International Journal of Food Science and Nutrition
www.foodsciencejournal.com
ISSN: 2455-4898
Received: 10-08-2026, Accepted: 09-09-2026, Published: 24-09-2026
Volume 11, Issue 3, 2026, Page No. 352-361

Production and quality evaluation of *Danwake* (A Nigerian cassava-cowpea-based dumpling) formulations fortified with leafy green vegetable powders

F A Masaya[1], R A Zanna[1], H K Lawan[1], A O Igwegbe[1*], A I Maijalo[1], F M Adam[1], Y M Alkali [1], H A Mudi[2]
[1] Department of Food Science and Technology, Faculty of Engineering, University of Maiduguri, PMB 1064, Maiduguri, Nigeria
[2] Department of Nutrition and Dietetic, Ramat Polytechnic, Maiduguri, Borno State, Nigeria
Corresponding Author: A O Igwegbe
DOI: https://doi.org/10.66856/ijfsn.2026.11.3.11170

Abstract
Danwake is a traditional dumpling made from a blend of cassava (*Manihot esculenta*) and cowpea (*Vigna unguiculata*) flours and enriched with boaboa leafy powder commonly consumed by individuals of all age groups in Northern Nigeria. Completely randomized single factor experiment of the form Y = βo + βixi + E was used to determine the main effects of different leafy vegetable powders on the functional properties, proximate, mineral content. The interactive effects of the combined powdered leafy vegetables on the same parameters were explored and is of the form: $Y = \beta o + \beta_i x_i + \beta_{ij} x_{ij} + E$ were (xi)) is the independent variables (baobab(b) *A. digitata*, drum strick *M. oleifera* (m), false-sesame (f) *C.sesamoides*, jute (j) *Corchorus spp*., spring onions(s) *A.fistulosum*, mint(t) *M. piperita*, celery (c) *A.graveolens* and parsley(p) *P.crispum*), (Y) response variable, βo and E represent the intercept and error term. There were 15 experimental runs consisting of CvCpb, CvCpm, CvCpf, CvCpj, CvCps, CvCpt, CvCpc, CvCpp, CvCpbm, CvCpbf, CvCpbj, CvCpbs, CvCpbt, CvCpbc and CvCpbp. Traditional *danwake* (CvCpb) serves as the experimental control. The functional properties indicated significant variations ($p<0.05$) among the *danwake* formulations. Both loose and packed bulk densities ranged from 0.381 - 0.413 and 0.500 - 0.533 g/ml, water and oil absorption capacity 0.850 - 3.850 g/g and 1.365 - 2.867 g/g, foam capacity and stability 2.995 - 26.23% and 93.75 - 120.1% and hot paste viscosity 26.10 - 257.7cp, respectively. There was significant difference ($p \leq 0.05$) in the moisture, protein, ash, fat, fiber and carbohydrate contents, which varied from 47.74 - 7.90, 2.16 - 4.12, 2.90 - 3.98, 1.33 - 1.74, 2.80 - 3.54 and 80.01 - 82.84 g/100g, respectively. There was a significant increase due to the interactive outcome of the independent variables on the formulations when compared with the traditional *danwake*. From the results observed all the formulations contained a relatively high amounts of sodium, calcium, potassium, phosphorus and magnesium that varied from 15.42-135.72, 57.54-685.97, 364.90-952.46, 140.70-756.14, and 26.40-94.41mg/100g) but the values for iron, zinc, copper and manganese that varied from 2.64-25.22, 2.46-13.35, 0.06-0.28, and 0.041-0.416 mg/100g, were relatively low. The Cassava: Cowpea flour ratios (70:30g/g) enriched with leafy powders, exhibited a range of values from 147.53-342.78mgQE/100g for total flavonoids, 0.265 – 0.551% for tannins, 360.11- 490.53mg/100g for phytate, 462.58 – 654.75mgGAE/100g for total phenolic, and 0.043-1.446% for oxalate content, for both the linear and interactive outcomes, respectively. It was concluded that a nutritious *danwake* with appreciable levels of macro and micronutrients could be produced from the combinations. Therefore, it was recommended that commercial production and diversification of seasonal leafy green powders should be in practice rather than focusing solely on baobab leaf powder for *danwake* preparation.

Keywords: *Danwake*, green vegetables, powders, minerals, fortified

Introduction

Food formulation and processing should be considered to achieve Recommended Nutrient Intake (RNI) especially among the elderly. The selection of the ingredients in food formulation from different combinations could provide the reasonable daily recommended amount of the essential nutrients for the maintenance of healthy life and normal body function. Therefore, dietary modification by increasing the consumption of a wide variety of fruits, vegetables, and whole grains daily is said to be a practical strategy for consumers to optimize their health and reduce the risk of chronic diseases. Perishable vegetables can contribute to waste problem and when incorporated into food products, it can overcome the problem. Thus, natural phytochemical and functional foods with possible health-enhancing properties such as vitamins, minerals, and antioxidants, are needed as a whole diet approach in reducing the low intake of micronutrient. However, '*Danwake'* (literally meaning the son of bean) an indigenous stiff dumpling popularly consumed in the Northern Nigeria, is traced to be of the Nupe origin (Niger/Kogi State). Originally, *danwake* is prepared from cowpea flour with the addition of baobab leaf powder and solutions of *trona* or '*kanwa*' (Sodium sesquicarbonate) and water to form a dough which is moulded into small balls and drop into a boiling water and allowed to cook for 15 to 20 minutes with continuous stirring with a perforated spatula to avoid sticking together. The balls are strained from the cooking water and placed into a bowl of water to reduce the mucilaginous form, *danwake* is served with ground chilli pepper (yaji), salt, seasoning cube and vegetable oil and eaten at any time of the day but it is mostly consumed as a breakfast meal. However, nowadays, *danwake* is prepared from blends of sorghum/beans flours, wheat/ beans flours, and cassava/beans flours with the addition of baobab leaf powder and solutions of *trona* or '*kanwa*' (Sodium sesquicarbonate) and consumed with boiled egg, lettuce, cabbage, tomatoes, onions and lime juice. Bambara groundnut is also incorporated into *danwake* flour formulation to replace bean or added together. People believe that the addition of *trona* reduces flatulence and facilitates cooking of the beans. The choice of cereal grains in *danwake* processing depends on individual needs and the availability of the desired flour.

Green leafy vegetables constitute essential components of human diet in Africa generally and particularly in West Africa (Kubmarawa *et al.*, 2009) [30]. Communities in Africa have a long history of using traditional leafy vegetables to supplement their diets (Chweya & Eyzaguirre, 1999) [15]. The varieties of leafy vegetables utilized are diverse and they are cooked and eaten as a relish together with a starchy staple food, usually in the form of porridge (Vainio-Mattila, 2000) [56]. Leafy vegetables dishes are often prepared with a single plant species or combination of different species in order to add flavour, taste, colour and aesthetic appeal to diet (Marshall, 2001; Fasuyi, 2006) [34]. Leafy vegetables are important protective foods and highly beneficial for the maintenance of health and prevention of diseases as they contain valuable food ingredients which can be utilized to build up and repair the body (Falade *et al.,* 2003) [20]. Indeed, these plants are valuable sources of nutrients especially in rural areas where they contribute substantially to protein, minerals, vitamins, fibre and other nutrients, which are usually in short supply in daily diets (Mohammed & Sharif, 2011) [37].

Cassava is the most widespread cultivated root vegetable grow in the tropics and its production is limited only to the tropical and subtropical regions due to its long growing period (8–24 months). Cassava is a perennial shrub belonging to the family *Euphorbiaceae* which plays an important role as staple for more than 500 million people Worldwide due to its high carbohydrate content (Blagbrough *et al*., 2010) [12]. According to Kenyon *et al* (2006), a wide range of products can be processed from cassava as demonstrated by data from the Collaborative Study of Cassava in Africa (COSCA). The fresh peeled tubers are eaten as a vegetable after boiling or roasting. Boiled and pounded into a paste, the tubers are often added to soups and stews (Fufu‖ in Nigeria). Because the fresh tubers deteriorate rapidly once they are harvested (post-harvest physiological deterioration; PPD), they are often preserved as sundried chips and consumed after cooking or being ground into a flour.

Cowpea grain is composed of high proportion of protein (17 to 25 %) which is rich in two essential amino acids, lysine and tryptophan (Ibro *et al.,* 2014) [26]. Cowpea is an important source of protein, carbohydrate, vitamins and minerals in the diet of many populations especially in developing countries (Udensi *et al*., 2007) [54]. Cowpea is a highly nutritious crop with a dry seed protein about 25% and protein digestibility higher than that of other legumes (Ologhobo and Fetuga, 1983) [45]. Cowpea protein shows a well-balanced amino acid content with a deficient of methionine (Carnaval *et al.*, 1990). The chemical composition of cowpea meals varies depending on the process used for their elaboration. In general cowpea meals can be considered as good source of available protein, carbohydrates, amino acid and energy (Laurena *et al*., 1991) [32]. Traditionally in Nigeria cowpea is consumed as porridge or processed and use in the production of homebased foods such as ‘Akara’ (fried cowpea paste), ‘moin-moin’ (steamed cowpea paste) and ‘Danwake’ (steam - cooked dumpling) (Nkama, 1993) [39]. Therefore, the objective of this study was to determine the production and quality evaluation of *danwake* formulations fortified with leafy green vegetable powders.

Materials and Methods

Source of materials and preliminary handling

The raw materials used in *danwake* formulations were; 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 ambient temperature for subsequent analysis. The chemicals and regents used were of analytical grade.

Production of Cowpea Flour

The Biu brown cowpea grains were transformed into flour following the procedure outlined by Masaya *et al*. (2017), as illustrated in Figure 1. The cowpea grains (Biu brown) were cleaned in tap water, soaked for 10 minutes in clean water, and then dehulled using a pestle and mortar. Thereafter, they were washed and sun-dried, milled using an attrition mill. The resulting product was then sieved through a 300µm sieve to achieve flour. The flour was stored in plastic buckets, tightly covered, and placed in cardboard at ambient temperature.

Cowpea
↓
Cleaning
↓
Steeping
↓
Washing
↓
Decorticating
↓
Sun drying
↓
Milling
↓
Sieving
↓
Cowpea flour

Fig 1: Flow Chart for Production of Cowpea Flour (Source: Masaya *et al*. 2017) [33].

Preparation of Vegetables Leaves into Powder

Fresh green leafy vegetable powder was prepared using the method outlined by Arasaretnam *et al*. (2017), with slight adjustments (Figure 2**)**. The edible parts of the plants were cleaned under running tap water, rinsed with distilled water, and then separated from the stems before dicing and drying under shade, for 120 hours. The dried samples were then finely ground into powder using a warring blender (Model: GK 240, UK) and stored in airtight containers prior to use.

Fresh green leaf
↓
Washing
↓
Separating
↓
Dicing
↓
Shed drying
↓
Blending
↓
Sieving
↓
Green leafy vegetable powder

Fig 2: Flow Chart for Preparation of Vegetable into Powders (Source: Arasaretnam *et al*. (2017).

Experimental Design

The method described by Dharmaraja and Dipayan (2018) [18], was adapted 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 were evaluated of the form $Y= \beta o + \beta_i x_i + \beta_{ij} x_{ij} + E$ giving fifteen (15) experimental units in all. Xi represents the vegetables powder. Boabab leaf powder enriched formulation served as the control.

Functional Properties of the *Danwake* Formulations Fortified with Leafy Green Vegetable Powders

Water/ Oil Absorption Capacity

The water absorption capacity of the formulated flour blend was determined according to the method described by Onwuka (2005) [46]. One gram (1g) of the sample was combined with 10mL of distilled water/ oil, stirred for 30 seconds, left to stand for 30 minutes, and subsequently centrifuged at 5000 rpm for 30 minutes. The volume of the resulting supernatant was then measured using a 10mL graduated cylinder.

Bulk Density Determination

Bulk density of the samples was determined according to the procedure described by Onwuka (2005) [46]. Twenty grams (20g) of the sample was placed into 50mL measuring cylinder and tapped to a constant volume. The bulk density (g/mL) was calculated as the weight of the sample (g) divided by the sample volume (mL).

Determination of Foam Capacity and Foam Stability

Foam capacity and foam stability were determined according to the method of Nayarana and Narasinga (1984) [38]. One gram (1g) of the powder or blend was placed into 10mL measuring cylinder, the mixture was shaken continuously for 5mins, the foam capacity was expressed in percentage as the difference in volume after and before whipping. While the foam stability was recorded 10minutes after shaking as a percentage of the initial volume.

Determination of Viscosity

The sample's viscosity was measured utilizing a Cannon Instrument Company viscometer, specifically the Model 2020, following the procedure outlined by Regenstein and Regenstein (1984) [49]. The viscosity assessment employed spindle No. 62 at a rotation speed of 100 revolutions per minute (rpm), and readings were recorded 120 seconds into the rotation.

Determination of Proximate Composition of the *Danwake* Formulations Fortified with Leafy Green Vegetable Powders

The samples were analyzed for the proximate composition (moisture, crude protein, total ash, total lipids, crude fiber using the established procedures of AACC (2000). Carbohydrates were 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 was 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 for 5 hours. 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 at 550°C for 5 hours.

Determination of Mineral Contents of *Danwake* Formulations Fortified with Leafy Green Vegetable Powders

A sample (3g) was weighed into a crucible and then ashed in Muffle furnace at 500°C for 6 hours. After cooling in desiccator, 2.5mL 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, 5.0ml of de ionized water was added and heated until a colorless solution was obtained. The mineral solution in each crucible was transferred into a 100.0ml volumetric flask by filtration through filter paper and the volume was made to the mark with de ionized water. The samples were analyzed for Ca, Mg, Na, K, while Fe. Mg, Na, K and Fe were determined using Atomic Absorption Spectrophotometer.

Determination of Phytochemical Content of *Danwake* Formulations Fortified with leafy green vegetable powders

Determination of Tannins Content

The Folin-Denis colourimetric procedure, as outlined by Kirk and Sawyer (1998) [29], was used to determine the tannin content. Five-gram (5g) sample was dispersed in 50mL 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, 2mL of the extract was transferred to a 50 mL volumetric flask. Simultaneously, another 50mL volumetric flask containing 2mL of standard tannin solution (tannic acid) and 2 mL of distilled water as a standard was prepared. In each flask, 1.0mL of Folin-Denis reagent was added. Next, 2.5mL of saturated sodium carbonate solution was introduced. The contents of each flask were adjusted to 50mL with distilled water, incubated for 90 minutes at room temperature. The respective absorbance was measured at 260nm 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

Determination of Oxalate Content

Oxalate content was determined using the titration procedure outlined by Day and Underwood (1986) [17]. One gram (1g) of the sample was weighed, placed in a 100mL Erlenmeyer flask and 75mL of 3 M H_2SO_4 was added. The mixture was stirred for 1hr using a magnetic stirrer, and the resulting solution was then filtered through Whatman #1 filter paper.

Subsequently, 25mL of the filtrate was withdrawn and subjected to a hot titration against a 0.05M $KMnO_4$ solution until the pink color persisted for at least 30 seconds. The oxalate content was determined based on the fact that 1 ml of 0.05M $KMnO_4$ corresponds to 2.2mg of oxalate.

$$\% \text{ Oxalate} = \frac{Titre\ value \times 0.9004}{Weight\ of\ sample}$$

Determination Total Phenolic Content

The total phenolic content (TPC) was determined spectrophotometrically according to the method described by Mathiventhan and Sivakaneshan (2013) [35]. Two grams (2g) of the sample were ground with 30mL of methanol in a mortar and pestle. 50mL 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 1mL of Folin-Ciocalteau reagent (10-fold dilution), followed by the addition of 0.8mL of 2% Na_2CO_3. The volume was adjusted to 10ml using a 4:6 water/methanol mixture. The solution was left to stand for 30 minutes, and the absorbance at 754nm 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 100g wet weight.

$$\text{TPC (mg GAE/g)} = \frac{A}{Slope} \times \frac{DF}{W}$$

Determination of Total Flavonoid Content

The method for assessing the total flavonoid content was carried out as outlined by Meda *et al*., (2005). 0.5mL of methanol extract was combined with equal volumes of methanol, $AlCl_3$ solution (10%, w/v), potassium acetate solution (1M), and distilled water (2mL). The resulting mixture underwent a 30-minute incubation at room temperature. Subsequently, the absorbance was measured at 415nm 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.

$$\text{FC (mg QE/g)} = \frac{A}{Slope} \times \frac{DF}{W}$$

Determination of Phytate Content

Phytate content was determined using the technique outlined by Anhwange *et al*. (2015). Four grams (4g) sample was immersed in 100cm³ of 2% hydrochloric acid (HCl) v/v for 3 hours and then filtered. To 25cm³ of the resulting filtrate in an Erlenmeyer flask, 5cm³ of a 0.3% ammonium thiocyanate solution and 53.5cm³ of distilled water were added, thoroughly mixed, and diluted with standard $FeCl_3$ (containing 0.00195g Fe^{3+}/cm³) until a brownish-yellow tint appeared during titration. A parallel titration was conducted for the blank, and 1 cm³ equivalent to 1.19mg of phytic phosphorus was measured. This value was then multiplied by a factor of 3.55 to determine the phytate content.

$$\text{Phytate content (mg/g)} = \frac{Phosphorus\ content \times 3.55}{Sample\ weight}$$

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

Functional Properties of *Danwake* Formulations Fortified with leafy green vegetable powders

The mean values for loose and packed bulk density varied from (0.381 - 0.413 and 0.500 - 0.533 g/ml), water absorption capacity (0.850 - 3.850 g/g), oil absorption capacity (1.365 - 2.867 g/g), foam capacity (2.995 - 26.23%), foam stability (93.75 - 120.1%) and viscosity (26.10 - 257.7 cp) of the *danwake* formulations for the linear response, are presented in Table 1. The values were significantly different ($p \leq 0.05$). Formulation CvCpm had the highest (0.413g/ml) and CvCpc had the least (0.38g/ml) loose and packed bulk density. Flour particle size and density play a crucial role in influencing bulk density. This becomes particularly important when assessing packaging needs, material handling, and applications involving wet processing in the food industry (Adebowale *et al*., 2008) [3]. Higher WAC and OAC were noted in formulations CvCpp (3.850g/g and 2.867g/g) and lower values in formulations CvCpf (0.850g/g) and CvCps (1.365g/g). The values obtained for the WAC and OAC is in the same trend with that reported by Jyoti and Sudesh (2020) [27] for Physicochemical and nutritional composition of composite flour enriched with spinach leaves powder for development of value-added baked products. Galla *et al*. (2017) noted that the rise in water absorption can be attributed to the presence of hydroxyl groups in the fiber structure, facilitating increased water interaction through hydrogen bonding. Similarly, Gomez *et al*. (2003) and Dachana *et al*. (2010) found that the addition of fiber enhances water absorption in cookies made from composite flour and bread flour, owing to the hydroxyl groups within the fiber. Comparable outcomes regarding water and oil absorption capacity were also observed by Ritika *et al*. (2016) and other researchers working with composite flours. The elevated moisture and oil absorption capacity of composite flours positively affect the taste, moisture and fat content, and texture of food, as reported by Prajapati *et al*. (2015). Formulation CvCpt had the highest Foam capacity and Foam Stability (26.23 and 120.1%), and least values were recorded in formulations CvCpm (2.995%) and CvCpb

(93.75%). Higher viscosity was observed in formulation CvCpf (257.7Cp) and lower value in formulation containing CvCps (26.10 Cp) in the linear response. While on the interactive response, formulation CvCpbm recorded higher loose and packed bulk density (0.417 and 0.549g/ml) and lower values in formulations CvCpbc and CvCpbf (0.374 and 0.510g/ml). This result observed to be closer to that reported by Ojinnaka *et al*. (2018). The fluctuation in bulk density may be associated with changes in the particle size density of vegetable powders, given that a consistent amount of cassava was utilized in the formulations. Iwe and Onadipe (2001) reported that starch content increases bulk density. Formulation CvCpbp (3.350g/g) had the highest and formulation CvCpbm (1.450g/g) had the least value for WAC. The ability to absorb water plays a crucial role in the production of ready-to-eat foods, and a substantial water absorption capacity is essential for maintaining the cohesive strength of the product (Houson and Ayenor, 2002) [23]. Studies indicate that carbohydrates play a role in influencing water absorption in food products (Adejuyitan *et al*., 2009) [4]. Variations in water absorption capacity among different samples may be attributed to differences in protein content and the extent of interaction with water (Butt and Batool, 2010) [13]. Oil absorption capacity of the flour/powder differed significantly ($p < 0.05$). Formulation CvCpc recorded the highest (3.048g/g) and formulation CvCpbs recorded the least (1.456g/g) value for OAC. The absorption capacity of oil holds significance, particularly in baked goods, as it signifies the appropriateness of flour to enhance flavor, texture, palatability, and prolong the shelf life of food products. (Aremu *et al*., 2007; Appiah *et al*., 2011) [8, 10]. Higher FC and FS (33.33 and 122.3%) was observed in formulation CvCpbt and formulation CvCpbs and lower values in formulation CvCpbj (4.590 and 95.50%) for both respectively. The result obtained is in the same trend to that reported by Ojinnaka *et al*. (2018) on partial replacement of wheat flour with mushroom (*Pleurotus tuber- regium*) powder and cocoyam (*Colocasia esculenta*) flour in the production of cookies. Due to the favorable foaming capability of flexible proteins, it is suggested by Ibeanu *et al*. (2016) that the ability to foam is influenced by the structure and properties of protein molecules. This implication hints at the potential of the flour to enhance textural and leavening attributes. According to Akubor *et al*. (2000), it was noted that bakery products can benefit from the incorporation of food ingredients exhibiting favorable foaming capacity and stability. Highest viscosity was obtained in formulation CvCpbf (287.6 Cp) and least value in formulation CvCpbs (54.50 Cp). Abiodun and Zainab (2018) [2] reported similar viscosity values on the chemical, functional, pasting and sensory properties of fried chips produced from cassava flour enriched with cowpea flour.

Table 1: Functional Properties of *Danwake* Formulations Fortified with Leafy Green Vegetable Powders

Formulation[2]	Parameters[1]						
	LBD(g/ml)	**PBD(g/ml)**	**WAC(g/g)**	**OAC(g/g)**	**FC (%)**	**FS (%)**	**Hot paste VIS (cp)**
Linear ($Y=\beta o+\beta ixi + E$)							
CvCpb (Control)	$0.409^{a}\pm0.01$	$0.526^{ab}\pm0.00$	$3.750^{a}\pm0.35$	$1.820^{b}\pm0.00$	$4.740^{d}\pm2.14$	$93.75^{d}\pm0.00$	$159.6^{c}\pm0.35$
CvCpm	$0.413^{a}\pm0.01$	$0.533^{a}\pm0.01$	$2.000^{b}\pm0.71$	$1.593^{b}\pm0.19$	$2.995^{d}\pm0.19$	$97.28^{cd}\pm8.27$	$145.2^{d}\pm5.09$
CvCpf	$0.404^{ab}\pm0.01$	$0.510^{abc}\pm0.09$	$0.850^{c}\pm0.21$	$1.683^{b}\pm0.32$	$4.410^{d}\pm2.08$	$94.41^{d}\pm3.87$	$257.7^{a}\pm0.35$
CvCpj	$0.404^{ab}\pm0.06$	$0.510^{abc}\pm0.09$	$1.500^{bc}\pm0.71$	$1.501^{b}\pm0.06$	$7.140^{cd}\pm2.02$	$102.9^{bcd}\pm4.03$	$247.9^{b}\pm1.41$
CvCps	$0.405^{ab}\pm0.01$	$0.526^{ab}\pm0.00$	$3.150^{a}\pm0.21$	$1.365^{b}\pm0.00$	$14.93^{bc}\pm0.31$	$109.0^{abc}\pm4.38$	$26.10^{h}\pm2.12$
CvCpt	$0.385^{bc}\pm0.00$	$0.513^{bc}\pm0.01$	$3.100^{a}\pm0.00$	$1.593^{b}\pm0.32$	$26.23^{a}\pm7.10$	$120.1^{a}\pm11.30$	$94.50^{e}\pm2.97$
CvCpc	$0.381^{c}\pm0.01$	$0.500^{c}\pm0.00$	$1.900^{b}\pm0.14$	$2.412^{a}\pm0.19$	$25.92^{a}\pm7.54$	$115.2^{ab}\pm0.64$	$58.10^{g}\pm2.67$
CvCpp	$0.385^{bc}\pm0.0$	$0.500^{c}\pm0.00$	$3.850^{a}\pm0.50$	$2.867^{a}\pm0.19$	$20.66^{ab}\pm2.71$	$117.5^{a}\pm2.69$	$70.19^{f}\pm0.42$
Interative ($Y=\beta o+\beta_i x_i+ \beta_{ij} x_{ij}+ E$)							
CvCpbm	$0.417^{a}\pm0.01$	$0.549^{a}\pm0.01$	$2.800^{b}\pm0.00$	$1.852^{bc}\pm0.08$	$32.29^{a}\pm1.47$	$115.5^{ab}\pm4.74$	$238.7^{bc}\pm1.91$
CvCpbf	$0.417^{a}\pm0.00$	$0.510^{c}\pm0.01$	$1.450^{d}\pm0.07$	$2.958^{a}\pm0.19$	$15.15^{b}\pm8.57$	$103.0^{de}\pm0.00$	$287.6^{a}\pm1.48$
CvCpbj	$0.404^{ab}\pm0.01$	$0.534^{abc}\pm0.01$	$1.850^{c}\pm0.21$	$1.957^{bc}\pm0.19$	$4.590^{c}\pm2.34$	$95.50^{e}\pm1.95$	$245.1^{b}\pm5.52$
CvCpbs	$0.404^{ab}\pm0.01$	$0.526^{bc}\pm0.00$	$1.800^{cd}\pm0.14$	$1.456^{c}\pm0.13$	$32.79^{a}\pm0.75$	$122.3^{a}\pm4.95$	$54.50^{f}\pm14.2$
CvCpbt	$0.404^{ab}\pm0.01$	$0.519^{c}\pm0.01$	$2.950^{b}\pm0.21$	$2.139^{b}\pm0.32$	$33.33^{a}\pm0.00$	$120.0^{ab}\pm4.67$	$107.5^{c}\pm7.64$
CvCpbc	$0.389^{bc}\pm0.01$	$0.541^{ab}\pm0.00$	$2.100^{c}\pm0.14$	$3.048^{a}\pm0.32$	$16.36^{b}\pm5.99$	$107.5^{cd}\pm2.26$	$62.05^{e}\pm8.49$
CvCpbp	$0.374^{c}\pm0.01$	$0.548^{a}\pm0.011$	$3.350^{a}\pm0.21$	$2.776^{a}\pm0.19$	$17.49^{b}\pm2.63$	$112.7^{bc}\pm0.28$	$76.31^{d}\pm0.64$

[1]Values are means ± standard deviations of three replications. In any column, means bearing similar superscripts are not significantly different ($p \geq 0.05$); LBD= Loss bulk density, PBD= Packed bulk density; WAC= Water absorption capacity; OAC= Oil absorption capacity FC= Foam capacity; FS= Foam stability

[2]*Cassava (Cv): Cowpea(Cp) in the ratio of 70:30; Ten gram (10 g) 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 (5 g+5 g) each boabab:moringa(bm); boabab:false-sesame(bf); baobab:jute(bj); baobab:spring onions(bs); baobab:mint(bt); baobab:celery(bc); baobab:parsley(bp) add*

Proximate Composition of of *Danwake* Formulations Fortified with Leafy Green Vegetable Powders (g/100g)

The proximate composition of Leafy Powder fortified Cassava-Cowpea (70:30) blend used for Danwake Preparation and the Control are indicated in Table 2. The moisture, protein, ash, fat, crude fiber and carbohydrate content are between (7.74 and 7.90, 2.16 and 4.12, 2.90 and 3.98, 1.33 and 1.74, 2.80 and 3.54 and 80.01 and 82.84 g/100g) for the linear response of the experiment. Formulation containing CvCpp had the highest moisture content (7.90g/100g) and formulation CvCpc had the least moisture and protein content (7.74 and 2.16g/100g). Higher ash content was obtained in formulation CvCpm (3.98g/100g) and lower value in formulation CvCpt (2.90g/100g). Formulation CvCpt had the highest fat content (1.74g/100g) and the control CvCpb with the least (1.33g/100g). Higher crude fiber and carbohydrate content were noted in formulations containing CvCpp and CvCpc (3.54 and 82.84g/100g) and lower values in formulation CvCpm (2.80 and 80.01g/100g) respectively. Flour possesses ample carbohydrates to fulfill energy requirements effectively (Butt and Batool, 2010) [13]. The moisture content in all flour samples remained below 10% (ranging from 6.81% to 8.03%), indicating a minimal risk of microbial spoilage and thereby ensuring an extended shelf life (Kure *et al*., 1998) [31]. This moisture level falls within an acceptable range, allowing the safe storage of flour for subsequent processing without the concern of microbial contamination. Flour with a moisture content below 14% demonstrates resistance to microbial growth, ensuring a prolonged shelf life (Ojo *et al*., 2017) [43]. Additionally, various studies have reported elevated levels of crude protein, fat, and fiber in mixtures of flour and green vegetables (Pant *et al*., 2012; Ajibola *et al*., 2015; Singh *et al*., 2018) [5, 47, 51]. The effect of ($Y=\beta o+\beta_i x_i+ \beta_{ij} x_{ij}+ E$) on the interactive outcome of the experiment indicate significant ($p<0.05$) differences in the chemical composition of the formulations. Higher moisture content was observed in formulation containing CvCpbs (9.83g/100g) and lower values in formulation CvCpbp for moisture, protein and fat content (7.71, 9.90 and 1.13g/100g) respectively. Moisture levels are a crucial and extensively employed factor in food processing, preservation, and storage. Consequently, these findings endorse the strategy of storing leaves in dehydrated condition. The reduced water content in these leaf powders serves to inhibit microbial attacks and facilitates increased storage capacity. Higher crude fiber was observed in formulation containing CvCpbm (9.67g/100g) and lower value in formulation CvCpbc (5.14g/100g). The fat, ash and crude fiber content from this study agreed with the findings of Olaniran *et al*. (2020) on the proximate composition and physicochemical properties of formulated cassava, cowpea and potato flour blends.

Table 2: Proximate Composition of of *Danwake* Formulations Fortified with leafy green vegetable powders (g/100g)

Formulations[2]	Parameters[1]					
	Moisture	**Crude Protein**	**Total Ash**	**Crude Fat**	**Crude Fiber**	**Carbohydrate**
Linear ($Y=\beta o+\beta ixi + E$)						
CvCpb (Control)	$7.82^{a}\pm0.22$	$2.78^{b}\pm0.07$	$3.14^{d}\pm0.03$	$1.33^{e}\pm0.02$	$2.94^{e}\pm0.04$	$81.99^{b}\pm0.22$
CvCpm	$7.75^{a}\pm0.01$	$4.12^{a}\pm0.02$	$3.98^{a}\pm0.16$	$1.34^{de}\pm0.00$	$2.80^{f}\pm0.04$	$80.01^{c}\pm0.05$
CvCpf	$7.79^{a}\pm0.13$	$2.62^{bc}\pm0.0$	$3.22^{cd}\pm0.03$	1.35 ± 0.02^{d}	$3.11^{c}\pm0.05$	$81.90^{b}\pm0.18$
CvCpj	$7.84^{a}\pm0.02$	$2.53^{c}\pm0.01$	$3.64^{c}\pm0.06$	$1.34^{de}\pm0.00$	$3.05^{d}\pm0.00$	$81.61^{b}\pm0.08$
CvCps	$7.97^{a}\pm0.02$	$2.69^{bc}\pm0.08$	$3.13^{d}\pm0.01$	$1.34^{de}\pm0.01$	$2.93^{e}\pm0.03$	$81.94^{b}\pm0.11$
CvCpt	$7.76^{a}\pm0.56$	$4.03^{a}\pm0.10$	$2.90^{e}\pm0.15$	$1.74^{a}\pm0.02$	$3.20^{b}\pm0.05$	$80.37^{c}\pm0.70$
CvCpc	$7.74^{a}\pm0.22$	$2.16^{d}\pm0.12$	$2.93^{e}\pm0.12$	$1.48^{e}\pm0.01$	$2.84^{f}\pm0.01$	$82.84^{a}\pm0.29$
CvCpp	$7.90^{a}\pm0.00$	$2.17^{d}\pm0.24$	$3.31^{c}\pm0.07$	$1.51^{b}\pm0.01$	$3.54^{a}\pm0.01$	$81.57^{b}\pm0.28$
Interative ($Y=\beta o+\beta_i x_i+ \beta_{ij} x_{ij}+ E$)						
CvCpbm	$8.19^{b}\pm0.43$	$13.05^{a}\pm0.02$	$3.02^{c}\pm0.02$	$1.40^{d}\pm0.02$	$9.67^{a}\pm0.11$	$64.67^{e}\pm0.43$
CvCpbf	$7.92^{b}\pm0.10$	$12.96^{a}\pm0.10$	$3.23^{b}\pm0.11$	$1.42^{cd}\pm0.00$	$5.16^{b}\pm0.04$	$69.32^{cd}\pm0.06$
CvCpbj	$7.88^{b}\pm0.54$	$11.55^{b}\pm0.03$	$3.31^{b}\pm0.08$	$1.43^{c}\pm0.02$	$5.34^{b}\pm0.55$	$70.48^{b}\pm1.02$
CvCpbs	$8.83^{a}\pm1.02$	$11.46^{b}\pm0.01$	$3.67^{a}\pm0.01$	$1.42^{cd}\pm0.00$	$5.32^{b}\pm0.55$	$69.30^{d}\pm0.98$
CvCpbt	$7.84^{b}\pm0.23$	$11.63^{b}\pm0.08$	$3.33^{b}\pm0.06$	$1.56^{b}\pm0.01$	$5.26^{b}\pm0.00$	$70.38^{bc}\pm0.22$
CvCpbc	$7.87^{b}\pm0.69$	$11.72^{b}\pm0.07$	$3.53^{a}\pm0.14$	$1.59^{a}\pm0.01$	$5.14^{b}\pm0.03$	$70.15^{c}\pm0.58$
CvCpbp	$7.71^{b}\pm0.17$	$9.90^{c}\pm0.58$	$3.61^{a}\pm0.20$	$1.13^{e}\pm0.00$	$5.41^{b}\pm0.55$	$72.23^{a}\pm0.63$

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

[2]Cassava (Cv): Cowpea(Cp) in the ratio of 70:30; Ten gram (10 g) 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 (5 g+5 g) 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

Mineral Composition of *Danwake* Formulations Fortified with leafy green vegetable powders (mg/100g)

The mineral composition of leafy powder fortified cassava-cowpea (70:30) blend used for the *danwake* preparation and the control are given in Table 3. Significant differences were observed among the formulations analyzed for the mineral composition. The result observed for the linear outcome of the experiment indicate sodium range from (15.416-130.154 mg/100g) formulation CvCpm had the highest (130.15mg/100g) and the control CvCpb had least sodium (15.42mg/100g), higher calcium content was obtained in the control CvCpb (578.7mg/100g) and lower value in formulation CvCpc (57.54mg/100g), the potassium varied from (364.85-557.60mg/100g) formulation containing CvCpm with highest (557.60mg/100g) and formulation CvCpc with the least value (364.85mg/100g), higher phosphorus content was seen in formulation containing CvCpm (360.81mg/100g) and lower value in formulation CvCpj (140.73mg/100g), magnesium ranged from (26.42-80.92 mg/100g) formulation containing CvCpm had the highest(80.92mg/100g) and formulation CvCpj with the lower values (26.42mg/100g), iron (2.64-17.99 mg/100g) formulation CvCpm with highest value (17.99mg/100g) and formulation CvCpc with the least value (2.64mg/100g), higher content of zinc was noted in formulation containing CvCps (3.62mg/100g) and lower value in the control CvCpb (2.46mg/100g), copper (0.11-0.28 mg/100g), manganese (0.082-0.261 mg/100g) formulation containing CvCpf had the highest value in copper and manganese (0.28 and 0.261mg/100g) and formulations CvCpc and CvCpp had least values (0.11 and 0.082mg/100g) respectively. The values obtained for the mineral compositions are closer to those reported by Odunlade (2017) [41] on the Chemical Composition and Quality Characteristics of Wheat Bread Supplemented with Leafy Vegetable Powders. Therefore, the leafy powder chosen in the formulations of this research could be suggested in dietary plans to alleviate anemia, a condition that impacts over one billion individuals globally (Trowbridge and Martorell, 2002) [53].

There was significant increase ($p < 0.05$) on the effect of Interaction ($Y=\beta o+\beta_i x_i+ \beta_{ij} x_{ij}+ E$) compared to the control, formulations containing baobab/moringa leaf powder fortified (70:30) cassava: cowpea (CvCpbm) had the highest concentration of Na, Ca, K, P, Mg, Fe, Zn (125.722, 685.97, 952.46, 756.14, 94.41, 25.22, 13.35g/100g) while lower values were observed in formulation containing (CvCpbs) Na (20.9784g/100g), formulation (CvCpbc) Ca (164.84g/mg), formulation (CvCpbc) K (759.71g/mg), formulation (CvCpbs) P and Mg (536.06 and 39.91mg/100g), formulation (CvCpbc) Fe (9.87mg/100g), formulation (CvCpbp) Zn (12.64g/100g), formulation (CvCpbm) Cu (0.14mg/100g) and formulation (CvCpbf) Mn (0.041mg/100g) respectively. It was observed all formulation containing moringa either alone or combined with other leafy powder had a higher mineral content except for copper and manganese respectively. Additional employees also noted increased levels of calcium (Ca), phosphorus (P), iron (Fe), zinc (Zn), β-carotene, and antioxidant activity in composite flour incorporating powders from green leafy vegetables. These findings align closely with the results documented by (Umma Khair *et al*. 2012; Pant *et al*. 2012; Kavitha and Ramadas 2013; Galla *et al*. 2017) [21, 28, 47, 55] in their research on formulated composite flour. The findings obtained in this study is also comparable to that reported by Ibrahim *et al*. (2018) on the influence of Baobab Leaf Enrichment on the Physicochemical, Sensory and Nutritional Characteristics of Plantain/Cashew Kernels Composite Flours.

Table 3: Mineral Composition of *Danwake* Formulations Fortified with leafy green vegetable powders (mg/100g)

			Minerals[1]						
Formulations[2]	**Na**	**Ca**	**K**	**P**	**Mg**	**Fe**	**Zn**	**Cu**	**Mn**
Linear (Y=βo+βixi + E)									
CvCpb (Control	$15.42^{h}\pm0.01$	$578.7^{a}\pm1.25$	$420.4^{b}\pm0.01$	$240.8^{c}\pm0.38$	$43.2^{d}\pm0.31$	$8.40^{b}\pm0.45$	$2.46^{h}\pm0.00$	$0.20^{d}\pm0.0$	$0.205^{b}\pm0.00$
CvCpm	$130.15^{a}\pm0.60$	$453.3^{c}\pm1.70$	$557.6^{a}\pm0.23$	$360.8^{a}\pm1.16$	$80.9^{a}\pm0.23$	$17.99^{a}\pm0.06$	$3.56^{b}\pm0.08$	$0.22^{b}\pm0.0$	$0.065^{g}\pm0.00$
CvCpf	$68.19^{c}\pm0.06$	$98.10^{d}\pm0.1$	$405.9^{d}\pm0.05$	$141.5^{g}\pm0.06$	$26.4^{g}\pm0.00$	$3.94^{d}\pm0.03$	$3.32^{c}\pm0.01$	$0.28^{a}\pm0.0$	$0.261^{a}\pm0.00$
CvCpj	$76.27^{b}\pm0.05$	$86.8^{e}\pm0.18$	$374.4^{f}\pm0.18$	$140.7^{g}\pm0.02$	$26.4^{g}\pm0.00$	$3.58^{e}\pm0.00$	$2.92^{f}\pm0.00$	$0.12^{h}\pm0.0$	$0.171^{c}\pm0.00$
CvCps	$15.85^{g}\pm0.00$	$541.3^{b}\pm0.3$	$410.9^{c}\pm0.03$	$252.2^{b}\pm0.39$	$37.5^{e}\pm0.04$	$7.14^{c}\pm0.02$	$3.62^{a}\pm0.01$	$0.13^{f}\pm0.0$	$0.167^{d}\pm0.00$
CvCpt	$30.68^{d}\pm0.09$	$62.45^{g}\pm0.29$	$392.6^{e}\pm0.12$	$153.5^{f}\pm1.16$	$50.9^{b}\pm0.01$	$3.01^{f}\pm0.07$	$3.16^{d}\pm0.02$	$0.16^{e}\pm0.0$	$0.096^{e}\pm0.00$
CvCpc	$23.88^{f}\pm0.051$	$57.54^{h}\pm0.12$	$364.9^{h}\pm0.05$	$157.3^{e}\pm0.05$	$29.3^{f}\pm0.00$	$2.64^{g}\pm0.01$	$3.02^{e}\pm0.01$	$0.11^{g}\pm0.0$	$0.043^{h}\pm0.00$
CvCpp	$25.55^{e}\pm0.063$	$75.06^{f}\pm0.27$	$371.9^{g}\pm0.04$	$162.9^{d}\pm0.06$	$45.7^{c}\pm0.03$	$3.30^{e}\pm0.04$	$2.85^{g}\pm0.00$	$0.21^{c}\pm0.0$	$0.082^{f}\pm0.00$
Interative ($Y=\beta o+\beta_i x_i+\beta_{ij}x_{ij}+E$)									
CvCpbm	$135.72^{a}\pm0.6$	$685.97^{a}\pm1.2$	$952.46^{a}\pm0.2$	$756.14^{a}\pm1.1$	$94.41^{a}\pm0.2$	$25.22^{a}\pm0.06$	$13.35^{a}\pm0.0$	$0.14^{g}\pm0.0$	$0.290^{c}\pm0.01$
CvCpbf	$81.842^{b}\pm0.0$	$560.61^{c}\pm1.7$	$815.26^{b}\pm0.1$	$636.0^{b}\pm0.38$	$54.71^{d}\pm0.3$	$15.63^{b}\pm0.45$	$13.10^{b}\pm0.0$	$0.15^{b}\pm0.0$	$0.041^{g}\pm0.00$
CvCpbj	$73.767^{c}\pm0.0$	$205.40^{d}\pm0.0$	$800.82^{c}\pm0.1$	$536.79^{f}\pm0.1$	$39.93^{f}\pm0.0$	$11.16^{c}\pm0.03$	$13.12^{b}\pm0.0$	$0.22^{a}\pm0.0$	$0.416^{a}\pm0.00$
CvCpbs	$20.978^{g}\pm0.0$	$194.11^{e}\pm0.0$	$769.26^{e}\pm0.2$	$536.06^{f}\pm0.0$	$39.91^{f}\pm0.0$	$10.81^{d}\pm0.00$	$12.71^{e}\pm0.0$	$0.21^{f}\pm0.0$	$0.323^{b}\pm0.00$
CvCpbt	$36.244^{d}\pm0.0$	$648.55^{b}\pm0.0$	$787.43^{d}\pm0.1$	$548.85^{f}\pm1.2$	$64.44^{b}\pm0.0$	$10.24^{e}\pm0.07$	$12.96^{c}\pm0.0$	$0.09^{d}\pm0.0$	$0.118^{d}\pm0.00$
CvCpbc	$29.448^{f}\pm0.0$	$169.74^{f}\pm0.3$	$759.71^{g}\pm0.1$	$552.63^{d}\pm0.0$	$42.75^{e}\pm0.0$	$9.870^{f}\pm0.01$	$12.82^{d}\pm0.0$	$0.06^{e}\pm0.0$	$0.083^{e}\pm0.00$
CvCpbp	$31.117^{e}\pm0.0$	$164.84^{g}\pm0.0$	$766.79^{f}\pm0.0$	$558.27^{c}\pm0.0$	$59.18^{c}\pm0.0$	$10.53^{de}\pm0.04$	$12.64^{f}\pm0.00$	$0.14^{c}\pm0.00$	$0.077^{f}\pm0.00$

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

[2]Cassava (Cv): Cowpea(Cp) in the ratio of 70:30; CvCp (70:30): Ten gram (10 g) 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 (5 g+5 g) 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

Phytochemical Composition of *Danwake* Formulations Fortified with leafy green vegetable powders

Significant difference exist among the phytochemical composition of the *danwake* formulations as shown in Table 4. The linear outcome of the experiment indicates the following: total flavonoid, tannin, phytate, total phenolic and oxalate content are between the range of (250.13-342.78, 0.065-0.551, 366.97-402.14, 579.11- 654.75 and 0.043-0.761) respectively. Higher values for total flavonoids, phytate and total phenolic were obtained in formulation containing CvCpt (342.78 mgQE/100g, 402.14 mg/100g and 654.75 mgGAE/100g) while lower values in control CvCpb (250.13 mgQE/100g), formulation CvCpp (366.97 mg/100g) and formulation CvCps (579.11 mgGAE/100g). Formulation containing CvCpm had the highest tannin content (0.551%) and least value was seen in formulation CvCpc (0.065%). Higher oxalate content was observed in formulation containing CvCpf (0.761%) and lower result was recorded in formulation CvCpm (0.043%) respectively.

The effect of interactive ($Y=\beta o+\beta_i x_i+\beta_{ij}x_{ij}+E$) on the response shows formulation CvCpbt had the highest total flavionod content (222.62 mgQE/100g) and least value was note, d in formulation CvCpbm (145.82 mgQE/100g). Higher value of tannin content was recorded in formulation containing CvCpbf (0.301%) and lower value in formulation CvCpbs (0.265%). Formulation containing CvCpbc recorded the highest phytate content (490.53 mg/100g) and least result was seen in formulation CvCpbf (360.11mg/100g). The highest oxalate content was obtained in formulation containing CvCpbj (1.446%) and the least value in formulation CvCpbf (0.012%) respectively. Echendu *et al*. (2009) documented a oxalate content of 0.0114 mg/g in 100% acha flour, whereas Ravindran and Sivakanesan (1996) reported a range of 0.0119–0.042 mg/g for mango kernel seed flour. Nwosu (2011) [40] identified a danger zone of 2–5 mg/g for oxalate in flours intended for consumption. Oxalate binds with calcium, rendering it inaccessible to the body (Barasi, 2003) [11]. Antinutritional factors like phytates create complexes with essential metal ions such as zinc, iron, and calcium in the human body, hindering their bioavailability and proteins crucial for growth and development (Soetan and Oyewole, 2009) [52]. Flavonoids, highlighted by Yao *et al*., (2004), act as potent antioxidants with effective radical scavenging properties, guarding against coronary heart disease and cancerous activities

Table 4: Phytochemical Composition of *Danwake* Formulations Fortified with Leafy Green Vegetable Powders

		Parameters[1]			
Formulation[2]	**Total Flavonoids (mgQuercetin/100g)**	**Tannins (%)**	**Phytate (mg/100g)**	**Total Phenolic (mgGAE/100g)**	**Oxalate (%)**
Linear ($Y=\beta o+\beta ixi + E$)					
CvCpb (Control)	250.13^{g}±0.28	0.545^{c}±0.00	396.26^{c}±0.00	581.04^{ef}±0.77	0.618^{c}±0.01
CvCpm	326.93^{b}±2.28	0.551^{a}±0.00	384.12^{e}±0.00	584.29^{d}±0.14	0.043^{h}±0.00
CvCpf	254.10^{e}±0.05	0.070^{g}±0.00	396.45^{b}±0.00	582.21^{e}±0.25	0.761^{a}±0.01
CvCpj	251.84^{f}±0.13	0.484^{e}±0.00	391.47^{d}±0.00	580.79^{f}±0.26	0.684^{b}±0.01
CvCps	250.87^{fg}±0.09	0.517^{d}±0.00	378.92^{f}±0.00	579.11^{g}±0.23	0.543^{d}±0.01
CvCpt	342.78^{a}±0.27	0.547^{b}±0.00	402.14^{a}±0.00	654.75^{a}±1.57	0.227^{e}±0.00
CvCpc	284.64^{d}±0.11	0.065^{h}±0.00	374.31^{g}±0.00	606.50^{c}±0.52	0.174^{f}±0.00
CvCpp	293.21^{c}±0.11	0.077^{f}±0.00	366.97^{h}±0.00	613.11^{b}±0.65	0.123^{g}±0.00
Interative ($Y=\beta o+\beta_i x_i+ \beta_{ij} x_{ij}+ E$)					
CvCpbm	145.82^{c}±0.28	0.295^{c}±0.00	471.33^{b}±0.00	462.83^{ef}±0.77	1.162^{c}±0.02
CvCpbf	177.55^{bc}±52.9	0.301^{a}±0.00	360.11^{g}±0.00	466.08^{d}±0.14	0.012^{g}±0.00
CvCpbj	149.79^{c}±0.05	0.295^{c}±0.00	415.09^{e}±0.00	464.00^{e}±0.25	1.446^{a}±0.02
CvCpbs	147.53^{c}±0.13	0.265^{e}±0.00	452.69^{c}±0.00	462.58^{f}±0.26	1.292^{b}±0.02
CvCpbt	222.62^{a}±2.28	0.294^{c}±0.00	434.75^{d}±0.00	536.54^{a}±1.57	0.379^{d}±0.01
CvCpbc	219.05^{b}±33.4	0.268^{d}±0.00	490.53^{a}±0.00	488.29^{c}±0.52	0.272^{e}±0.00
CvCpbp	183.19^{abc}±5.1	0.296^{b}±0.00	377.62^{f}±0.00	494.90^{b}±0.65	0.170^{f}±0.00

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

[2]Cassava (Cv): Cowpea(Cp) in the ratio of 70:30; CvCp (70:30): Ten gram (10 g) 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 (5 g+5 g) 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

Conclusion

This study was able to produce a nutritionally rich *danwake* formulation with elevated levels of micronutrients and macronutrients; and significant functional characteristics ─ including increased bulk density, foam stability and foam capacity, oil and water absorption capacity, and as well as viscosity in the formulations when compared to the control. The moisture contents of the formulations were below 10%, indicating reduced risk of microbial spoilage and an extended shelf life. Also, there were significant ($p < 0.05$) increase on the effect of ($Y=\beta o+\beta_i x_i+ \beta_{ij} x_{ij}+ E$) on the *danwake* formulations with the complementation of two vegetables as compared with the control. All the formulated products contain a relatively high amount of calcium, potassium, phosphorus, magnesium, and sodium but lower values for iron, zinc, copper and manganese. Formulation containing cassava/cowpea flours/baobab/moringa leaf powders had the highest nutrient content, respectively. This study also concluded that the leafy vegetables if consumed or blended with other foods in sufficient amount would contribute greatly to the human nutritional requirement for normal growth and adequate protection against diseases arising from malnutrition and weight management. Thus, the use and commercialization of alternative vegetable powders for *danwake* preparation was recommended.

Conflict of Interest

The Authors hereby declare no any conflict of interest with regard to this research.

References

1. American Association of cerealchemists. Approved methods of the American Association of Cereal Chemists. 10th ed. St. Paul: The Association; 2000.
2. Abiodun AO, Zainab OA. Chemical, functional, pasting and sensory properties of fried chips produced from cassava flour enriched with cowpea flour. Croatian Journal of Food Science and Technology. 2018;10(2):220-225. doi: 10.17508/cjfst.2018.10.2.08
3. Adebowale AA, Sanni LO, Onitilo MO. Chemical composition and pasting properties of tapioca grit from different cassava varieties and roasting method. African Journal of Food Science. 2008;2:77-82.
4. Adejuyitan JA, Otunola ET, Akande EA, Bolarinwa IF, Oladokun AM. Some physicochemical properties of flour obtained from fermentation of tiger nut (*Cyperus esculentus*). Journal of Food Science. 2009;3(2):51-55.
5. Ajibola CF, Oyerinde VO, Adeniyan OS. Physicochemical and antioxidant properties of whole-wheat biscuits incorporated with *Moringa oleifera* leaves and cocoa powder. Journal of Scientific Research and Reports. 2015;7(3):195-206.
6. Akubor PI, Isolokwu PC, Ugbane O, Onimawo AI. Proximate composition and functional properties of African breadfruit kernel and wheat flour blends. Food Research International. 2000;33:707-712.
7. Anhwange BA, Tyohemba RL, Tukura BW, Ogah P. Screening of some indigenous wild fruits for anti-nutritional factors. Journal of Scientific Research and Reports. 2014;5(3):220-227.
8. Appiah F, Asibuo JY, Kumah P. Physicochemical and functional properties of bean flours of three cowpea varieties in Ghana. African Journal of Food Science. 2011;5(2):100-104.
9. Arasaretnam S, Kiruthika A, Mahendran T. Nutritional and mineral composition of selected green leafy vegetables. Ceylon Journal of Science. 2017;47(1):35-41. doi: 10.4038/cjs.v47i1.7484
10. Aremu MO, Olaofe O, Akintayo ET. Functional properties of some Nigerian varieties of legume seed flours and flour concentration effect on foaming and gelatinization properties. Journal of Food Technology. 2007;5(2):109-115.
11. Barasi ME. Human nutrition: a health perspective. 2nd ed. London: Hodder Arnold; 2003.
12. Blagbrough S, Bayoumi AL, Rowan MG, Beeching JR. Cassava: an appraisal of its phytochemistry and its

biotechnological prospects—review. Phytochemistry. 2010;17:1940-1951.
13. Butt MS, Batool R. Nutritional and functional properties of some promising legumes protein isolates. Pakistan Journal of Nutrition. 2010;9(4):373-379.
14. Carnovale E, Marletta L, Marconi E, Brois E. Nutritional and hydration properties in cowpea. In: Cowpea genetic resource: contributions in cowpea exploration evaluation and research from Italy and the International Institute of Tropical Agriculture. Rome: International Institute of Tropical Agriculture; 1990. 113.
15. Chweya JA, Eyzaguirre PB. The biodiversity of traditional leafy vegetables. Rome: IPGRI; 1999.
16. Dachana KB, Rajiv J, Indrani D, Prakash J. Effect of dried moringa (*Moringa oleifera* L.) leaves on rheological, microstructural, nutritional, textural and organoleptic characteristics of cookies. Journal of Food Quality. 2010;33:660-677.
17. Day RA, Underwood AL. *Quantitative analysis*. 5th ed. Englewood Cliffs: Prentice-Hall; 1986.
18. Dharmaraja S, Dipayan S. Introduction to statistical methods, design of experiments and statistical quality control. New Delhi: Indian Institute of Technology Delhi; 2018. 223-264.
19. Echendu CA, Obizoba IC, Anyika JU, Ojimelukwe PC. Changes in chemical composition of treated and untreated hungry rice “acha” (*Digitaria exilis*). Pakistan Journal of Nutrition. 2009;8(11):1779-1785.
20. Falade OS, Sowunmi OR, Oladipo A, Tubosun A, Adewusi SRA. The level of organic acids in some Nigerian fruits and their effects on mineral availability in composite diets. Pakistan Journal of Nutrition. 2003;2:82-88.
21. Galla NR, Pamidighantam PR, Karakala B. Nutritional, textural and sensory quality of biscuits supplemented with spinach (*Spinacia oleracea* L.). International Journal of Gastroenterology and Food Science. 2017;7:20-26.
22. Gomez M, Ronda F, Carlos A, Pedro B, Cballero A, Apesteguia A. Effect of dietary fibre on dough rheology and bread quality. European Food Research and Technology. 2003;216:51-56.
23. Houson P, Ayenor GS. Appropriate processing and food functional properties of maize flour. African Journal of Science and Technology. 2002;3:126-131. doi: 10.4314/ajst.v3i1.15297
24. Ibeanu V, Onyechi U, Ani P, Ohia C. Composition and sensory properties of plantain cake. African Journal of Food Science. 2016;10(2):25-32.
25. Ibrahim FM, Anderson YEO, N’Guessan YK, Ernest KK. Influence of baobab leaf enrichment on the physicochemical, sensory and nutritional characteristics of plantain/cashew kernels composite flours. International Journal of Environmental and Agriculture Research. 2018;4(7).
26. Ibro G, Sorgho MC, Idris AA, Moussa B, Baributsa D, Lowenberg-DeBoer J. Adoption of cowpea hermetic storage by women in Nigeria, Niger and Burkina Faso. Journal of Stored Products Research. 2014;58:87-96.
27. Jyoti, Jood S. Physicochemical and nutritional composition of composite flour enriched with spinach leaves powder for development of value-added baked products. International Journal of Chemical Studies. 2020;8(4):1841-1844.
28. Kavitha V, Ramadas VS. Nutritional composition of raw fresh and shade dried form of spinach leaf (*Spinacia oleracea*). Biomedical Research. 2013;1(8):767-770.
29. Kirk H, Sawyer R. Frait Pearson chemical analysis of food. 8th ed. Edinburgh: Longman Scientific and Technical; 1998. 211-212.
30. Kubmarawa D, Andenyang IF, Magomya AM. Proximate composition and amino acid profile of two nonconventional leafy vegetables (*Hibiscus cannabinus* and *Haematostaphis barteri*). African Journal of Food Science. 2009;3:233-236.
31. Kure OA, Bahago EJ, Daniel EA. Studies on the proximate composition and effect of flour particle size of acceptability of biscuits produced from blends of soyabeans and plantain flours. Namoda Technical Scope Journal. 1998;3(2):17-22.
32. Laurena AFM, Rodriguez NG, Sabino AF, Zomora, Mendoza EMT. Amino acid composition relative, nutritive value and *in vitro* protein digestibility of several *Philippine indigenous* legumes. Plant Foods for Human Nutrition. 1991;41:59-68.
33. Masaya FA, Nkama I, Gervase IA, Danbaba N, Alkali YM. Effects of cowpea, yeast and trisodium hydrogen dicarbonate dehydrate levels on proximate and mineral composition of yar’tsala, a traditional rice-based snack of northern Nigeria. Archives of Current Research International. 2017;10(1):1-15.
34. Marshall F. Agriculture and use of wild and weedy greens by the Piik Ap Oom Okiek of Kenya. Economic Botany. 2001;55:32-46.
35. Mathiventhan U, Sivakaneshan R. 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. 2013;2(8):123-132.
36. Meda A, Lamien CE, Romito M, Millogo J, Nacoulma OG. Determination of total phenolic, flavonoid and proline contents in Burkina Faso honeys as well as their radical scavenging activity. Food Chemistry. 2005;91:571-577.
37. Mohammed MI, Sharif N. Mineral composition of some leafy vegetables consumed in Kano, Nigeria. Nigerian Journal of Basic and Applied Science. 2011;19(2):208-212.
38. Narayana K, Narasinga MS. Functional properties of raw and heat processed winged bean (*Psophocarpus tetragonolobus*) flour. Journal of Food Science. 1984;49:944-947.
39. Nkama I. Traditional methods of production of high protein energy foods from grain legumes in the North-Eastern Nigeria. Annals of Borno. 1993;10:138-148.
40. Nwosu JN. The effects of processing on the antinutritional properties of *Ozoroa insignis* seed. Journal of American Science. 2011;7:1-6.
41. Odunlade TV, Famuwagun AA, Taiwo IKA, Gbadamosi ISO, Oyedele IDJ, Adebooye OC. Chemical composition and quality characteristics of wheat bread supplemented with leafy vegetable powders. Journal of Food Quality. 2017;2017:9536716. doi: 10.1155/2017/9536716

42. Ojinnaka MC, Obasi NE, Owuala JK. Partial replacement of wheat flour with mushroom (*Pleurotus tuber-regium*) powder and cocoyam (*Colocasia esculenta*) flour in the production of cookies. Nigerian Agricultural Journal. 2018;49(2):46-54.
43. Ojo MO, Ariahu CC, Chinma EC. Proximate, functional and pasting properties of cassava starch and mushroom (*Pleurotus pulmonarius*) flour blends. American Journal of Food Science and Technology. 2017;5(1):11-18.
44. Olaniran AF, Okonkwo AO, Owolabi OO, Osemwegie O, Badejo TE. Proximate composition and physicochemical properties of formulated cassava, cowpea and potato flour blends. IOP Conference Series: Earth and Environmental Science. 2020;445:012042. doi: 10.1088/1755-1315/445/1/012042
45. Ologhobo AD, Fetuga BL. *Varietal difference* in fatty acid composition of oils from cowpea and lima bean. Food Chemistry. 1983;10:267-274.
46. Onwuka GI. *Food analysis* and instrumentation: theory and practice. Lagos: Naphtali Prints; 2005.
47. Pant R, Chawla R, Sadana B, Kushwaha S. Development and nutritional evaluation of cereal pulse based snacks using drumstick leaves. Agricultural Research Journal. 2012;49(2):99-103.
48. Prajapati R, Chandra S, Chauhan N, Singh GR, Kumar S. Effect of incorporation of flours on the functional properties of composite flours. South Asian Journal of Food Technology and Environment. 2015;1(3):233-241.
49. Regenstein JM, Regenstein CE. Food protein chemistry: an introduction for food scientists. New York: Academic Press; 1984. 1-356.
50. Ritika BY, Baljeet SY, Mahima S, Roshanlal Y. Suitability of wheat flour blends with malted and fermented cowpea flour noodle making. International Food Research Journal. 2016;23(5):2193-2202.
51. Singh S, Yadav A, Sony A. Nutritional evaluation and sensory characteristics of products developed from waste leaves of cauliflower. International Journal of Current Microbiology and Applied Science. 2018;7:4782-4790.
52. Soetan KO, Oyewole OE. The need for adequate processing to reduce the anti-nutritional factors in plants used as human foods and animal feeds: a review. African Journal of Food Science. 2009;3(9):223-232.
53. Trowbridge F, Martorell M. *Forging effective* strategies to combat iron deficiency. Summary and recommendations. Journal of Nutrition. 2002;85:875-880.
54. Udensi EA, Edwu FC, Isinguzo JN. Anti-nutritional factor of vegetable cowpea (*Vigna sesquipedalis*) seeds during thermal processing. Pakistan Journal of Nutrition. 2007;6(2):194-197.
55. Umma SK, Shinya O, Emiko Y, Yoshiya M. Phenolic acids, flavonoids and total antioxidant capacity of selected leafy vegetables. Journal of Functional Foods. 2012;4(4):979-987.
56. Vainio-Mattila K. Wild vegetables used by the Sambaa in the Usambara Mountains, North-East Tanzania. Annales Botanici Fennici. 2000;37:57-67.
57. Yao LH, Jiang YM, Shi J, Tomas-Barberan FAT, Datta N, Singanusong R. Flavonoids in food and their health benefits. Plant Foods for Human Nutrition. 2004;59(3):113-122.