# Physico-Chemical Properties of Water Yam and Cowpea Flour Blends for Production of Snacks

## J. O. Nwafor[1*], A. N. Kanu[1], E. C. Kelechukwu[1], N. O. Nwohu[1] and V. N. Ezebuiro[1]

[1]National Root Crops Research Institute, Umudike, Nigeria.

*Authors' contributions*

*This work was carried out in collaboration among all authors. Author JON designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors JON, ECK, NON and VNE managed the analyses of the study. Authors JON and ANK managed the literature searches. All authors read and approved the final manuscript.*

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## ABSTRACT

**Aim:** The aim of this study is to produce flour from different blend ratio of water yam and cowpea and determination of the physico chemical properties of the snacks produced from the flour blends.
**Introduction:** Snacks are something consumed occasionally for pleasure rather than for nutritive purpose. They are mainly produced by wheat flour. Wheat flour, the main ingredient for production of snacks are imported and thus, the cost of importation of wheat flour eat deep into the Nigeria economy and has placed a considerable burden on the foreign exchange reserve, in the long run causes increase in wheat products. Furthermore, over consumption of wheat products leads to celiac disease associated with immunological disease of the upper intestine triggered by the ingestion of gluten containing cereals. Production of alternative flour to wheat flour can be a welcome idea. Cereal has high nutritional value and it has an appreciable protein content.
**Study Design:** The physico chemical analysis was carried out at the biochemistry laboratory of National Root Crop Research Institute Umudike.
**Methodology:** The water yam (*Dioscorea alata*) and cowpea (*Vigna unguiculata*) flours were prepared and they were used for water yam/ cowpea blend at different ratio of (ie 100%:0, 90:10,

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*Corresponding author: Email: nwaforjames81@gmail.com;*

80:20, 70:30, 60:40 and 50:50). The 100% water yam was the control sample. Functional properties and proximate composition of the samples were determined.

**Results and Discussion:** According to the result generated from the sensory evaluation, it was discovered that yam/ cowpea blend in the ration of 50:50, 60:40 and 70:30 were more acceptable than the other samples. This can be related to the high content of cowpea in the samples.

**Conclusion:** The yam /cowpea blend in the concentration of 50; 50 was more preferred than the other samples by the panelist. As a means of nutritional balance yam fortified with cowpea can boost the protein intake of population consuming yam as its main staple.

## 1. INTRODUCTION

Yam (*Dioscorea spp.*) is an elite crop, preferred over other root and tuber crops in West Africa, the leading producer of yams. Yam is estimated to feed millions of people and is extremely important for at least 60 million people comprising rural producers, processors and consumers in West Africa [1]. Apart from serving as food, yam has a lot of potential industrial uses but unfortunately has not been commercially processed to any significant extent. *Dioscorea alata* is one of the six yam species of economic importance but in Nigeria, it is less utilized for major food products as a result of traditional bias which fails to recognize the unique quality characteristics and the good agronomic flexibility of the species. The species has high yield, high multiplication ratio and better tuber storability, than the preferred indigenous *D. rotundata. D. alata* has an advantage for sustainable cultivation especially when yam production seems to be on the decline as a result of high cost of production, low yields and post-harvest losses among others.

In Nigeria and other developing countries of the world, the economic situation is such that the low income families cannot afford animal protein to meet recommended dietary allowance. There, their diets are mostly of cereals and roots which are devoid of protein. As reported by Onwuka and Ihuma [2], study by the food and Agricultural organization showed that more than one billion people are undernourished. The global menace can be curbed through food enrichment or fortification of legumes and tuber crops [3].

Fortification is a deliberate action where micro nutrient is added to food to boost it nutrient regardless of the original nutrient in the unprocessed food. Anthropometric abnormalities is prevalent where protein is deficit in the nutrient of population with high consumption of starch food [4]. As such is imperative to improve the nutritional quality of yam through fortification with protein rich source will be a welcome idea.

Cake, chinchin, and bread is popular food in Nigeria and other West African Countries and form part of diet for most ethnic groups in Nigeria [5]. Chin chin is a fried snack popular in West Africa. It is a sweet, cookie-like product made from wheat flour, fat, sugar and egg [6].

The outer crust of *cake* is crisp and the interior is spongy like bread. It is considered to be the most commonly consumed cowpea-based food in West Africa [7,8]. Seeds of cowpea can be cooked in the dried form, sprouted or ground into flour in intermediate product. Being in the class of legumes, they are often referred to as poor man's meat 'due to their use as primary protein sources [9]. It is an important dietary staple in West African countries because of its high nutritional value, low cost and broad availability in the region. Legumes are valuable source of proteins, hence blends of tubers and legume diet will satisfy both the protein and carbohydrate requirements of man. Therefore, is necessary to evaluate the Physico-chemical properties of blend flours of water yam and cowpea for production of snacks.

## 2. MATERIALS AND METHODS

### 2.1 Sample Collection

*Dioscorea alata* was obtained fromIzzi Local Government Area of Ebonyi State, Nigeria. The yam tuber was carefully selectedto avoid rot, bruises or sign of spoilage. Cowpea (*Vigna ungiuculata*) and other ingredients were also purchased from Eke market in Ebonyi State.

### 2.2 Preparation of Water Yam and Cowpea Flour

Standard procedure for the preparation of instant yam flour was used for the production of water yam flour as described by Olu et al. [10]. Water yam tubers were manually peeled with a sharp

stainless knife and cut into thin slices so as to ensure efficient heat circulation during blanching and drying. Slices were washed, in order to prevent browning of the yam slices. Yam slices was drained and rapidly blanched at 100℃ for 5 min. The pre-cooked yam slices were dried at 60℃ for 24 hr. The dried yam slices were milled and packaged in polythene bag.

## 2.3 Preparation of Water Yam /Cowpea Flour

Different ratios of water yam and cowpea flours were formulated ranging from 90:10, 80:20, 70:30, 60:40 and 50:50 respectively. 100 percent water yam flour served as control sample, the samples was represented with the codes A, B, C, D, E and F respectively. These were kept aside for preparation of water yam cowpea blend snacks using the following ingredients, margarine, granulated sugar (sucrose), salt, dry baker's yeast, water, vegetable oil.

## 2.4 Sensory Analysis

The sensory analysis was done by the 9-point hedonic scale assessment as described by Iwe [11]. Students from the Department of Chemistry Benue State University Makurdi were selected based on their familiarity with chinchin. The panelists scored the coded snacks in terms of degree of likeness for appearance, taste, texture, crispness and general acceptability.

## 2.5 Statistical Analysis

The statistical package IBM SPSS Programme version 20 was used to analyze data. Results were expressed as mean ± standard error of mean (SEM). One-way analysis of variance (ANOVA) with Duncan post hoc test were used to evaluate the statistical difference between the different groups, the results were considered significance at ($P < 0.05$).

## 2.6 Proximate Analysis of Flours

### 2.6.1 Determination of moisture content

The moisture content of the samples was determined using the hot oven method as described by AOAC [12]. Two grams of each of the samples was put into a washed and dried crucible and placed in the oven at temperature 50°C degrees until the weight was constant. The samples were cooled and weighed. The weight loss was obtained as moisture content and was calculated as:

$$\%\text{Moisture Content} = \frac{W_2 - W_3}{W_2 - W_1}$$

Where:

W1=Initial weight of empty crucible
W2= weight of crucible + sample before drying
W3=final weight of crucible + sample after drying

### 2.6.2 Determination of ash content

Crucibles were placedand lid in the furnace at 550°C overnight to ensure that impurities on the surface of crucible are burned off. Crucibles were cooled in the desecator for 30 min, the crucible were then weighed. About 5 g of sample were weighed into the crucible. It was heat over low Bunsen flame with lid half covered. When fumes are no longer produced. Crucibles were placed in afurnace. It was heated at 550°C overnight. The lid was not covered during heating. The lid was placed over complete heating to prevent loss of fluffy ash. Crucible and lid were weighed when the sample turns to gray. If not, the crucible and lid were returned to the furnace for the further ashing.

$$\textbf{Calculation:} \quad \text{Ash\%} = \frac{\text{Weight of ash x } 100}{\text{Weight of sample}}$$

### 2.6.3 Determination of crude fat

The method described by AOAC [13] was used. Petroleum ether was placed in the bottle and was later transferred into the incubator at 105°C overnight to ensure that weight of bottle is stable. About 3-5 g of sample was weighed, filtered and wrap. The sample was transferred into extraction thimble in the soxhlet. Petroleum ether of about 250 ml was filled into the bottle and taken to the heating mantle, Soxhlet apparatus was connected and the water was turned on to cool it. The heating mantle was switched on. The sample was heated to about 14 hrs heat rate of 150 drop/min, the solvent was evaporated by using the vacuum condenser. The bottle was incubated at 80-90°C until solvent was completely evaporate and bottle was completely dried. After drying, the bottle was transferred with partially covered lid to the desicator to cool, the bottle and it dried content was reweigh.

$$\textbf{Calculation} \quad \text{Fat (\%)} = \frac{\text{weight of fat  x } 100}{\text{Weight of sample}}$$

### 2.6.4 Determination of protein

Sample (0.5-1.0 g) was placed in digestion flask, then 5 g was added in Kjedahl catalyst and 200 ml of conc. $H_2SO_4$, tube containing the above chemical exempt sample as blank was prepared and placed in flasks in inclined, position and heat gently until frothing ceases. It was boiled briskly until solution clear, then cooled and 60 ml of distilled water was added cautiously, flask was immediately connected to digestion bulb on condenser and with tip of condenser immersed in standard acid and 5-7 drops of mix indicator in receiver. Flask was rotated to mix content thoroughly, then heated until all NH3 is distilled, Receiver was removed wash tip of condenser and excess standard acid was titrated, standard NaOH solution was then distilled.

**Calculation** protein (%) = $\frac{(A-B) \times N \times 1.4007 \times 6.25}{W}$

Where

A = volume (ml) of 0.2N HCL used sample titration
B= volume (ml) of 0.2N HCL used in blank titration
N = normality of HCL
W = weight (g) of sample
14.007 = atomic weight (g) of nitrogen
6.25 = the protein – nitrogen conversation factor for fish and its by-product

### 2.6.5 Determination of fibre

The crude fiber was determined by method as described by AOAC [13]. Exactly 2 g of each sample was defatted. The defatted sample was boiled in 200 ml of 1.25% Tetra Oxo Sulphate (VI) solution under reflux for 30 minutes. After that the sample was washed with hot water, using a two-food muslin cloth to trap the particles, the washed sample was transferred quantitatively back to the flask and boiled again in 200 ml of 1.25% sodium hydroxide solution for 30 minutes and washed before it was transferred to a weighed porcelain crucible and dried in the oven at 105ºC for three hours. After cooling in a desicator it was re-weighed. The percentage crude fiber was calculated as follows

% Crude fiber = $\frac{W2 - W3 \times 100}{W1}$

Where:

W1 = weight of sample
W2 = weight of sample + crucible
W3 = weight of crucible + ash

## 2.7 Functional Properties of Water Yam/ Cowpea Blend

Bulk density and swelling index were determined using the method of Onwuka and Onwuka [14] as described by Amandikwa [15], while water and oil absorption capacities were determined by the method of Abbey and Ibeh [16].

### 2.7.1 Determination of bulk density

The bulk density was determined as described by Onwuka and Onwuka [14]. A cylinder (10 ml) was dried and gently filled with 5 g flour sample. The bottom of the cylinder was tapped gently on a laboratory bench several times. This continued until no further diminution of the test flour in the cylinder after filling to mark. The volume of the sample was read from the measuring cylinder.

The bulk density was calculated:

$$\text{Bulk density g/ml} = \frac{\text{Initial wt of samples}}{\text{Volume of sample}}.$$

### 2.7.2 Water absorption capacity

The water absorption capacity was determined as described by Abbey and Ibeh [16]. Flour sample (1 g) of each treatment was weighed separately into clean centrifuge tube of known weights, and then mixed with distilled water to make 10 ml dispersion. The tubes were then centrifuged at 3500 rpm for 15 min. The supernatant was decanted and each tube together with its content was reweighed. The gain in weight was the water absorption capacity of the flour sample.

$$\text{Water absorption capacity} = \frac{B - A}{A} \times 100$$

B=final weight after centrifuge
A= initial weight of sample

### 2.7.3 Determination of oil absorption capacity

The water absorption capacity was determined as described by Abbey and Ibeh [1]. Each flour sample (1 g) was weighed separately and introduced into clean centrifuge tube of known weight. Groundnut oil was mixed with the flour in each of the test tube to make up to 10 ml dispersion. The tubes were centrifuged at 3500 rpm for 15 min. The supernatant was

discarded and the test tubes were reweighed. The gain in weight was calculated as the oil absorption capacity.

$$\text{Oil absorption capacity} = \frac{B - A}{A} x100$$

B=final weight after centrifuge
A= initial weight of sample

### 2.7.4 Determination of swelling index

This was determined as the ratio of the swollen volume to the ordinary volume of a unit weight of the flour as described by Onwuka and Onwuka [14]. One gram of the sample was weighed into a clean dry measuring cylinder. The volume occupied by the sample was recorded before the addition of 5 ml distilled water into the sample. This was allowed to stand undisturbed for an hour, after which the volume was observed and recorded again. The index of swelling ability of the sample was calculated by the formula:

$$\text{Swelling index} \frac{\text{Volume occupied by sample after swelling}}{\text{Volume occupied by sample before swelling}}$$

## 3. RESULTS AND DISCUSSION

### 3.1 Proximate Composite of the Water Yam/ Cowpea Blend

The moisture content ranged from 5.18 – 7.75% with the highest value observed in the water yam/ cowpea flour containing 50:50 blends. This is probably due to the high content of water yam fiber that has the ability to imbibe moisture from the environment and swell water yam has been shown to have hygroscopic or water absorbing properties [17]. The low moisture content generally observed in the sample may add the advantage or prolonging the shelf life of the products, if properly packaged.

The protein content of the sample ranged from 9.03% - 19.63%. The high protein content of the products is as a result of the addition of cowpea flour. Raw cowpea has been reported to contain about 19-21% protein [18]. The progressive solubilization and leaching out of the nitrogenous substances during soaking and boiling of the legume may be responsible for the slight protein reduction in the samples [19] other than these, the general high level of protein, however demonstrates the effect of supplementing legume in water yam.

The result of the analysis show that the fat content of the formulate water yam were generally low, ranging from 0.05 – 0.11%. The presence cowpea in formulation with water yam is responsible for the generally low-fat content of the resulting products, although most of the legumes, with the exception of groundnuts and soybeans contain less than 3% fat [20].

The value obtained the determination of crude fiber content of the formulated water yam and cowpea flour ranged from 1.23 – 1.76%. Higher value were recorded 3.1- 3.8% [21]. Fiber is needed to assist in digestion and keep the gastrointestinal tract healthy and can also help to keep the blood sugar stable. It slows down the release of glucose during digestion. So, cells require less insulin to absorb that glucose. The American diabetes Association recommends that people with diabetes should consume 25- 50 g of fiber per day [22]. The fecal bulking action of insoluble fiber makes it useful in the treatment of constipation and diverticular disease [23].

The results of the ash content analysis of the formulated sample showed significant different (p ≤ 0.05) with values ranging from 0.79 - 3.54 lower values 1.36% [21] was recorded by other researchers.

**Table 1. Proximate composite of the water yam/cowpea blend**

| Samples | Moisture (%) | Ash (%) | Fiber (%) | Fat (%) | Protein(%) | CHO (%) | Energy(k) |
|---|---|---|---|---|---|---|---|
| A | $5.18^f\underline{+}0.28$ | $0.79^f\underline{+}0.01$ | $1.23^f\underline{+}0.05$ | $0.05^f\underline{+}0.20$ | $9.03^f\underline{+}0.44$ | $81.38^a\underline{+}0.28$ | $333^c\underline{+}1.08$ |
| B | $5.18^f\underline{+}0.28$ | $1.93^e\underline{+}0.23$ | $1.49^e\underline{+}0.01$ | $0.06^e\underline{+}0.71$ | $11.06^e\underline{+}0.09$ | $78.36^b\underline{+}2.18$ | $336^b\underline{+}3.26$ |
| C | $6.45^d\underline{+}0.23$ | $2.15^d\underline{+}0.23$ | $1.54^d\underline{+}0.03$ | $0.07^d\underline{+}0.04$ | $12.16^d\underline{+}0.31$ | $73.98^c\underline{+}0.40$ | $340^b\underline{+}1.09$ |
| D | $6.02^e\underline{+}0.06$ | $2.47^c\underline{+}0.32$ | $1.63^c\underline{+}0.02$ | $0.08^c\underline{+}0.04$ | $13.84^c\underline{+}0.75$ | $71.04^d\underline{+}0.39$ | $345^a\underline{+}0.18$ |
| E | $7.40^b\underline{+}0.42$ | $2.48^b\underline{+}0.18$ | $1.73^b\underline{+}0.01$ | $0.09^b\underline{+}0.11$ | $15.53^b\underline{+}0.13$ | $68.74^e\underline{+}0.97$ | $348^a\underline{+}0.18$ |
| F | $7.75^a\underline{+}0.28$ | $3.54^a\underline{+}0.05$ | $1.76^a\underline{+}0.18$ | $0.11^a\underline{+}0.18$ | $19.63^a\underline{+}0.54$ | $63.75^f\underline{+}0.81$ | $349^a\underline{+}1.01$ |

*Means are $\underline{+}$ standard deviation of duplicate determination. Means with the same superscript within the same column are not significantly different (P>0.05). Where: A: 100% water yam flour, B: 90% water yam flour, 10% cowpea flour C: 80% water yam flour, 20% cowpea flour D: 70% water yam flour, 30% cowpea flour E: 60% water yam flour, 40% cowpea flour F: 50% water yam flour, 50% cowpea flour*

**Table 2. Functional property of composite flour of water yam / cowpea blend**

| Sample | BD(g/ml) | WAC(ml/g) | OAC(ml/g) | SWI(ml) | GT% |
|---|---|---|---|---|---|
| A | $0.76^a\pm0.01$ | $2.53^b\pm0.08$ | $3.31^a\pm0.01$ | $0.96^a\pm0.01$ | $6.75^b\pm0.07$ |
| B | $0.74^c\pm0.02$ | $2.67^a\pm0.14$ | $2.75^c\pm0.26$ | $0.94^c\pm0.03$ | $6.55^d\pm0.06$ |
| C | $0.76^b\pm0.01$ | $2.23^e\pm0.09$ | $2.55^e\pm0.43$ | $0.95^b\pm0.02$ | $6.56^c\pm0.08$ |
| D | $0.61^f\pm0.03$ | $2.09^f\pm0.18$ | $2.79^b\pm0.05$ | $0.93^d\pm0.04$ | $6.45^e\pm0.21$ |
| E | $0.69^e\pm0.04$ | $2.52^c\pm0.12$ | $2.63^d\pm0.08$ | $0.91^f\pm0.05$ | $7.35^a\pm0.05$ |
| F | $0.72^d\pm0.02$ | $2.33^d\pm0.15$ | $2.41^f\pm0.04$ | $0.92^e\pm0.02$ | $6.41^f\pm0.09$ |

*Where A =100% water yam flour and B= 90% water yam flour and 10% cowpea flour, C =80 water yam flour and 20% cowpea flour, D = 70% water yam flour and 30% cowpea flour, E =60% water yam flour and 40% cowpea flour, F =50% water yam flour and 50% cowpea flour*

**Table 3. Sensory evaluation of snacks produced from water yam/cowpea blend**

| Sample | Taste | Flavour | Aroma | Texture | Colour | General acceptability |
|---|---|---|---|---|---|---|
| A | $4.52^e\pm1.61$ | $6.15^e\pm1.52$ | $6.17^e\pm1.56$ | $6.06^f\pm1.41$ | $6.20^f\pm1.67$ | $6.25^d\pm1.62$ |
| B | $5.53^d\pm0.96$ | $6.20^e\pm1.33$ | $6.29^d\pm1.33$ | $6.32^e\pm1.21$ | $6.65^a\pm1.20$ | $6.35^c\pm1.29$ |
| C | $6.45^c\pm1.23$ | $6.34^d\pm1.39$ | $6.34^d\pm1.42$ | $6.38^d\pm1.78$ | $6.64^b\pm1.37$ | $6.44^c\pm1.46$ |
| D | $7.46^b\pm1.89$ | $6.43^c\pm1.96$ | $6.45^c\pm1.96$ | $6.42^c\pm1.75$ | $6.24^e\pm1.60$ | $6.59^b\pm1.74$ |
| E | $7.56^a\pm076$ | $6.52^b\pm1.26$ | $6.57^b\pm1.31$ | $6.55^b\pm1.61$ | $6.43^c\pm1.56$ | $6.64^b\pm1.32$ |
| F | $7.57^a\pm1.34$ | $6.55^a\pm1.21$ | $6.72^a\pm1.45$ | $7.22^a\pm1.32$ | $6.32^d\pm1.23$ | $7.46^a\pm1.24$ |

*Where A =100% water yam flour and B= 90% water yam flour and 10% cowpea flour, C =80 water yam flour and 20% cowpea flour, D = 70% water yam flour and 30% cowpea flour, E =60% water yam flour and 40% cowpea flour, F =50% water yam flour and 50% cowpea flour*

The values from the carbohydrate content analysis of the formulated samples ranged from 63.75 81.38% There is significant different (p ≤ 0.05). Higher carbohydrate value was reported for water yam formulated at sample F (50:50). The higher carbohydrate values recorded by other researchers may be attributed to the higher content of the water yam and cowpea blends [24].

The values obtained for the total energy content of the formulated samples ranging from 333 – 349 kcal were found to be within the range value of 314 – 420 kcal [25]. The values stated showed the amount of energy in food that can be supplied to the body for maintenance of basic body function such as breathing, circulation of blood, physical activities and the rmic effect of food. Increasing addition of coconut fiber was inversely proportional to the energy value of the products.

### 3.2 Functional Properties of the Water Yam/ Cowpea Blend

**Bulk density:** The result of bulk density of the blends ranged from 0.61±0.01 - 0.76±0.02 g/ml with the highest value found in the sample with 100:0 formulations. There was a gradual reduction of the bulk density with increase in the addition of the cowpea flour, although the sample with 90:10, 80:10, 70:30 formulations did not

have significant differences (p ≥ 0.05). Higher values of bulk density (2.45±0.10 and 2.60±0.05) were recorded by Egounlety et al. [21] the bulk density of the product may require identical packaging space. The less the bulk density the more packaging space is required [21].

The Water Absorption Capacity of the water yam-cowpea flour blend ranged from 2.09±0.03 - 2.67±0.14 in which sample B had the highest valued while sample D had the lowest valued of 2.09±0.03. It was found to decrease with increase of cowpea flour inclusion. This may be connected to the fact that water fiber has hygroscopic properties, thus, swelling on exposure to moisture [17].

Swelling power of the varieties ranged from 0.96±0.01 - 0.91±0.01%. *Water yam blend,* the reference variety had significantly (p < 0.05) higher value of 12.06%. *D. roundata* is known to have higher swelling power in comparison to other species of yam as observed in this study [26,27]. Swelling power is largely controlled by the strength and character of the micellar network within starch granules. The low swelling power obtained is attributed highly ordered internal arrangement in their starch granules.

The oil absorption capacity of the blend flour varied in trend from those obtained for water absorption capacity. The values ranged from

03.31±0.01 – 2.41±0.01 with the highest value recorded for the sample 50:50 formulations. The hydrophobicity of protein is known to play a major role in fat absorption. This acts to resist physical entrapment of oil by the capillary of non-polar side chain of the amino acids of the protein molecules there were significant differences ($p \leq 0.05$) among all the samples.

## 3.3 Sensory Evaluation of Snack Produced from Water Yam/ Cowpea Blend

Samples A, B, C and D showed no significant difference in their colour. However, sample E and F showed a significant difference ($P > 0.05$) which ranged from golden brown to light brown. The substitution of the sample with higher fraction of cowpea makes the color lighter. The texture of samples A and C was not significantly different, while samples B and D had the same texture compared to samples E and F which had different textures form all other samples.

The flavor of the samples did not show any significant difference in sample A, B C and D but sample E and F are significantly difference ($P > 0.05$) from each other. This can be traced to the addition of high ratio of cowpea flour. The taste of A, B, C and D were not significantly different ($P > 0.05$) from each other. They contained lesser quantity of cowpea flour but with the exception of A which had no cowpea flour. In conclusion sample F was more accepted than other samples in term of their flavor, taste, aroma and general acceptability.

## 4. CONCLUSION

The findings from this study showed that sample F was more accepted by the panelist followed by sample E, D and C. The taste of the samples became sweeter with substitution as compared to E (60:40) and F (50:50) which had better taste. Sample A (100) control, had the list taste, flour and aroma due to no cowpea flour. The textures of the flours were different due to the quantity of cowpea flour that was added to each sample. Increase in protein, fiber, ash, and fat, in sample F (50:50) makes the blend good source for nutritional balance in water yam and cowpea flour. Increase in aroma, taste and general acceptability in sample C (80:20), shows that addition of 20% cowpea can also give the highest acceptability. Fortification of water yam flour with cowpea has been shown to increase it nutritional quality.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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