Evaluation of the Nutrients, Anti-nutrients and Anti-oxidant activities of Leafy Vegetable Powders Fortified "Danwake" (A Northern Nigerian Cassava- Cowpea Dumpling).

Abstract

Danwake is cassava-cowpea flour with baobab leaf powder based dumpling a common meal for the lower income people of Northern Nigeria. In this study, attempts were made to compare danwake produced 10g eight hitherto leafy powders or their combination (5g+5g) with traditional baobab powder were used to fortify randomized cassava-cowpea (70:30) in a completely linear and interactive experimental design. Standard procedure were used to evaluate the proximate, mineral, phytonutrient, vitamin Aand C and the antioxidant activity of the cooked danwake using a total of 15 raw formulations (8 linear and 7 interactive runs). Moisture, crude protein, total ash, crude fat, crude fiber and carbohydrate contents varied significantly in both the linear and interactive outcomes as follows (29-49.80%; 21.91-68.52%; 3.33-6.17%; 6.480-11.74%; 2.177-4.633, 2.467-4.467%; 0.420-0.657%,0.350-0.500%; 1.850-5.210%; 3.43-6.76% and 34.24-58.43%, 9.307-64.11%). Potassium was the dominant element of all greater in the linear outcome (1716-1258mg/100g) than in the interactive outcome (1400.69-101mg/100g) because of the addition of potash, iron, zinc, copper and manganese level were low in both outcomes. Phytate and oxalate content were higher in the interactive outcome than the linear 209.1-230.0 mg/100g, 206.2-273.01mg/100g and 0.040-0.545%, 0.014-0.240% respectively. While total flavonoids and phenolic compounds were observed to be greater in the linear outcome respectively (145.7-200.04 mg/QE/100g and 326.0-836.8mgGAE/100g). Combined leafy powders produced danwake with greater vitamin C (6.455-8.331mg/100g) and vitamin A (0.027-0.490µg/100g) but comparable radical scavenging activity (81.10-116.99%). In general vegetable powders from mint, celery, parsley, moringa among others produced danwake with greater nutritional values and antioxidant activity and are recommended for use in danwake preparation.

Keywords: Danwake, Leafy vegetables, Minerals, Vitamins, Antioxidant activity, Phytonutrients.

Introduction

'Danwake,' which translates to "the son of bean," is a traditional firm dumpling widely enjoyed in Northern Nigeria, and its roots can be traced back to the Nupe people in Niger and Kogi States respectively. Originally made from cowpea (*V. unguiculata*) flour the dough incorporates powdered baobab leaf *(A. digitata)* with a mixture of trona, also known as *"kanwa,"* or sodium sesquicarbonate and water. The resulting dough is shaped into small balls, which are then boiled for 15 to 20 minutes in boiling water. Stirring consistently with a perforated spatula is crucial during the cooking process to prevent the dumplings from sticking together. The cooked balls are strained, then immersed in a bowl of water to minimize their slimy texture. *Danwake* is typically enjoyed with a mixture of ground chili pepper (yaji), salt, seasoning cube, and vegetable oil. It can be savored at any time of the day, although it is commonly consumed as a breakfast dish. However, nowdays, *danwake* is prepared from blends of flours made from sorghum and beans, wheat and beans, and cassava and beans alongside the addition of powdered baobab leaf and solutions of sodium sesquicarbonate, sometimes known as "*kanwa"* or trona and consumed with boiled egg, lettuce, cabbage, tomatoes, onions and lime juice. Bambara groundnut is integrated into the composition of danwake flour, either as a replacement for beans or in combination with them. The inclusion of trona is thought to decrease flatulence and simplify the cooking process of the beans. The selection of cereal grains used in *danwake* production is influenced by personal preferences and the accessibility of the preferred flour.

The need to explore the leafy greens for *danwake* preparation implies benefiting from arrang of health promoting agents in these greens. In era of globalization, local foods needs to be expose to the wider markets and greater number of consumers, this implies modifiying its preparation, packaging, apart from fortification with hitherto unused leafy greens. Powdered leafy greens are underrated as rich sources of protein and other macro and micro nutrient, however it is known the processing by drying and processing into powders enhances the existing constituents especially protein, minerals and vitamins.

The current emphasis of consumption of dietary fiber rich foods can only be met by regular and adequate consumption of leafy greens which are rich source of both soluble and insoluble dietary fiber. The importance of dietary in nutrition and wellness cannot be over stressed.

2.0 Materials and Methods

2.1 Source of Materials and Preliminary Handling

The ingredients utilized in the preparation of danwake included cowpea grain, dried cassava tuber, and various green leafy vegetables such as baobab (*Adansonia digitata L*), drumstick (*Moringa oleifera*), false sesame (*Ceratotheca sesamoides Endl*), parsley (*Petroselinum crispum*), spring onions (*Allium fistulosum*), celery (*Apium graveolens L*), mint leaf (*Mentha piperita L*), jute leaf (*Corchorus spp.)*, and trona (*sodium sesquicarbonate or kanwa*). These components were procured in bulk from the Gomboru Market Maiduguri in Borno State, Nigeria. The processing of the samples took place at the Department of Food Science and Technology Food Processing Laboratory, University of Maiduguri, Borno State, Nigeria. The raw materials were transformed into a powdered form and stored in airtight containers at room temperature for subsequent analysis. The chemicals and regents used were assumed of analytical grade.

2.2 Production of Cowpea into Flour

The Biu brown cowpea grains were transformed into flour following the procedure outlined by Masaya *et al*.,[1]. Initially, the cowpea grains (Biu brown) underwent cleaning, a 5-10 minute soaking in clean water, and subsequent decortication using a pestle and mortar. Afterward, they were washed and sun-dried before being milled using an attrition mill. The resulting product was then sieved through a 300µm sieve to achieve a fine flour. The flour was stored in plastic buckets, tightly covered, and placed in cardboard at room temperature.

2.3 Preparation of Vegetables

Fresh leafy green vegetables underwent a transformation into powder using a method outlined by Arasaretnam *et al*., [2], with slight adjustments as depicted in Figure 2. The edible parts of the plants were meticulously cleaned under running tap water and then further rinsed with distilled water. Subsequently, they were separated from the stems, diced, and shade dried for a period ranging from 72 to 120 hours until complete dehydration. The resulting dried samples were then finely ground into powder using a blender (Model: GK 240, UK) and stored in airtight containers for future utilization.

2.4 Preparation of *Danwake* Samples

Danwake samples were produced in the Food Processing Laboratory of the Department of Food Science and Technology, adhering to the methodology outlined by Dairra *et al*., [3], illustrated in Figure 1. A mixture of 500 g of danwake flour/blends and 600 ml of potash water was manually combined in plastic containers to form a dough. The dough was shaped into small 10g balls and immersed in boiling water within cooking pots, undergoing a cooking time of 15 to 30 minutes until reaching doneness. Throughout the cooking process, occasional stirring with a perforated metal spatula was employed to prevent the balls from sticking together. Subsequently, the cooked balls were placed in water, drained using a strainer.

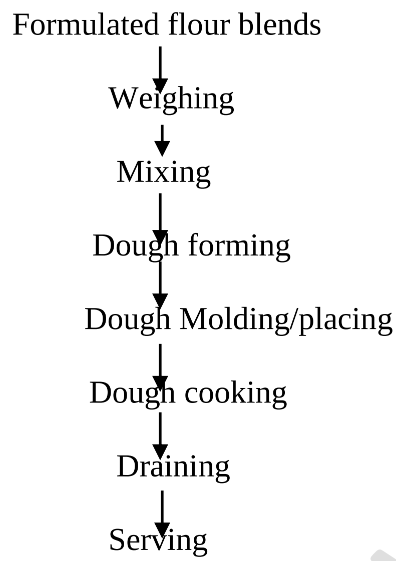

Figure 1: Flow Chart for the Production of *Danwake*

Source: Dairra *et al*., [3].

2.5 Experimental Design

The method described by [4] was adapoted for the experimental design for this study. A single factor completely randomized linear experiment of the form: $Y = \beta o + \beta ixi + E$ was used to evaluate the main effects of the vegetable powders (xi) the process variables on the response variable (Yi), βo and E represent the intercept and error term. Also the interactive effects (xij) of the 1:1 combination of the baobab and other vegetable powders was evaluated it is of the form $Y = \beta o + \beta_i x_i + \beta_{ij} x_{ij} + E$ giving fifteen (15) experimental units in all. Xi represent the vegetables powder. Boabab leaf powder enriched formulation served as the experimental control.

2.6 Proximate composition

The samples were analyzed for the proximate composition (moisture, crude protein, total ash, total lipids, crude fiber using the established procedures of [5]. Carbohydrate was determined by difference and calorific values were calculated as shown below. Moisture contents were determined by drying the samples at 150ºC for 1h, Protein contents (% N x 6.25) were determined by the micro-Kjedahl method. Crude fat were determined using solvent extraction in a Soxhlet apparatus with petroleum ether (boiling point: 40 - 60ºC). The ash contents were determined by dry ashing in a muffle furnace at 550°C, 5 h. Dietary fiber was determined using alternate digestion of 1g sample with dilute sulphuric acid (1.25%) and dilute sodium hydroxide (1.25%)solutions, washing, drying and finally ashing in a muffle furnace, 550°C, 5 h.

2.7 Determination of Mineral Content

A sample (3 g) was weighed into a crucible was subjected to ashing in furnace for 6 hour at 500°C. After cooling in desiccator, 2.5 mL of 6N HNO_3 was added to the crucible and heated gently on a hot plate until brown fumes disappeared. To the remaining material in each crucible, 5.0 ml of de ionized water was added and heated until a colorless solution was obtained. The mineral solution in each crucible was transferred into a 100.0 ml volumetric flask by filtration through filter paper and the volume was made to the mark with de ionized water following the method described by [6]. The samples were analyzed for Ca, Mg, Na, K, and Fe. Mg, Na, K and Fe which were determined using Atomic Absorption Spectrophotometer (VGP 210, Buck Scientific, Italy).

2.8.0 Phytochemical Analysis

2.8.1 Determination of Tannins

The Folin-Denis colorimetric procedure, as outlined by [7], was employed. Five gram (5g) sample was dispersed in 50 mL of distilled water and agitated. This mixture was left at room temperature for 30 minutes with intermittent shaking every 5 minutes. Following this, centrifugation was conducted to acquire an extract. Subsequently, 2 mL of the extract was transferred to a 50 mL volumetric flask. Simultaneously, another 50 mL volumetric flask containing 2 mL of standard tannin solution (tannic acid) and 2 mL of distilled water as a standard was prepared. In each flask, 1.0 mL of Folin-Denis reagent was added. Next, 2.5 mL of saturated sodium carbonate solution was introduced. The contents of each flask were adjusted to 50 mL with distilled water and allowed to incubate for 90 minutes at room temperature. The respective absorbance was measured at 260 nm using a spectrophotometer, employing a reagent blank, and the instrument was zero-calibrated. The tannin content was calculated as follows;

$$\%\ \text{tannin} = \frac{An}{W} \times \frac{C}{Va} \times \frac{Vf}{1} \times \frac{100}{1}$$

Where;

An = absorbance of test sample

C = concentration of standard solution

Va = volume of extract analyzed

W = weight of sample used

Vf = total volume of extract

2.8.2 Determination of Oxalate Content

The titration procedure outlined by [8] was employed. One gram (1g) of the sample was carefully weighed and placed in a 100 ml Erlenmeyer flask, followed by the addition of 75 ml of 3 M H_2SO_4. The mixture was stirred for one hour using a magnetic stirrer, and the resulting solution was then filtered through Whatman #1 filter paper. Subsequently, 25 mL of the filtrate was withdrawn and subjected to a hot titration against a 0.05 M $KMnO_4$ solution until the pink color persisted for at least 30 seconds. The oxalate content was determined based on the fact that 1 ml of 0.05 M $KMnO_4$ corresponds to 2.2 mg of oxalate.

2.8.3 Total Phenolic Content (TPC)

The total phenolic content was determined spectrophotometrically according to the described method by [9]. Two grams (2g) of the sample were ground with 30 ml of methanol in a mortar and pestle. Subsequently, 50 ml of methanol was added, thoroughly mixed, and then centrifuged to obtain a clear supernatant. A 0.2 mL aliquot of the methanol extract was combined with 1 mL of Folin-Ciocalteau reagent (10-fold dilution), followed by the addition of 0.8 mL of 2% Na2CO3. The volume was adjusted to 10 ml using a 4:6 water/methanol mixture. The solution was left to stand for 30 minutes, and the absorbance at 754 nm was measured using a spectrophotometer. Concentrations were determined using gallic acid as a standard, and the results were expressed as mg gallic acid equivalent per 100 g wet weight.

2.8.4 Determination of Total Flavonoid Content

The method for assessing the total flavonoid content was carried out as outlined by Meda *et al*., [10]. In this procedure, 0.5 mL of methanol extract was combined with equal volumes of methanol, AlCl3 solution (10%, w/v), potassium acetate solution (1 M), and distilled water (2 mL). The resulting mixture underwent a 30-minute incubation at room temperature. Subsequently, the absorbance was measured at 415 nm using a spectrophotometer from PG Instruments, England. The quantification of total flavonoids was accomplished by employing a calibration curve with quercetin (0.1 mg/mL) as the standard.

2.8.5 Determination of Phytate Content

The technique outlined by Anhwange *et al*. [11] was employed for the determination of phytate levels. Four grams (4 g) sample of powder was immersed in 100 cm^3 of 2% hydrochloric acid (HCl) v/v for 3 hours and then filtered. To 25 cm^3 of the resulting filtrate in an Erlenmeyer flask, 5 cm^3 of a 0.3% ammonium thiocyanate solution and 53.5 cm^3 of distilled water were added, thoroughly mixed, and diluted with standard $FeCl_3$ (containing 0.00195 g Fe^{3+}/cm^3) until a brownish-yellow tint appeared during titration. A parallel titration was conducted for the blank, and 1 cm^3 equivalent to 1.19 mg of phytic phosphorus was measured. This value was then multiplied by a factor of 3.55 to determine the phytate content.

2.9 Antioxidant Activity

Antioxidant activity of the samples were determined using DPPH assay as described by Azim Almey *et al*. [12] with slight modifications. Sample stock solutions (1 mg/mL) were diluted with ascorbic acid to concentrations of 0, 10, 50, 75, 100, 150, 200, 300, and 400 μg/mL. A DPPH solution (2 mL) was added to 1 mL of the sample solution at each concentration, allowed to stand for 30 minutes, and absorbance at a wavelength of 517 nm was measured. Controls were prepared by mixing 1 mL of methanol and 2 mL of DPPH solution, and ascorbic acid was used as the standard. Antioxidant capacity based on the DPPH free radical scavenging ability of sample was calculated using the following equation:

$$\% RSA = \frac{Ac - As}{Ac} \times 100$$

Ac= Absorbance of control
As= Absorbance of sample
Ac= Absorbance of control

2.10 Vitamin Analysis

2.10.1 Determination of Vitamin A (Retinol)

A specific quantity (1 gram) of the specimen was measured and crushed in a test tube alongside 20 mL of N-hexane for a duration of 10 minutes. Afterward, 3 mL of the resulting upper hexane extract was duplicated and transferred to dry test tubes, where it was evaporated until dry. Following this, 0.2 mL of acetic anhydride-chloroform reagent and 2 mL of 50% trichloroacetic acid (TCA) in chloroform were introduced. The absorbance was then recorded at 620 nm at 15 and 30-second intervals. [13].

2.10.2 Determination of Vitamin C (Ascorbic acid)

About 0.5 grams of the specimen were measured and crushed in a test tube containing 10 milliliters of a 0.4% solution of oxalic acid for a duration of 10 minutes. The mixture underwent centrifugation for 5 minutes, followed by filtration. A volume of 1 milliliter from the filtered solution was moved to a dry test tube, and 9 milliliters of 2,6-dichlorophenol-indophenol were introduced. Absorbance readings at 520 nm were taken at 15 and 30-second intervals. [13].

2.11 Statistical Analysis

Data generated on the responses was subjected to analysis of variance (ANOVA) using SPSS version 20, means was separated by Duncan multiple range test and Significance will be accepted at 5% probability (α = $p<0.05$) correlational analysis between parameters was established.

Results and Discussion

3.1: Proximate Composition(g/100g) of Leafy Powder Fortified Cassava-Cowpea (70:30) Blend Danwake (cooked)

The proximate composition of the cooked danwake are given in **Table 1.** The moisture, protein, ash, fat, fiber and carbohydrate contents varied significantly ($p \leq 0.05$) from 29.09-49.80, 3.303-6.170, 2.177-4.633, 0.420-0.753, 1.860-5.210, 34.24- 58.43 g/100g respectively for the linear outcome of the experiment. Formulations CvCps, CvCps, CvCpm, CvCpf and CvCpj had higher moisture contents that were significantly not different while lower amounts were found in parsley, celery and false-sesame enriched danwake and with greater carbohydrate contents. The combined effects of baobab and other leafy powders were noted in greater amount of nutritional values, higher moisture content were seen in CvCpbp (68.52%), CvCpbc (57.18%), CvCpbt (48.70%) and lower values in CvCpbm (29.57%) and CvCpbf (21.91%). Formulations CvCpc (3.303%), CvCpf (0.420g/100g) and CvCpj (1.860g/100g) had lower levels of protein, fat and crude fiber respectively. Except CvCpp and CvCpm, others had protein contents between 3.3 and 3.9g/100g for the linear outcome. Higher ash content was noted in formulation CvCpt (4.633g/100g) and least value in CvCpp (2.177g/100g) while CvCpp had the highest carbohydrate (56.60g/100g) and CvCpm the least value (34.24g/100g). The results observed were in agreement with the findings of [14] on the nutrient improvement and sensory evaluation of "danwake"- a cassava based snack.

There were significant increase in the nutrients except carbohydrate in the cooked danwake as a result of complementation of two leafy powders ($Y=\beta_o+\beta_i x_i+ \beta_{ij} x_{ij}+ E$) compared to the control. Higher moisture and ash contents were obtained in formulation CvCpbp 68.52 and 4.467g/100g and lower values in CvCpbf 21.91 and 2.467g/100g respectively. There were increase in crude protein content in all formulations notably CvCpbm (11.74%), CvCpbc (10.63%), CvCpbp (10.61%). Formulation CvCpbm had the highest protein content (11.74g/100g) and least value in formulation CvCpbj (6.480g/100g). Higher fat and carbohydrate content were observed in formulations CvCpbf (0.500 and 64.11g/100g) and lower values in formulation CvCpbc (0.350g/100g) and CvCpbp (9.307g/100g) respectively. Formulation containing CvCpbf had the highest crude fiber (6.76g/100g) and formulation CvCpbj (3.43g/100g) with least value respectively. The level of crude fiber in both foods and plants signifies the proportion of complex carbohydrate such as lignin that cannot be digested. A substantial dietary fiber intake is said to facilitate the elimination of carcinogens, potential mutagens, steroids, bile acids, and xenobiotics. This occurs either by binding to fiber components or through absorption and prompt excretion. Consequently, these waste substances contribute to the well-being of both ruminants and non-ruminants. According to [15], the ash content serves as a crucial indicator for evaluating the nutritional quality of foods as it reflects the overall mineral composition of the food items as well as level of refining/processing. The observed increase in nutrient content of the cooked danwake were in the same trend with that reported by [16] on the chemical composition and quality characteristics of wheat bread supplemented with leafy vegetable powders.

Table 1: Proximate Composition (g/100g) of Leafy Powder Fortified Cassava-Cowpea Danwake (cooked)

Formulations	Moisture	Crude Protein	Total Ash	Crude Fat	Crude Fiber	Carbohydrate
Linear(Y=βo+βixi + E)						
CvCpb(Control)	43.78±2.11^{b}	3.850±0.02^{b}	3.170±0.04^{e}	0.657±0.04^{b}	2.097±0.44^{cd}	46.45±2.24^{b}
CvCpm	49.80±2.40^{a}	6.170±0.55^{a}	3.510±0.00^{c}	0.753±0.02^{a}	5.210±0.03^{a}	34.56±2.00^{d}
CvCpf	49.57±4.70^{a}	3.980±0.27^{b}	2.340±0.01^{g}	0.420±0.02^{d}	3.737±0.15^{b}	39.95±4.84^{c}
CvCpj	49.14±3.93^{a}	3.843±0.14^{b}	2.960±0.04^{f}	0.450±0.00^{d}	1.860±0.16^{d}	41.75±3.81^{bc}
CvCps	50.34±3.54^{a}	3.817±0.01^{bc}	3.260±0.00^{d}	0.437±0.01^{d}	2.077±0.18^{cd}	40.07±3.70^{c}
CvCpt	29.09±1.87^{c}	3.367±0.01^{cd}	4.633±0.05^{a}	0.433±0.04^{d}	4.043±0.14^{b}	58.43±1.71^{a}
CvCpc	30.05±0.64^{c}	3.303±0.01^{d}	4.240±0.05^{b}	0.423±0.04^{d}	3.727±0.13^{b}	58.26±0.83^{a}
CvCpp	32.25±1.07^{c}	6.010±0.39^{a}	2.177±0.03^{h}	0.580±0.00^{c}	2.283±0.06^{c}	56.60±1.48^{a}
Interative(Y=βo+$\beta_i x_i$+ $\beta_{ij} x_{ij}$+ E)						
CvCpbm	29.57±1.37^{e}	11.74±0.45^{a}	3.683±0.04^{c}	0.490±0.00^{ab}	3.77±0.13^{c}	50.75±1.00^{b}
CvCpbf	21.91±1.07^{f}	6.607±0.52^{d}	2.467±0.03^{f}	0.500±0.00^{a}	4.41±0.33^{b}	64.11±1.24^{a}
CvCpbj	40.81±0.55^{d}	6.480±0.39^{d}	3.150±0.03^{c}	0.460±0.00^{c}	6.76±0.03^{a}	42.34±0.63^{c}
CvCpbs	42.50±3.18^{d}	8.897±0.48^{c}	4.123±0.04^{b}	0.470±0.00^{bc}	3.43±0.31^{c}	40.58±3.32^{c}
CvCpbt	48.70±1.21^{c}	9.160±0.15^{c}	2.840±0.03^{e}	0.480±0.00^{abc}	3.59±0.27^{c}	35.23±1.45^{d}
CvCpbc	57.18±6.70^{b}	10.63±0.34^{b}	4.093±0.10^{b}	0.350±0.03^{d}	3.57±0.10^{c}	24.18±2.59^{e}
CvCpbp	68.52±0.02^{a}	10.61±0.52^{b}	4.467±0.05^{a}	0.370±0.02^{d}	3.55±0.30^{c}	12.48±0.12^{f}

Values are standard deviations of three determinations. In any column, means bearing similar superscripts are not significantly different ($p \geq 0.05$);

Cassava (Cv) and Cowpea (Cp) in the ratio of 70:30;

CvCp (70:30): Ten gram (10g) each of Baobab(b); Moringa(m); False-sesame(f); Jute(j); Spring onions(s); Mint(t); Celery(c); Parsely(p) added;

CvCp (70:30): Ten gram (5g+5g) each boabab:moringa(bm); boabab:false-sesame(bf); baobab:jute(bj); baobab:spring onions(bs); baobab:mint(bt); baobab:celery(bc); baobab:parsley(bp) added.

3.2: Mineral Composition (mg/100g) of Leafy Powder Fortified Cassava-Cowpea (70:30) Danwake.

There were significant reduction on the mineral levels of cooked danwake compared with raw formulation due to enhanced water content of the cooked danwake. However, moringa and baobab leaf powders fortified danwake contained higher levels of minerals than other formulations **Table 2.** In the linear outcome of the experiment the minerals varied as follows; Na 4.317-7.560mg/100g, Ca 33.87-376mg/100g, K 12581-1716.44mg/100g, P 53.38-409.5mg/100g, Mg 11.62-21.84mg/100g, Fe 0.193-0.367mg/100g, Zn 0.533-0.993mg/100g, Cu 0.00-0.195mg/100g and Mn 0.107-0.237mg/100g. The control danwake had greater Na and Ca, moringa fortified danwake had greater P, Mg, Fe, Zn and Mn. Potassium is the dominant element.

In the interactive outcome, linear levels of Ca, P, Mg, Fe and Zn were observed and significantly varied. [17] on nutritional quality of plant foods and [18] on effects of sun and shade drying on nutrient qualities of six seasonal green leafy vegetables used in soups and dishes in Taraba State observed a similar phenomenon to the findings in this study, indicating a reduction in iron content during processing. The iron values obtained in this research align with those reported by [19] in their study on the impact of blanching and drying on micronutrients in selected green leafy vegetables consumed in Tiv community, Benue State, Nigeria. Notably, there was a significant increase in potassium content in the cooked danwake, possibly attributed to the addition of potash water during dough formation. Sodium and potassium play crucial roles as intracellular and extracellular cations, respectively, contributing to the regulation of plasma volume, acid-base balance, and nerve and muscle contraction [20]. However, lower Na is desired for healthy cardiovascular. As for magnesium, this mineral is recognized for preventing various health issues such as cardiomyopathy, muscle degeneration, growth retardation, alopecia, dermatitis, immune dysfunction, gonadal atrophy, spermatogenesis disorders, congenital malformations, and bleeding disorders (Chaturvedi *et al*., [21]. [22] highlight the diverse biochemical roles of iron in the body, serving as an essential component in oxygen-carrying hemoglobin and acting as a vital catalytic center in numerous enzymes, including cytochrome oxidase.

Table 2: Mineral Composition (mg/100g) of Leafy Powder Fortified Cassava-Cowpea (70:30) Blend Danwake (cooked)

Formulation	Na	Ca	K	P	Mg	Fe	Zn	Cu	Mn
Linear(Y=βo+βixi + E)									
CvCpb(Control)	7.560 ± 0.05^{a}	376.2 ± 0.00^{a}	11270.5 ± 58.8^{b}	65.45 ± 1.11^{f}	13.33 ± 0.19^{bc}	0.220 ± 0.00^{cd}	0.607 ± 0.01^{bc}	0.140 ± 0.00^{e}	0.140 ± 0.00^{e}
CvCpm	6.730 ± 0.05^{abc}	231.7 ± 3.29^{b}	12581 ± 198^{a}	409.5 ± 3.74^{a}	21.84 ± 0.31^{a}	0.367 ± 0.01^{a}	0.993 ± 0.01^{a}	0.150 ± 0.00^{b}	0.161 ± 0.00^{d}
CvCpf	4.317 ± 1.43^{e}	40.02 ± 10.4^{e}	8554.9 ± 119.9^{c}	76.67 ± 0.00^{e}	16.37 ± 5.67^{abc}	0.273 ± 0.09^{bc}	0.743 ± 0.25^{bcd}	0.195 ± 0.00^{a}	0.178 ± 0.00^{c}
CvCpj	6.090 ± 2.04^{abcd}	53.43 ± 16.1^{de}	2676.6 ± 37.5^{d}	53.38 ± 6.87^{g}	11.62 ± 4.03^{c}	0.193 ± 0.06^{c}	0.533 ± 0.18^{e}	0.000 ± 0.00^{h}	0.117 ± 0.00^{f}
CvCps	6.880 ± 0.05^{ab}	206.3 ± 2.93^{c}	2558.77 ± 13.4^{d}	71.92 ± 1.22^{e}	14.77 ± 0.00^{bc}	0.250 ± 0.00^{bcd}	0.670 ± 0.00^{cde}	0.088 ± 0.00^{g}	0.114 ± 0.01^{g}
CvCpt	5.653 ± 0.04^{bcde}	56.31 ± 0.79^{d}	2089.9 ± 32.9^{e}	84.45 ± 0.70^{d}	17.82 ± 0.25^{abc}	0.297 ± 0.01^{ab}	0.813 ± 0.01^{abc}	0.110 ± 0.00^{f}	0.237 ± 0.00^{a}
CvCpc	5.257 ± 0.03^{cde}	33.87 ± 4.91^{f}	1955.72 ± 10.2^{e}	94.09 ± 1.59^{c}	19.16 ± 0.27^{b}	0.317 ± 0.01^{ab}	0.873 ± 0.01^{ab}	0.147 ± 0.00^{c}	0.107 ± 0.00^{h}
CvCpp	4.617 ± 0.03^{de}	37.95 ± 4.80^{ef}	1716.44 ± 8.95^{f}	103.5 ± 0.86^{b}	14.97 ± 0.21^{abc}	0.250 ± 0.00^{bcd}	0.683 ± 0.01^{bcde}	0.143 ± 0.00^{d}	0.202 ± 0.00^{b}
Interative($Y=\beta o+\beta_i x_i+ \beta_{ij}x_{ij}+ E$)									
CvCpbm	6.127 ± 0.04^{a}	479.06 ± 13.9^{a}	10199.2 ± 160.6^{a}	131.4 ± 2.22^{a}	26.98 ± 0.00^{a}	0.477 ± 0.01^{a}	1.230 ± 0.00^{a}	0.052 ± 0.00^{f}	0.199 ± 0.00^{c}
CvCpbf	6.010 ± 0.04^{a}	30.67 ± 0.09^{d}	10064.8 ± 52.5^{b}	82.31 ± 1.39^{d}	16.76 ± 0.24^{d}	0.293 ± 0.03^{d}	0.763 ± 0.01^{e}	0.104 ± 0.00^{c}	0.100 ± 0.00^{d}
CvCpbj	4.677 ± 0.03^{b}	25.54 ± 0.06^{e}	7830.8 ± 40.9^{c}	80.74 ± 1.37^{d}	21.54 ± 0.31^{c}	0.357 ± 0.01^{c}	0.983 ± 0.01^{cd}	0.149 ± 0.00^{a}	0.284 ± 0.00^{a}
CvCpbs	4.013 ± 0.03^{c}	140.7 ± 11.9^{b}	1493.62 ± 7.79^{e}	102.1 ± 0.85^{c}	16.44 ± 0.24^{d}	0.417 ± 0.01^{b}	0.753 ± 0.01^{e}	0.105 ± 0.00^{b}	0.221 ± 0.00^{b}
CvCpbt	4.807 ± 0.03^{b}	31.57 ± 1.71^{d}	1776.5 ± 28.0^{d}	99.35 ± 0.83^{c}	21.14 ± 0.00^{d}	0.350 ± 0.00^{c}	0.960 ± 0.00^{d}	0.063 ± 0.00^{e}	0.080 ± 0.00^{g}
CvCpbc	3.257 ± 0.29^{e}	39.61 ± 0.86^{c}	1405.35 ± 5.03^{e}	129.2 ± 1.56^{a}	25.70 ± 0.14^{b}	0.357 ± 0.45^{c}	1.020 ± 0.08^{c}	0.081 ± 0.00^{d}	0.089 ± 0.00^{f}
CvCpbp	3.767 ± 0.02^{d}	42.32 ± 2.12^{c}	1400.69 ± 7.31^{e}	123.2 ± 2.09^{b}	25.09 ± 0.36^{b}	0.450 ± 0.00^{ab}	1.140 ± 0.02^{b}	0.041 ± 0.00^{g}	0.095 ± 0.00^{e}

Values are means ± standard deviations of three determinations. In any column, means bearing similar superscripts are not significantly different ($p \geq 0.5$);

Na=Sodium;Ca=Calcium;K=Potassium;P=Phorsphrous;Mg=Magnesium;Fe=Iron;Zn=Zinc;Cu=Copper;Mn=Manganse

Cassava (Cv) and Cowpea (Cp) in the ratio of 70:30;

CvCp (70:30) fortified with 10g of each leafy powders: Baobab(b); Moringa(m); False-sesame(f); Jute(j); Spring onions(s); Mint(t); Celery(c); Parsely(p)

CvCp (70:30) fortified with 5g of baobab and 5g other leafy powder:boabab:moringa(bm); boabab:false-sesame(bf); baobab:jute(bj); baobab:spring onions(bs); baobab:mint(bt); baobab:celery(bc); baobab:parsley(bp)

3.3: Phytonutrient Composition of Leafy Powder Fortified Cassava-Cowpea (70:30) Danwake (cooked)

The phytonutrient contents declined in the cooked danwake compared to the raw formulations **Table 3**. The values ranged from 145.7-200.4mgQE/100g, 0.019-0.425%, 209.1-230mg/100g, 335.5- 386.8mgGAE/100g and 0.014-2.808% for total flavonoid, tannin, phytate, total phenolic and oxalate content for the linear response respectively. The control CvCpb had the higher level of phytonutrients in tannin 0.425%, phytate 227.9mg/100g. Formulation containing CvCpt had the highest total flavonoid (200.4 mgQE/100g), total phenolic (386.8 mgGAE/100g) and phytate content (230 mg/100g) and least values in the control CvCpb (145.7 mgQE/100g) for total flavonoids, CvCpp (209.1 mg/100g) for phytate and CvCpm for total phenolic (326.0 mgGAE/100g).

The interactive outcome ($Y=\beta o+\beta_i x_i+ \beta_{ij}x_{ij}+ E$) of the experiment indicated CvCpbt had the highest total flavonoid and total phenolic (129.4 mgQE/100g and 315.8 mgQE/100g) and the least values were observed in CvCpbm (84.97 mgQE/100g) and in CvCpbc (258.7 mgQE/100g). The level of flavonoids, tannins, phenolics obtained were lower when baobab and one other leafy powder was combined to fortifty CvCp(70:30). Higher tannin content was seen in formulation CvCpbs (0.123%) and least value in formulation CvCpbm (0.027%). While CvCpbt (0.537%) recorded the highest oxalate and CvCpbs (0.004%) with the least. Phytate found in plant-based raw materials and foods is recoygnized as a significant factor that diminishes the accessibility of minerals and certain proteins [23]. Phytate forms complexes with minerals in the digestive tract, hindering the body's ability to absorb and utilize these essential nutrients [24]; Melaku *et al*., [25]. Consequently, reducing phytate levels is anticipated to enhance the bioavailability of these minerals (Anuonye *et al*., [26].

The findings of the study align with those of Samuel *et al*. [27], who observed that increasing the quantity of soybean flour in bread leads to a higher tannin content. Tannins negatively impact iron absorption, influence cation excretion, and elevate protein and essential amino acid excretion, thereby causing harm to the intestinal tract, impeding growth, and fostering carcinogenesis (Anuonye *et al.,* [26]. [28] also noted that the presence of tannins in both fresh and processed foods can result in browning and other pigmentation issues.

Table 3: Anti-nutrient Composition of Leafy Powder Fortified Cassava-Cowpea (70:30) Blend Danwake (cooked)

Formulation	TotalFlavonoids (mgQuercetin/100g)	Tannins (%)	Phytate (mg/100g)	TotalPhenolic (mgGAE/100g)	Oxalate (%)
Linear(Y=βo+βixi + E)					
CvCpb(Control)	145.7±0.86^{f}	0.425±0.02^{a}	227.9±1.85^{ab}	343.3±0.04^{cd}	0.014±0.00^{h}
CvCpm	190.1±1.31^{b}	0.019±0.01^{g}	220.9±1.80^{d}	326.0±16.6^{c}	0.022±0.00^{f}
CvCpf	148.9±0.54^{e}	0.224±0.00^{c}	226.7±0.49^{bc}	343.9±0.03^{cd}	0.217±0.01^{c}
CvCpj	146.7±0.89^{f}	0.226±0.00^{b}	225.2±1.83^{c}	335.5±13.2^{cd}	0.015±0.00^{g}
CvCps	145.6±0.88^{f}	0.029±0.00^{e}	217.9±1.77^{e}	342.1±0.02^{cd}	0.128±0.01^{a}
CvCpt	200.4±0.02^{a}	0.199±0.00^{d}	230±0.00^{a}	386.8±0.24^{a}	0.240±0.00^{b}
CvCpc	166.0±1.26^{d}	0.212±0.00^{c}	215.6±1.55^{e}	367.7±16.4^{b}	0.191±0.00^{d}
CvCpp	170.8±1.04^{e}	0.224±0.00^{c}	209.1±1.67^{f}	353.4±15.3^{bc}	0.080±0.00^{e}
Interative($Y=\beta o+\beta_i x_i+\beta_{ij} x_{ij}+E$)					
CvCpbm	84.97±0.49^{d}	0.027±0.00^{g}	271.0±2.21^{a}	274.4±1.65^{c}	0.061±0.00^{d}
CvCpbf	95.01±4.49^{c}	0.032±0.00^{f}	206.2±0.00^{e}	273.5±3.30^{c}	0.043±0.00^{de}
CvCpbj	87.26±0.52^{d}	0.121±0.00^{c}	238.7±1.94^{d}	274.9±1.35^{c}	0.409±0.00^{c}
CvCpbs	85.95±0.53^{d}	0.123±0.00^{a}	260.4±2.21^{b}	275.2±3.28^{c}	0.004±0.00^{e}
CvCpbt	129.4±0.71^{a}	0.121±0.00^{b}	250.0±2.03^{c}	315.8±1.67^{a}	0.537±0.05^{a}
CvCpbc	97.27±0.65^{c}	0.113±0.00^{d}	265.8±3.90^{ab}	258.7±2.03^{d}	0.545±0.03^{a}
CvCpbp	113.1±1.65^{b}	0.109±0.00^{e}	273.01±10.2^{a}	286.3±6.00^{b}	0.454±0.00^{b}

Values are means ± standard deviations of three determinations. In any column, means bearing similar superscripts are not significantly different ($p \geq 0.05$);

Cassava (Cv) and Cowpea (Cp) in the ratio of 70:30;

CvCp (70:30): fortified with 10g of each leafy powders Baobab(b); Moringa(m); False-sesame(f); Jute(j); Spring onions(s); Mint(t); Celery(c); Parsely(p)

CvCp (70:30): fortified with 5g of each leafy powders boabab:moringa(bm); boabab:false-sesame(bf); baobab:jute(bj); baobab:springonions(bs); baobab:mint(bt); baobab:celery(bc); baobab:parsley(bp)

4: Vitamin A, Vitamin C and the Antioxidant Activities of Leafy Powder Fortified Danwake (cooked)

There were significant decrease in the vitamin content and antioxidant activity of cooked danwake with the values ranging from 0.017-0.857µg/100g, 3.285-6.582mg/100g and 90.96-116.72% for the linear response and 0.027-0.490, 6.455- 9.751 and 78.77-116.99 for the interactive outcome of the experiment for vitamin A, C and anti-oxidant activities respectively **(Table 4)**. In general, formulation containing moringa / baobab powders contained relatively high amount of Vitamin A, C and antioxidant activity. The radical scavenging ability of the cooked danwake indicates that CvCpm (116 µg/100g) had the highest radical scavenging ability compared to the control (102.6 µg/100g). Free radical scavenging activity is measured using DPPH free radical in which antioxidants release hydrogen into food materials to neutralize DPPH (Qiao *et al*., [29]. Antioxidant activities of single leafy powder seemed higher 90.96% than the combined effect of the two different leafy powder 78.77% despite slightly greater vitamin A and C in the danwake fortified with combined leafy powders. According to [30], antioxidants have anti-inflammatory, anti-allergic, and anti-cancer effects. It is well known that vitamin C strengthens the immune system and benefits the skin, eyes, and fetus conditions, and regulate body processes [31]. Provitamin A has been linked to improvements in eyesight, bone formation, reproduction, cell division and differentiation has been previously documented (Igbabul *et al*., [32]. Variations in RSA content have been reported in some veggies originating from several global regions. That may be because cooking methods not only affect the quantity of antioxidant molecules as well as the generation, via heat or chemical processes, of more potent antioxidants that scavenge free radicals (Bajpai *et al*., [33]. Cooking has an impact on antioxidant activity, according to this study. This is due to the fact that various vegetable processing techniques, including freezing, sterilizing, heating, steaming, chopping, drying, and blanching, can alter the amount and makeup of some nutritional antioxidants, such as vitamin C. Families want to incorporate vitamin C into their diets, but this study shows that both the source of vitamin C and the method of preparation are important. Vitamin C is heat-labile and water-soluble, so losses during cooking can be due to extreme temperatures and leaching of the vitamin into the water used to cook the vegetables [34], Olayinka *et al*., [35]. Studies have reported similar comparable vitamin C losses during cooking (Hossain *et al*., [36], [37], Yuan *et al*., [38]. Despite significantly reducing vitamin C levels, they had significant antioxidant activities. A large number of plant secondary metabolites with antioxidant activity have been isolated [39]. These include vitamins A and E, as well as a number of food-derived polycyclic aromatics belonging to the major classes of nutritional antioxidants: stilbenes, flavonoids, and phenolic acids (Sarangarajan *et al*.,[40].

Table 4: Vitamin A, Vitamin C and the Antioxidant Activity of Leafy Powder Fortified Cassava-Cowpea (70:30) Blend Danwake (cooked)

Formulation	Vit A (μg/100g)	Vit C (mg/100g)	Antioxidant Act. (%)
Linear(Y=βo+βixi + E)			
CvCpb(Control)	0.017±0.00^{f}	5.158±0.04^{b}	102.6
CvCpm	0.857±0.03^{a}	6.582±0.01^{a}	116.72
CvCpf	0.013±0.00^{g}	3.285±0.00^{g}	95.97
CvCpj	0.005±0.00^{h}	3.315±0.00^{f}	102.21
CvCps	0.020±0.00^{e}	4.102±0.01^{c}	90.96
CvCpt	0.212±0.00^{b}	3.804±0.02^{e}	114.59
CvCpc	0.030±0.00^{d}	3.894±0.00^{d}	104.31
CvCpp	0.076±0.00^{c}	6.960±0.00^{f}	102.17
Interative($Y=\beta o+\beta_i x_i+\beta_{ij}x_{ij}+E$)			
CvCpbm	0.490±0.02^{a}	9.751±0.01^{a}	116.99
CvCpbf	0.147±0.03^{d}	8.331±0.02^{c}	98.98
CvCpbj	0.027±0.02^{f}	6.455±0.00^{h}	112.26
CvCpbs	0.060±0.01^{e}	6.485±0.00^{g}	78.77
CvCpbt	0.424±0.01^{b}	8.803±0.01^{b}	94.19
CvCpbc	0.135±0.03^{d}	7.272±0.00^{d}	81.10
CvCpbp	0.202±0.00^{c}	7.064±0.00^{e}	92.08

Values are means ± standard deviations of three determinations. In any column, means bearing similar superscripts are not significantly different ($p \geq 0.05$);

Cassava (Cv) and Cowpea (Cp) in the ratio of 70:30;

CvCp (70:30): fortified with 10g of each leafy powders Baobab(b); Moringa(m); False-sesame(f); Jute(j); Spring onions(s); Mint(t); Celery(c); Parsely(p)

CvCp (70:30): fortified with 5g of each leafy powders boabab:moringa(bm); boabab:false-sesame(bf); baobab:jute(bj); baobab:spring onions(bs); baobab:mint(bt); baobab:celery(bc); baobab:parsley(bp)

Conclusion

There were obvious general decrease in the proximate composition, mineral and vitamin contents as well as the antioxidant activity of cooked danwake as a result of water imbibition and leach of nutrients during cooking in both linear and interactive outcomes of the experiment. This calls for modification of cooking method to reduce loss of nutrients. This conclusion is based on higher nutritional value of raw danwake formulation.

References

1. Masaya, F.A., Nkama, I., Gervase, I.A., Danbaba, N and Alkali,Y.M. (2017). Effects of Cowpea, Yeast and Trisodium Hydrogen Dicarbonate Dehydrate $[Na_3CO_3.HCO_3.2H_2O]$ Levels on Proximate and Mineral Composition of Yar’tsala, A Traditional Rice-based Snack of Northern Nigeria. *Archives of current research international*. 10(1):Page1-15.Article no.ACRI.36217.

2. Arasaretnam, S., Kiruthika, A and Mahendran, T. (2017). Nutritional and mineral composition of selected green leafy vegetables. *Ceylon Journal of Science 47(1) 2018:35-41DOI: http://doi.org/10.4038/cjs.v47i1.7484*

3. Diarra, M., Nkama, I., Hamker, B.R and Idrisa, Y.L. (2015). Mineral and Vitamin contents of Danwake from sorghum, wheat and cassava bases. *Journal of Human Nutrition and Food Science.* 3(1): 1054.

4. Dharmaraja, S. and Dipayan, S. (2018). Introduction to Statistical Methods, Design of Experiments and Statistical Quality Control. Department of Mathematics, Indian Institute of Technology Delhi, New Delhi, India. Pp 223-264.
5. AACC American Association of Cereal Chemist (2000). *“Approved methods of the American Association of Cereal Chemist*” 10th Edition, The Association, ST Paul, Minnesota USA.
6. AOAC, (2005). Official Methods of Food Analysis (17th edition). Association of Official Analytical Chemists, Maryland.
7. Kirk, H and Sawyer, R. (1998). Frait Pearson Chemical Analysis of Food. 8th edition. Longman Scientific and Technical. Edinburgh., 211-212.
8. Day R.A and Underwood A.L. (1986). Quantitative Analysis 5th ed. Prentice. Hall Publication, p. 701.
9. Mathiventhan, U. and Sivakaneshan, R (2013). Total Phenolic Content and Total Antioxidant Activity of Sixteen commonly consumed Green Leafy Vegetables stored under different conditions, *European International Journal of Science and Technology* 2(8): 123-132.
10. Meda A., Lamien C.E., Romito M., Millogo, J and Nacoulma, O.G. (2005). Determination of total phenolic, flavonoid and proline contents in Burkina Faso honeys as well as their radical scavenging activity. Food Chemistry, 91: 571-577.

11. Anhwange, B.A., Tyohemba, R.L., Tukura, B.W and Ogah, P. (2015). Screening of Som Indigenous Wild Fruits for Anti-Nutritional Factors. *Journal of Scientific Research & Reports 5(3): 220-227, Article no.JSRR.2015.089 ISSN: 2320-0227.*
12. Azlim Almey AA, Ahmed Jalal Khan C, Syed Zahir I, Mustapha Suleiman K, Aisyah MR, (2010). Total phenolic content and primary antioxidant activity of methanolic and ethanolic extracts of aromatic plants’ leaves. Int Food Res J 2010; 17: 1077-1084.
13. AOAC. (1990). Official methods of food analysis (15th edition). Williams S. (ed) Association of Official Analytical Chemists, Washington D.C. pp. 152 - 164.

14. Ejim, M.N and Omachi B.A. (2022). Nutrient improvement and sensory evaluation of" danwake"–A cassava based snack. *Timboji-african academic publications International journal.* vol. 8 No. 2 ISSN:-2667-4112
15. Lienel, H.H. (2002)..Ash analysis, an introduction to chemical analysis of foods. (Ed. Nielsen, S.S.). CBS publishers New Delhi. P: 123 – 133.
16. Odunlade, T. V., Famuwagun, A.A., Taiwo I.K.A., Gbadamosi, I.S.O., Oyedele,I.D.J and Adebooye, O.C. (2017). Chemical Composition and Quality Characteristics of Wheat Bread Supplemented with Leafy Vegetable Powders. *Journal of Food Quality Volume* Article ID 9536716, 7 pages https://doi.org/10.1155/2017/9536716
17. Oguntona, T. (1998). Green leafy vegetables In Osagie A. U., and Eka O. U. (Eds.), Nutritional quality of plant foods (pp. 120–133). Nigeria: Post harvest research unit, Department of Biochemistry, University of Benin, Benin city.
18. Wachap, E.D. (2005). Effects of sun and shade drying on nutrient qualities of six seasonal green leafy vegetables used in soups and dishes in Taraba State. PhD Thesis. Department of Home Science, Nutrition and Dietetics, University of Nigeria, Nsukka.
19. Umoh, E.J. and Okudu, H.O. (2017). Effect Of Blanching and Drying On Some Micronutrients of Selected Green Leafy Vegetables Consumed In Tiv Community, Benue State Nigeria. *PAT Dec, 2017; 13 (2): 57-63 ISSN: 0794-5213 On-line copy available at ww.patnsukjournal.net/current issue Publication of Nasarawa State University, Keffi*
20. Akpanyung, E.O (2005). Proximate and mineral composition of bouillon cubes produced in Nigeria. *Pakistan Journal of Nutrition*, 4: 327-329.
21. Chaturvedi, V.C., Shrivastava, R. and Upreti, R.K. (2004). Viral infections and trace elements: A complex trace element. *Current Science*, 87: 1536-1554.
22. Geissler, C.A. and Powers, H.J. (2005). Human Nutrition. 11th Ed., Elsevier, Churchill Livingstone.
23. Shimelis, E.A and Rakshit, S.K. (2005). Proximate Composition and Physico-chemical Properties of Improved dry Bean (*phaseolus vulgaris L.*) Varirties Grown in Ethiopia. Food Science and Technology International, 38, 331-338.
24. Sandberg, S. A. (2002). Bioavailability of minerals in legumes. *Br. Journal Nutr*. 88, 281–285. doi: 10.1079/BJN/2002718.
25. Melaku, U., West, C. E., and Habtamu, F. (2005). Content of zinc, iron, calcium and their absorption inhibitors in foods commonly consumed in *Ethiopia. Journal Food Compos*. Anal.18, 803–817. doi: 10.1016/j.jfca.2004.09.008.
26. Anuonye, J. C., John, O., Evans, E., and Shemelohim, A. (2010). Nutrient and antinutrient composition of extruded acha/soybean blends. *Journal of Food Proc. Preserv.* 4, 45–50. doi: 10.1111/j.1745-4549.2009.00425.x
27. Samuel, F. O., Otegbayo, B. O., and Alalade, T. (2012). Nutrient and anti-nutrient content of soy-enriched tapioca.Food Nutr. Sci. 3, 784–789. doi: 10.4236/fns.2012.36105
28. Onwuka, G.I. (2005). Food Analysis and Instrumentation. Theory and practice Naphtali. Prints, Lagos Nigeria ISBN: 978047686.
29. Qiao, D., Ke, C., Hu, B., Luo, J., Ye, H. and Sun, Y. (2009). Antioxidant activities of polysaccharides from hyriopsiscumingii.Carbohydrate Polymers 78(2): 199–204.
30. Crozier A., Ashihara H and Clifford M.N. (2006). Plant Secondary Metabolites and the Human Diet. Oxford,UK: Blackwell Publishing.
31. David, J.E. and Joseph, O. (2018). Cashew nut nutrition and facts, www.nutrition-and-you.com (Accessed 12/06/2018)

32. Igbabul, B., Grace, N. and Julius, A. (2014). Quality Evaluation of Composite bread Produced fromWheat, Maize and orange Fleshed Sweet Potatoes Flours. *American Journal of Food Science and Technology*. (2)1:109-115.
33. Bajpai, M., Mishra, A. and Prakash, D. (2005). Antioxidant and free radical scavenging activities of some leafy vegetables. *International Journal of Food Science and Nutrition*, 56(7), 473-481. https://doi.org/10.1080/09637480500524299.
34. Adefegha, S.A and Oboh, O. (2011). "Cooking enhances the antioxidant properties of some tropical green leafy vegetables," *African Journal of Biotechnology*, vol. 10, no. 4, pp. 632–639.
35. Olayinka, O.O., Kareem,A.M., Ariyo, I.B., Omotugba, S.K and Oyebanji, A.O. (2012). "Antioxidant contents (vitamin C) of raw and blanched different fresh vegetable samples," Food and Nutrition Sciences, vol. 3, no. 1, pp. 18–21.
36. Hossain, A., Khatun, M.A., Islam, M and Huque,R. (2017) "Enhancement of antioxidant quality of green leafy vegetables upon different cooking method," Preventive nutrition and food science, vol. 22, no. 3, pp. 216–222.
37. Funke, O.M. (2011). "Evaluation of nutrient contents of Amaranth leaves prepared using different cooking methods," Food and Nutrition Sciences, vol. 2, no. 4, pp. 249–252.
38. Yuan, G., Sun, B., Yuan, J and Wang, Q. (2009). "Effects of different cooking methods on health-promoting compounds of broccoli," *Journal of Zhejiang University Science B*, vol. 10, no. 8, pp. 580–588.
39. Kumar, S. (2011)."Free radicals and antioxidants: human and food system," Advances in Applied Science Research, vol. 2, no. 1, pp. 129–135.
40. Sarangarajan, R.., Meera, S., Rukkumani,S., Sankar, P and Anuradha, G. (2017)."Antioxidants: friend or foe?," *Asian Pacific Journal of Tropical Medicine*, vol. 10, no. 12, pp. 1111–1116.