

## Research Article

# Chemical Composition and Quality Characteristics of Wheat Bread Supplemented with Leafy Vegetable Powders

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The study investigated the effect of supplementation of the leaf powders of *Telfairia occidentalis*, *Amaranthus viridis*, and *Solanum macrocarpon* on the chemical composition and the quality characteristics of wheat bread. The bread samples were supplemented with each of the vegetable leaf powders at 1%, 2%, and 3% during preparation. The bread samples were assayed for proximate composition, mineral composition, physical, sensory, and antioxidant properties using standard methods. The addition of vegetable powders significantly increased the protein (9.50 to 13.93%), fibre (1.81 to 4.00%), ash (1.05 to 2.38%), and fat (1.27 to 2.00%). Supplementation with vegetable powder however significantly decreased ( $p < 0.05$ ) the carbohydrate and moisture contents. Significant ( $p < 0.05$ ) increases were recorded for all evaluated minerals as the level of vegetable powder increased. Supplementation with vegetable powder caused significant decrease in total phenolic content, percentage DPPH inhibition, metal chelating ability, ferric reducing antioxidant power, and total antioxidant capacity. Sensory results showed that there was significant decrease in sensory qualities with increasing supplementation. This therefore suggests that bread supplemented with vegetable powder could have more market penetration if awareness is highly created.

## 1. Introduction

In Nigeria, one of the notably consumed staple foods with no need of introduction is bread. It is consumed widely across all age groups [1]. Bread is a baked product that is traditionally produced from wheat flour. It is rich in carbohydrate and fat but low in protein and minerals [2]. Recently, the need for supplementation of imported wheat for bread production with indigenous agricultural crops has been echoed from various quarters in order to reduce the stress on the economy [3, 4]. Supplementation with other agricultural produce that can boost the functionality, nutritional content, and the diversity of bread in the country is a desired goal for the country. Efforts have been made to improve the nutritional content of bread by supplementing with flours like wheat and undefatted rice bran [2], wheat, maize, and orange fleshed sweet potato [5], and moringa seed powder [1].

With the increasing menace of degenerative diseases [6] coupled with ever increasing rate of the consumption of bread [7], supplementation with indigenous green leafy vegetables like *Telfairia occidentalis* (fluted pumpkin), *Amaranthus viridis* (amaranth), and *Solanum macrocarpon* (African eggplant) is a veritable choice. Leafy vegetables are relatively inexpensive but with quality nutrients. Vegetables largely contain phytochemicals, protein, and minerals [3, 8]. Green leafy vegetables are not only rich in nutrients but also possess medicinal properties [9, 10]. The use of vegetable powder for food supplementation has been reported by Arise et al. [11], Haneen [12], and Fasogbon et al. [13]. There is however limited information on the supplementation of wheat bread with either fluted pumpkin, amaranth, or African eggplant. Thus, this study aimed to evaluate the effect of the supplementation of each of the leaf powders of fluted pumpkin, amaranth, and African eggplant on the proximate,

TABLE 1: Formulation of wheat-vegetable dough.

Mixture	Wheat flour (g)	Vegetable powder (g)	Yeast (g)	Margarine (g)	Sugar (g)	Salt (g)	Water (mL)
(1)	100	0	1.5	5	10	1	60
(2)	99	1	1.5	5	10	1	60
(3)	98	2	1.5	5	10	1	60
(4)	97	3	1.5	5	10	1	60

mineral, physical, antioxidant, and sensory properties of bread.

## 2. Materials and Methods

**2.1. Procurement of Samples.** Wheat flour, sugar, salt, yeast, and margarine were procured from Obafemi Awolowo University Central Market. Fresh fluted pumpkin, amaranth, and African eggplant were obtained from the Teaching and Research Farm of Obafemi Awolowo University, Nigeria.

**2.2. Production of Vegetable Powders.** Fresh vegetables (fluted pumpkin, amaranths, and African eggplant) were individually sorted, washed, destalked, and cut thinly. Each of the varietal vegetables was sliced and dried using a cabinet dryer at 55°C for 8 hrs. The dried leaves were milled to fine powder using a clean Marlex Excella (Marlex Appliances PVT, Daman, India) blender. The powders were packaged, labelled, and stored in different Ziploc® pouches for further usage.

**2.3. Formulations of Wheat-Vegetable Dough.** Wheat flour was individually mixed with each of the vegetables (*T. occidentalis*, *A. viridis*, and *S. macrocarpon*) and at varying proportions (100:0; 99:1; 98:2; 97:3) to make a total of 10 dough samples. The wheat-vegetable flour blends were mixed with other ingredients for dough formation as presented in Table 1.

**2.4. Production of Vegetable Enriched Breads.** Wheat-vegetable dough was kneaded, scaled, cut, moulded, and placed in properly greased baking pans following the modified conditions for bread baking by Famuwagun et al. [3]. The dough was allowed to proof in a proofing chamber at 40°C for 60 min at a relative humidity of about 40%. The proofed dough was baked in an industrial electric oven at 220°C for 15 min. The baked bread samples were allowed to cool to 28°C before packaging, labelling, and further analyses [1].

### 2.5. Chemical Analyses of the Vegetable Enriched Breads

**2.5.1. Proximate Composition.** The protein, moisture, fibre, fat, ash, and carbohydrate of the vegetable enriched bread samples and 100% wheat bread were determined using AOAC methods [14].

**2.5.2. Mineral Content.** Bread sample (5 g) was ashed, and the mineral contents (magnesium, iron, sodium, zinc, and calcium) were determined using Atomic Absorption Spectrophotometer.

**2.5.3. Extraction for Antioxidant Assays.** A suspension of 1 g of the bread sample was made in 10 ml of distilled water. The suspension was stirred for 1 h on a magnetic stirrer. The mixture was then filtered with Whatman number 1 filter paper. The residue was discarded while the supernatant was used for antioxidant assays [15] as discussed below.

**2.5.4. DPPH Radical Scavenging Activity Assay.** The ability to scavenge DPPH radical was determined using the method described by Pownall et al. [16]. To 1 ml of different concentrations (0.5, 1.0, 1.5, 2.0, and 2.5 mg/ml) of each of the sample extracts in a test tube was added 1 mL of 0.3 mM DPPH in methanol. The mixture was incubated in the dark for 30 min and absorbance was read at 517 nm against a DPPH control containing only 1 mL of methanol in lieu of the sample extract. The percent inhibition was calculated from the equation below where  $A_{\text{control}}$  is the absorbance of the control reaction and  $A_{\text{sample}}$  is the absorbance of the test compound:

$$\% \text{ inhibition} = \frac{A_{\text{control}} - A_{\text{sample}}}{A_{\text{control}}} \times 100. \quad (1)$$

**2.5.5. Metal Chelating Ability Assay.** This was determined using the method described by Singh and Rajini [17]. Aliquot (1 mL) of different concentrations (6.25, 12.5, 25.0, 50.0, and 100.0 mg/ml) of the sample extract was mixed with 1 mL of the 20th diluents of the mixture of 2 mM  $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$  and 5 mM ferrozine. The reaction was initiated by the addition of ferrozine (1 mL) after 5 min. After a further 10 min incubation period, the absorbance of the solution was measured at 562 nm using a UV Spectrophotometer. The percent inhibition of ferrozine-Fe + 2 complex formations was calculated using the formula where  $A_{\text{control}}$  is the absorbance of the control reaction and  $A_{\text{sample}}$  is the absorbance of the test compound:

$$\% \text{ metal chelating effect} = \frac{A_{\text{control}} - A_{\text{sample}}}{A_{\text{control}}} \times 100. \quad (2)$$

**2.5.6. Ferric Reducing Antioxidant Power.** This was evaluated using the method of Benzie and Strain [18]. FRAP working reagent was prepared by mixing 300 mmol/L acetate buffer of pH 3.6, 10 mmol/L 2,4,6-tri-(2-pyridyl)-1,3,5-triazine, and 20 mmol/L  $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$  in the ratio of 10:1:1, respectively. A 50  $\mu\text{L}$  aliquot of the sample extract at concentration (0.0, 0.2, 0.4, 0.0.6, 0.8, and 1 mg/mL) and 50  $\mu\text{L}$  of standard solutions of ascorbic acid (20, 40, 60, 80, and 100  $\mu\text{g}/\text{mL}$ ) were added to 1 mL of the prepared FRAP reagent. The absorbance was measured at 593 nm exactly 10 min after initiation with FRAP

TABLE 2: Proximate composition (%) of wheat bread enriched with green leafy vegetable powders.

Bread sample	Moisture	Fat	Fibre	Ash	Protein	Carbohydrate
99% WF: 1% TOL	24.5 ± 0.02 <sup>c</sup>	1.3 ± 0.03 <sup>d</sup>	2.0 ± 0.02 <sup>g</sup>	1.1 ± 0.02 <sup>g</sup>	10.9 ± 0.10 <sup>e</sup>	60.2 ± 0.01 <sup>a</sup>
98% WF: 2% TOL	23.4 ± 0.05 <sup>e</sup>	1.4 ± 0.02 <sup>c</sup>	2.8 ± 0.02 <sup>d</sup>	1.7 ± 0.01 <sup>e</sup>	11.2 ± 0.02 <sup>c</sup>	59.6 ± 0.02 <sup>d</sup>
97% WF: 3% TOL	22.6 ± 0.02 <sup>f</sup>	1.4 ± 0.04 <sup>c</sup>	4.0 ± 0.03 <sup>a</sup>	2.2 ± 0.02 <sup>b</sup>	13.9 ± 0.02 <sup>a</sup>	55.9 ± 0.02 <sup>h</sup>
99% WF: 1% AVL	25.1 ± 0.01 <sup>b</sup>	1.3 ± 0.01 <sup>d</sup>	1.9 ± 0.02 <sup>h</sup>	1.1 ± 0.01 <sup>g</sup>	10.5 ± 0.02 <sup>f</sup>	60.1 ± 0.01 <sup>b</sup>
98% WF: 2% AVL	23.8 ± 0.02 <sup>e</sup>	1.3 ± 0.02 <sup>d</sup>	2.2 ± 0.01 <sup>f</sup>	1.9 ± 0.02 <sup>d</sup>	11.0 ± 0.02 <sup>d</sup>	59.9 ± 0.01 <sup>c</sup>
97% WF: 3% AVL	21.9 ± 0.01 <sup>g</sup>	1.4 ± 0.02 <sup>c</sup>	3.1 ± 0.01 <sup>c</sup>	2.4 ± 0.01 <sup>a</sup>	12.4 ± 0.01 <sup>b</sup>	58.8 ± 0.02 <sup>g</sup>
99% WF: 1% SML	25.9 ± 0.02 <sup>b</sup>	1.4 ± 0.01 <sup>c</sup>	1.9 ± 0.02 <sup>h</sup>	1.1 ± 0.02 <sup>g</sup>	9.8 ± 0.02 <sup>h</sup>	59.9 ± 0.01 <sup>c</sup>
98% WF: 2% SML	24.9 ± 0.03 <sup>d</sup>	1.7 ± 0.05 <sup>b</sup>	2.4 ± 0.02 <sup>e</sup>	1.5 ± 0.01 <sup>f</sup>	10.1 ± 0.02 <sup>g</sup>	59.3 ± 0.01 <sup>e</sup>
97% WF: 3% SML	22.5 ± 0.02 <sup>f</sup>	2.0 ± 0.03 <sup>a</sup>	3.5 ± 0.01 <sup>b</sup>	2.0 ± 0.02 <sup>c</sup>	10.8 ± 0.01 <sup>e</sup>	59.2 ± 0.01 <sup>f</sup>
100% WF	26.9 ± 0.03 <sup>a</sup>	1.3 ± 0.01 <sup>d</sup>	1.8 ± 0.02 <sup>i</sup>	1.1 ± 0.02 <sup>g</sup>	9.5 ± 0.02 <sup>i</sup>	59.9 ± 0.01 <sup>c</sup>

Mean values along the same column with different superscripts are significantly different ( $p < 0.05$ ); WF: wheat flour; TOL: *Telfairia occidentalis* leaf powder; AVL: *Amaranthus viridis* leaf powder; SML: *Solanum macrocarpon* leaf powder.

reagent. The blank contained 50  $\mu$ L of distilled water and 1 mL of FRAP reagent.

**2.5.7. Total Antioxidant Capacity Assay.** The total antioxidant capacity (TAC) of the bread samples was evaluated using the method of Prieto et al. [19]. The total antioxidant activity is expressed as mg ascorbic acid equivalence per gram of extract (mg AAE/g extract).

**2.5.8. Physical Properties of Vegetable Enriched Breads.** The physical properties (volume, weight, and specific volume) of bread loaves produced were determined using the method of Khalil et al. [20] with some modifications. The loaf volume was measured using solid displacement method described by Khalil et al. [20]. Bread loaf was placed in a container of known volume filled with sorghum grains. The volume of grains displaced by the loaf was considered as the loaf volume which was measured. The weight of the loaf was evaluated and the specific volume of the loaf was determined from the ratio of loaf volume to loaf weight.

**2.5.9. Sensory Evaluation of Vegetable Enriched Breads.** The vegetable bread samples were differently coded and presented to twenty randomly selected judges for evaluation of taste, colour, flavour, texture, appearance, and overall acceptance using a nine-point hedonic scale, where 1 to 9 represented dislike extremely and like extremely, respectively. Bread produced from 100% wheat flour served as the control sample.

**2.5.10. Statistical Analysis.** Data obtained from the chemical analyses and sensory evaluation were subjected to analysis of variance and means were separated using Duncan's Multiple Range Test at 95% confidence level [21].

### 3. Results and Discussion

**3.1. Proximate Composition of Vegetable Enriched Breads.** The proximate composition of the vegetable (fluted pumpkin, African eggplant, and amaranth) enriched breads is presented in Table 2.

**3.2. Moisture Content.** The moisture content of the enriched bread significantly ( $p < 0.05$ ) decreased (26.9 to 21.9%) as

the substitution levels of fluted pumpkin, African eggplant, and amaranth increased. The relatively low moisture (25.9 to 21.9%) of the enriched bread compared to the control (100% wheat) bread (26.9%) indicates that the bread samples enriched with either fluted pumpkin (*T. occidentalis*), African eggplant (*S. macrocarpon*), or amaranth (*Amaranthus viridis*) leaf powders would have longer shelf life than the 100% bread sample.

The bread samples enriched with African eggplant were observed to have the highest moisture content across all the entire vegetable group. Thus, the enriched bread group that was closest to the 100% wheat bread in terms of moisture was the bread enriched with the African eggplant (*S. macrocarpon*).

The moisture contents of the vegetable enriched bread (21.9 to 25.9%) were close to the moisture content of 29.6% reported for green tea fortified bread [22]. The presented results for moisture were however lower than the range (34.1 to 35.6%) reported by Olaoye et al. [23] for soy enriched whole wheat bread. The differences in the results could be attributed to the differential quantity and chemical composition of the supplements added.

**3.3. Protein Content.** As presented in Table 2, the protein content of the vegetable enriched breads (9.5 to 13.9%) increased significantly ( $p < 0.05$ ) as the substitution level of vegetables increased. The bread sample enriched with fluted pumpkin had the highest protein content (10.9 to 13.9%) across all the differential vegetables used. The 100% wheat bread recorded the least protein content (9.5%) while the bread sample enriched with fluted pumpkin at 3% enrichment level recorded the highest protein content (13.9%) which shows a percentage increase of 46.6%. The increment in the protein content of the enriched bread could be attributed to high protein content in dried vegetable powders. Dried fluted pumpkin, African eggplant, and amaranth leaves' powders have been reported to contain 31.7, 27.2, and 23.6% protein, by Kajihaua et al. [24], Dougnon et al. [25], and Udousoro and Ekanem [26], respectively.

The observed protein contents (9.8 to 13.9%) of the vegetable enriched breads at 1 to 3% enrichment level in this study were within the reported range of the protein content

TABLE 3: Mineral nutrients (mg/100 g) of wheat bread fortified with green leafy vegetable powders.

Bread sample	Magnesium	Iron	Sodium	Zinc	Calcium
99% WF: 1% TOL	172.5 ± 0.05 <sup>d</sup>	48.6 ± 0.01 <sup>d</sup>	18.2 ± 0.02 <sup>h</sup>	10.0 ± 0.22 <sup>cd</sup>	259.0 ± 0.30 <sup>h</sup>
98% WF: 2% TOL	176.0 ± 0.02 <sup>b</sup>	49.1 ± 0.02 <sup>c</sup>	21.8 ± 0.05 <sup>e</sup>	11.5 ± 1.50 <sup>b</sup>	280.0 ± 0.25 <sup>e</sup>
97% WF: 3% TOL	179.0 ± 0.02 <sup>a</sup>	53.7 ± 0.02 <sup>b</sup>	22.7 ± 0.07 <sup>d</sup>	13.4 ± 0.15 <sup>a</sup>	306.0 ± 0.30 <sup>d</sup>
99% WF: 1% AVL	167.2 ± 0.01 <sup>f</sup>	35.1 ± 0.03 <sup>h</sup>	22.3 ± 0.09 <sup>d</sup>	7.8 ± 0.02 <sup>e</sup>	250.0 ± 0.30 <sup>i</sup>
98% WF: 2% AVL	170.5 ± 0.03 <sup>e</sup>	38.5 ± 0.02 <sup>g</sup>	25.5 ± 0.08 <sup>b</sup>	9.6 ± 0.55 <sup>e</sup>	262.0 ± 0.05 <sup>f</sup>
97% WF: 3% AVL	174.5 ± 0.03 <sup>c</sup>	39.6 ± 0.01 <sup>f</sup>	27.1 ± 0.03 <sup>a</sup>	10.2 ± 0.81 <sup>c</sup>	307.5 ± 0.45 <sup>c</sup>
99% WF: 1% SML	157.5 ± 0.04 <sup>i</sup>	42.6 ± 0.04 <sup>e</sup>	19.9 ± 0.21 <sup>g</sup>	9.8 ± 0.11 <sup>d</sup>	261.0 ± 0.15 <sup>g</sup>
98% WF: 2% SML	161.0 ± 0.02 <sup>h</sup>	48.2 ± 0.02 <sup>d</sup>	21.0 ± 0.03 <sup>f</sup>	10.7 ± 0.45 <sup>c</sup>	310.3 ± 0.15 <sup>b</sup>
97% WF: 3% SML	162.0 ± 0.01 <sup>g</sup>	54.2 ± 0.02 <sup>b</sup>	23.3 ± 0.01 <sup>c</sup>	14.0 ± 0.15 <sup>a</sup>	330.5 ± 0.25 <sup>a</sup>
100% WF	155.5 ± 0.02 <sup>j</sup>	33.5 ± 0.02 <sup>i</sup>	15.9 ± 0.02 <sup>i</sup>	6.7 ± 0.02 <sup>f</sup>	248.5 ± 0.40 <sup>j</sup>

Mean values along the same column with different superscripts are significantly different ( $p < 0.05$ ); WF: wheat flour; TOL: *Telfairia occidentalis* leaf powder; AVL: *Amaranthus viridis* leaf powder; SML: *Solanum macrocarpon* leaf powder.

(10.6 to 18.0%) of bread enriched with 5 to 20% tilapia fish flour by Adeleke and Odedeji [27]. The values were however lower than 14.0 to 21.0% reported by Gomes Natal et al. [28] for potato bread enriched with 30 to 70% whole soy flour.

**3.4. Ash Content.** Significant ( $p < 0.05$ ) increase was obtained for the ash content (1.1 to 2.4%) of the vegetable enriched bread samples. The increment could be attributed to ash content in green leafy vegetables. The bread samples enriched with amaranth at 3% enrichment level had the highest (2.4%) ash content which is an index for mineral contents. The ash content (1.1 to 2.4%) obtained in this work is comparable to 1.7 to 2.6% reported for the ash content of cookies enriched moringa leaf powder [12].

**3.5. Fat Content.** Increase was obtained (1.3 to 2.0%) for the fat content of the vegetable enriched bread samples as presented in Table 2. The relative increase in the fat content of the enriched bread samples indicates that the bread would be distinctively palatable in taste than the control bread sample because fat improves palatability [29]. The bread enriched with African eggplant at 3% inclusion level recorded the highest fat (2.0%). Comparing across the vegetables used, samples enriched with African eggplant leaf powder had the highest based on fat. The fat reported in this study is lower than 7.3 to 15.8% and 3.5 to 5.5% documented by Bolarinwa et al. [1] and Igbabul et al. [5], respectively, for bread enriched with moringa seed flour and bread produced from the blends of wheat, maize, and orange fleshed sweet potato flour.

**3.6. Crude Fibre Content.** The crude fibre content (1.8 to 4.0%) of the bread samples also increased significantly ( $p < 0.05$ ) with increase in enrichment levels. Among the vegetable used and across enrichment levels, bread samples enriched with fluted pumpkin leaf powder had the highest fibre which suggests that fluted pumpkin leaf powder had higher fibre content. There was no significant difference ( $p < 0.05$ ) in the fibre content of bread samples enriched with 1% fluted pumpkin and 1% amaranth leaf powders. The reported fibre content in this work is higher than 0.03 to 0.14% reported for bread produced from the mix of wheat, plantain, and soybean flour by Olaoye et al. [23].

**3.7. Carbohydrate Content.** As presented in Table 2, the carbohydrate contents (60.2 to 55.9%) of enriched bread decreased with enrichment with vegetables used. The sample enriched with fluted pumpkin leaf powder had the lowest (55.9%) in terms of the carbohydrate content. The observed decrease in carbohydrate content was also reported by Bolarinwa et al. [1] and Sanful and Darko [30] for bread enriched with moringa seed flour and soy enriched bread, respectively.

**3.8. Mineral Contents of Vegetable Enriched Breads.** The mineral composition for the bread samples is presented in Table 3. The magnesium contents of the bread samples (155.9 to 179.0 mg/100 g) as presented in Table 3 increased significantly ( $p < 0.05$ ) upon the addition of vegetables. Among the vegetables used, sample enriched with fluted pumpkin had the highest magnesium content even at diverse enrichment levels. The calcium contents (248.5 to 330.5 mg/100 g) of the bread samples also increased significantly with addition of vegetables. The calcium content in this study is higher than 54 to 84 mg/100 g reported for potato bread fortified with soybeans flour [28]. The bread enriched with African eggplant leaf powder at 3% enrichment level recorded the highest. Zinc (6.7 to 14.0 mg/100 g), sodium (15.9 to 23.3 mg/100 g), and iron (33.5 to 53.7 mg/100 g) also increased significantly with increase in addition of vegetables. The iron content in this study is higher than 19.4 to 26.4 mg/100 g reported for composite bread produced from wheat, orange fleshed sweet potato flour, and maize [5]. The range of zinc contents in this study is higher than 0.22 to 0.41 mg/100 g reported for moringa fortified bread [1]. It can be inferred from the results that the enrichment with either fluted pumpkin, African eggplant, and amaranth resulted in increase of all the evaluated mineral contents of the bread samples.

**3.9. Antioxidant Properties of Vegetable Enriched Breads.** The antioxidant properties of the bread samples are presented in Table 4. The total phenolic content of the bread samples (85.5 to 106.0 mgGAE/g) significantly ( $p < 0.05$ ) increased with addition of vegetables. Among the vegetables used, samples enriched with fluted pumpkin had the highest total phenolic content across all enrichment levels. The DPPH scavenging ability of the bread samples (35.0 to 52.0%) also increased

TABLE 4: Antioxidant properties of wheat bread fortified with green leafy vegetable powders.

Bread sample	TPC (mgGAE/g)	DPPH (%)	MCA (%)	FRAP ( $\mu$ AAE/g)	TAC (mgAAE/g)
99% WF: 1% TOL	92.1 $\pm$ 0.03 <sup>e</sup>	38.8 $\pm$ 0.01 <sup>g</sup>	44.0 $\pm$ 0.01 <sup>f</sup>	128.8 $\pm$ 0.05 <sup>e</sup>	14.1 $\pm$ 0.01 <sup>c</sup>
98% WF: 2% TOL	93.8 $\pm$ 0.02 <sup>d</sup>	40.9 $\pm$ 0.02 <sup>e</sup>	50.7 $\pm$ 0.01 <sup>b</sup>	129.6 $\pm$ 0.01 <sup>d</sup>	14.1 $\pm$ 0.01 <sup>c</sup>
97% WF: 3% TOL	106.0 $\pm$ 0.01 <sup>a</sup>	45.3 $\pm$ 0.01 <sup>b</sup>	52.8 $\pm$ 0.02 <sup>a</sup>	134.0 $\pm$ 0.02 <sup>a</sup>	28.1 $\pm$ 0.02 <sup>a</sup>
99% WF: 1% AVL	87.1 $\pm$ 0.02 <sup>g</sup>	35.0 $\pm$ 0.02 <sup>j</sup>	42.6 $\pm$ 0.04 <sup>g</sup>	127.8 $\pm$ 0.01 <sup>f</sup>	12.1 $\pm$ 0.06 <sup>e</sup>
98% WF: 2% AVL	90.3 $\pm$ 0.04 <sup>f</sup>	40.1 $\pm$ 0.01 <sup>f</sup>	46.8 $\pm$ 0.01 <sup>e</sup>	129.6 $\pm$ 0.01 <sup>d</sup>	14.1 $\pm$ 0.08 <sup>c</sup>
97% WF: 3% AVL	105.9 $\pm$ 0.01 <sup>c</sup>	38.7 $\pm$ 0.01 <sup>h</sup>	48.9 $\pm$ 0.01 <sup>c</sup>	131.2 $\pm$ 0.01 <sup>c</sup>	14.9 $\pm$ 0.04 <sup>c</sup>
99% WF: 1% SML	87.1 $\pm$ 0.02 <sup>g</sup>	43.0 $\pm$ 0.01 <sup>d</sup>	42.4 $\pm$ 0.02 <sup>g</sup>	128.0 $\pm$ 0.01 <sup>e</sup>	14.2 $\pm$ 0.06 <sup>c</sup>
98% WF: 2% SML	92.5 $\pm$ 0.02 <sup>e</sup>	44.7 $\pm$ 0.01 <sup>c</sup>	42.8 $\pm$ 0.04 <sup>g</sup>	129.9 $\pm$ 0.02 <sup>d</sup>	14.9 $\pm$ 0.02 <sup>c</sup>
97% WF: 3% SML	105.0 $\pm$ 0.01 <sup>b</sup>	52.0 $\pm$ 0.01 <sup>a</sup>	47.3 $\pm$ 0.01 <sup>d</sup>	133.0 $\pm$ 0.01 <sup>b</sup>	19.2 $\pm$ 0.03 <sup>b</sup>
100% WF	85.5 $\pm$ 0.02 <sup>h</sup>	38.5 $\pm$ 0.02 <sup>i</sup>	41.5 $\pm$ 0.01 <sup>h</sup>	126.7 $\pm$ 0.01 <sup>g</sup>	12.4 $\pm$ 0.01 <sup>d</sup>

Mean values along the same column with different superscripts are significantly different ( $p < 0.05$ ); WF: wheat flour; TOL: *Telfairia occidentalis* leaf powder; AVL: *Amaranthus viridis* leaf powder; SML: *Solanum macrocarpon* leaf powder.

TABLE 5: Physical properties of wheat bread fortified with green leafy vegetable powders.

Bread sample	Weight (g)	Volume (cm <sup>3</sup> )	Specific volume (cm <sup>3</sup> /g)
99% WF: 1% TOL	138.3 $\pm$ 0.03 <sup>d</sup>	572.2 $\pm$ 0.01 <sup>c</sup>	4.1 $\pm$ 0.02 <sup>b</sup>
98% WF: 2% TOL	146.4 $\pm$ 0.02 <sup>b</sup>	567.9 $\pm$ 0.02 <sup>e</sup>	3.9 $\pm$ 0.04 <sup>e</sup>
97% WF: 3% TOL	154.2 $\pm$ 0.02 <sup>a</sup>	552.1 $\pm$ 0.01 <sup>g</sup>	3.6 $\pm$ 0.02 <sup>g</sup>
99% WF: 1% AVL	136.8 $\pm$ 0.04 <sup>e</sup>	573.6 $\pm$ 0.05 <sup>b</sup>	4.2 $\pm$ 0.02 <sup>b</sup>
98% WF: 2% AVL	142.5 $\pm$ 0.02 <sup>c</sup>	569.4 $\pm$ 0.02 <sup>d</sup>	4.0 $\pm$ 0.03 <sup>d</sup>
97% WF: 3% AVL	147.0 $\pm$ 0.03 <sup>b</sup>	555.7 $\pm$ 0.01 <sup>f</sup>	3.8 $\pm$ 0.02 <sup>f</sup>
99% WF: 1% SML	136.4 $\pm$ 0.01 <sup>e</sup>	573.1 $\pm$ 0.03 <sup>b</sup>	4.2 $\pm$ 0.02 <sup>b</sup>
98% WF: 2% SML	138.2 $\pm$ 0.01 <sup>d</sup>	563.0 $\pm$ 0.02 <sup>e</sup>	4.1 $\pm$ 0.02 <sup>c</sup>
97% WF: 3% SML	146.6 $\pm$ 0.02 <sup>b</sup>	553.0 $\pm$ 0.01 <sup>g</sup>	3.8 $\pm$ 0.02 <sup>f</sup>
100% WF	134.4 $\pm$ 0.01 <sup>f</sup>	579.5 $\pm$ 0.02 <sup>a</sup>	4.3 $\pm$ 0.02 <sup>a</sup>

Mean values along the same column with different superscripts are significantly different ( $p < 0.05$ ); WF: wheat flour; TOL: *Telfairia occidentalis* leaf powder; AVL: *Amaranthus viridis* leaf powder; SML: *Solanum macrocarpon* leaf powder.

significantly ( $p < 0.05$ ) with the proportionate addition of vegetables. Bread samples enriched with African eggplant had the highest DPPH radical scavenging ability across all the vegetables and enrichment levels used. The metal chelating ability, ferric reducing antioxidant power, and total antioxidant capacity of the bread samples which increased significantly ( $p < 0.05$ ) with the proportionate addition of vegetables are 41.5 to 52.8%, 126.7 to 134.0  $\mu$ AAE/g, and 12.4 to 28.1 mgAAE/g, respectively. The bread samples enriched with fluted pumpkin had the highest metal chelating ability, ferric reducing antioxidant power, and total antioxidant capacity across all the vegetables and enrichment levels used. The inclusion of vegetable leaf powders in bread caused improvement in the antioxidant properties of the bread.

**3.10. Physical Characteristics of Vegetable Enriched Breads.** The physical properties of the bread samples are presented on Table 5. The loaf volume and specific volume of the bread samples decreased significantly ( $p < 0.05$ ) from 579.5 to 552.1 cm<sup>3</sup> and 4.3 to 3.6 cm<sup>3</sup>/g, respectively. This could be attributed to the reduction in gluten content as a result of the supplementation. Other researchers have also reported

that supplementation of wheat flour with nonglutinous flour results in lower bread volumes [31]. It could therefore be postulated that the increase in the quantity of yeast used and/or longer proofing time could possibly improve the physical characteristics. The bread loaf volume is one of the important physical characteristics to consumer. This is because they desire aesthetically light breads. Loaf weight and weight loss are related inversely. While weight loss (154.2 to 134.4 g) decreased significantly as the enrichment level increased, loaf volume increased. The bread enriched with African eggplant had the closest match to the physical characteristics of the 100% wheat bread among all the vegetables used.

**3.11. Sensory Attributes of Vegetable Enriched Breads.** Results of the sensory evaluation (Table 6) revealed that the sensory qualities (taste, colour, flavour, texture, general acceptance, and overall acceptance) of the bread samples decreased with increasing addition of vegetable. The control sample was the most preferred in terms of all the evaluated sensory parameters. It was also notably observed that the taste of the sample at 3% inclusion level was neither liked nor disliked for bread enriched with 3% African eggplant powder and 3% amaranth

TABLE 6: Sensory properties of wheat bread fortified with green leafy vegetable powders.

Sample	Taste	Colour	Flavour	Texture	Appearance	Overall acceptability
99% WF: 1% TOL	7.5 ± 0.45 <sup>c</sup>	8.0 ± 0.12 <sup>b</sup>	6.0 ± 0.14 <sup>c</sup>	7.3 ± 0.04 <sup>b</sup>	7.2 ± 0.16 <sup>b</sup>	7.9 ± 0.05 <sup>b</sup>
98% WF: 2% TOL	6.4 ± 0.05 <sup>f</sup>	7.7 ± 0.14 <sup>c</sup>	5.5 ± 0.07 <sup>e</sup>	6.9 ± 0.04 <sup>d</sup>	6.7 ± 0.05 <sup>d</sup>	7.2 ± 0.06 <sup>c</sup>
97% WF: 3% TOL	6.2 ± 0.11 <sup>g</sup>	5.0 ± 0.10 <sup>f</sup>	5.0 ± 0.08 <sup>g</sup>	6.1 ± 0.05 <sup>g</sup>	5.0 ± 0.08 <sup>g</sup>	4.0 ± 0.04 <sup>j</sup>
99% WF: 1% AVL	7.7 ± 0.08 <sup>b</sup>	6.2 ± 0.19 <sup>d</sup>	5.9 ± 0.02 <sup>d</sup>	7.0 ± 0.13 <sup>c</sup>	7.0 ± 0.03 <sup>c</sup>	6.5 ± 0.06 <sup>d</sup>
98% WF: 2% AVL	6.9 ± 0.09 <sup>e</sup>	5.5 ± 0.12 <sup>e</sup>	5.4 ± 0.04 <sup>f</sup>	6.3 ± 0.10 <sup>f</sup>	6.2 ± 0.06 <sup>e</sup>	5.9 ± 0.06 <sup>g</sup>
97% WF: 3% AVL	5.9 ± 0.31 <sup>h</sup>	4.9 ± 0.45 <sup>g</sup>	5.2 ± 0.09 <sup>g</sup>	6.0 ± 0.04 <sup>h</sup>	4.8 ± 0.05 <sup>i</sup>	4.4 ± 0.05 <sup>i</sup>
99% WF: 1% SML	7.2 ± 0.21 <sup>d</sup>	6.2 ± 0.37 <sup>d</sup>	6.2 ± 0.03 <sup>b</sup>	7.0 ± 0.04 <sup>c</sup>	6.6 ± 0.03 <sup>d</sup>	6.1 ± 0.06 <sup>e</sup>
98% WF: 2% SML	6.9 ± 0.12 <sup>e</sup>	5.4 ± 0.12 <sup>e</sup>	5.4 ± 0.05 <sup>e</sup>	6.7 ± 0.10 <sup>e</sup>	5.3 ± 0.05 <sup>f</sup>	6.0 ± 0.05 <sup>f</sup>
97% WF: 3% SML	5.1 ± 0.22 <sup>i</sup>	4.8 ± 0.25 <sup>h</sup>	4.9 ± 0.14 <sup>g</sup>	6.1 ± 0.04 <sup>h</sup>	4.9 ± 0.04 <sup>h</sup>	5.0 ± 0.07 <sup>h</sup>
100% WF	8.2 ± 0.12 <sup>a</sup>	8.5 ± 0.21 <sup>a</sup>	7.0 ± 0.31 <sup>a</sup>	7.5 ± 0.07 <sup>a</sup>	8.5 ± 0.07 <sup>a</sup>	8.7 ± 0.04 <sup>a</sup>

Mean values along the same column with different superscripts are significantly different ( $p < 0.05$ ); WF: heat flour; TOL: *Telfairia occidentalis* leaf powder; AVL: *Amaranthus viridis* leaf powder; SML: *Solanum macrocarpon* leaf powder.

leaf powder. The bread samples enriched with amaranth leaf powder were the most preferred among all the vegetables used based on the adjudged preferences of the panellists. In terms of colour, sample enriched with 1% fluted pumpkin was liked very much while the control sample was liked extremely based on hedonic representations. Across all the vegetables used with respect to colour, the sample enriched with fluted pumpkin ranked best even at the different enrichment levels. The flavour of the samples significantly decreased ( $p < 0.05$ ) with increasing inclusion. The samples enriched with African eggplant had the highest preference among all the vegetables used for processing. Also, the texture, appearance, and acceptance of the samples significantly decreased ( $p < 0.05$ ) with increase in enrichment levels. The bread sample enriched with 1% fluted pumpkin had the highest preference based on these sensory attributes. The samples enriched with fluted pumpkin had the highest preference among the vegetables used. In terms of overall acceptability, the bread samples enriched with between 1 and 2% vegetable leaf powders were acceptable to the consumers while the samples with 3% inclusion level were neither liked nor disliked. This could be because of the newness of such inclusion in a staple food like bread in the country as most people are not used or accustomed to the consumption of green bread in the country. The results from this work indicate the feasibility of adding green leafy vegetable powders to bread and as enrichment agents.

#### 4. Conclusion

The enrichment of bread with either fluted pumpkin, African eggplant, or amaranth resulted in increase in proximate, mineral, and antioxidant contents of the enriched bread. Bread enriched with vegetables was acceptable at low inclusion levels (1-2%) by consumers that are fit to eat bread no matter the age group. The acceptability of bread samples with higher inclusion level(s) would only be possible with a lot of awareness creation about the health potentials. This work emphasized the possibility of enriching bread with green leafy vegetables highlighted.

#### Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this research work.

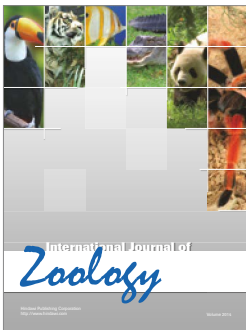
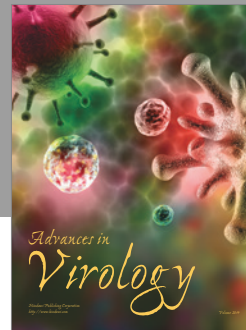
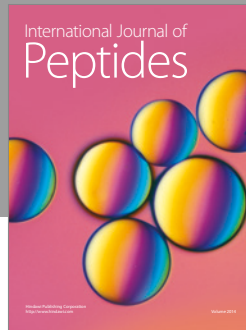
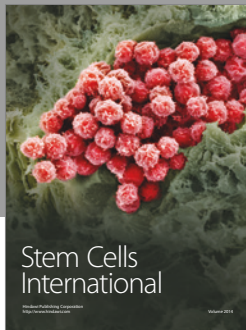
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