6.65 ± 1.66^{ab}	6.10 ± 1.65^{ab}	6.30 ± 1.72^{ab}
D (4%moringa)	5.10 ± 1.94^{b}	5.45 ± 1.70^{a}	5.95 ± 1.82^{b}	5.55 ± 2.04^{b}	5.55 ± 1.73^{b}
E (0% moringa)	7.65 ± 1.66^{a}	6.85 ± 1.84^{a}	7.75 ± 1.16^{a}	7.70 ± 1.59^{a}	7.60±1.82^{a}

Mean scores with the same super scripts in the same column are not significantly different (p<0.05)

4. CONCLUSION

This study shows that processed moringa leave powder (*Moringa oleifera*) could be used in the production of acceptable and palatable bread products. The enrichment of bread products could be best achieved at moringa levels of 2% to 4%. It was shown that the use of moringa leave powder as an enrichment agent at both levels significantly improved the nutritional quality of the bread samples as well as their functionality in providing the essential nutrients such as phytochemicals needed for the prevention and management of some health conditions. Therefore the use of *Moringa oleifera* in bread enrichment is effective in producing nutritionally balanced food product.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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