



## Proximate and Mineral Composition of A Sorghum Stem Sheath Beverage (Poporo) Spiced with *Aframomum melegueta* Extract

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### Authors' contributions

This work was carried out in collaboration between all authors. Author BIOA designed and supervised the study, author IBO managed the literature search and correction of the thesis and manuscript while author TOA wrote the first draft of the manuscript. All authors read and approved the final manuscript.

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### ABSTRACT

**Aims:** The nutritional quality of a non-alcoholic beverage produced from sorghum stem sheath (Poporo) spiced with alligator pepper (*Aframomum melegueta*).

**Study Design:** Multifactorial design was used for this study.

**Place and Duration of Study:** The study was carried out in the Chemistry, Food Processing, Sensory and Microbiology Laboratories of the Department of Food Science and Technology, Federal University of Technology, Akure, Ondo State, Nigeria, between September, 2011 and July, 2012.

**Methodology:** Dried sorghum stem sheath was cleaned by removing extraneous materials, milled and sieved. The most appropriate ratio of 1:30 (w/v) stem sheath flour to water based on preliminary test was employed for the beverage formulation. Alligator pepper was added in sequential concentrations of 0.5, 1, 1.5, 2, and 2.5% making a total of 6 samples with the control. The nutritional quality of the beverage (**poporo**-which is the beverage obtained from aqueous extract of dried stem sheath of *Sorghum bicolor*) was

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investigated. The samples were subjected first to pasteurization at 75°C for 15mins. The formulated beverage samples with alligator pepper extract were analyzed to determine its nutrient profile: proximate and mineral compositions.

**Results:** Proximate analysis of the spiced stem sheath beverage showed the moisture content to range between 87.7-88.2%, crude protein between 0.005-0.047% and crude fat from 0.009-0.140% while pH and titratable acidity were 7 and 4 for all the beverage samples respectively. The plain beverage sample had the least protein and fat contents thereby indicating the significant effect of the *Aframomum melegueta* spice on the beverage samples at  $p < 0.05$ . High mineral contents were also recorded for the spiced beverage samples: magnesium ranged between 145-200 mg/100ml, sodium ranged between 25.00-25.20mg/100ml, potassium 23.03-26.68mg/100ml, calcium 50.00-54.54mg/100ml, iron 4.00-5.91mg/100ml, zinc 2.50-3.51mg/100ml, manganese 0.38-0.89 and copper 0.041-0.079mg/100ml. In all the samples the plain ones (control) had the least mineral contents.

**Conclusion:** The nutrient profile increased significantly at  $p < 0.05$  with the addition of alligator pepper, the degree of enhancement was dependent on the concentration of the spice. The overall sensory evaluation revealed that the sample spiced with 0.5% extract of alligator pepper was most preferred by the panellists.

*Keywords: Beverage; proximate composition; mineral; sensory; sample; alligator pepper.*

## 1. INTRODUCTION

Sorghum is one of the most important staple crops in Nigeria. Its production was estimated to surpass all other cultivated crops in Nigeria as reported by [1]. For instance, in the Nigeria savannah zone, sorghum is grown on an estimated area of 4.5 million hectares with annual production output of about 6 million tonnes [2]. The leaves and grains are also incorporated into livestock feeds and the stalks for thatching houses and making fences [3]. The stem is sweet and contains some sugars and minerals which make it useful for syrup manufacture. The dried stem is used as fuel in the tropics [4]. It is a very valuable industrial crop for brewing alcoholic and non- alcoholic drinks as well as in the baking and confectionery industry in Nigeria [5]. Sorghum has greater unutilized potentials than any other crop. Information available in the literature reveals that the sorghum stem sheath is still confined to traditional use only.

The mature black purple sheath of the stem sorghum (locally known as *poporo*) generally sold in small bundles is used as colour additives in cooking meals and also taken as beverages when steeped or boiled in water in many homes [6]. It can also be used to extend food shelf life. *Sorghum bicolor* has the highest known concentration of apigenin which corresponds to its anthocyanin quantity thereby making it a great commercial value as natural colorant in Nigeria [7]. Sorghum stem sheath extract are used as folklore for the management of anaemia and some other diseases in many Nigeria homes. It is used to boost blood levels to treat anaemia, stop pain and inflammation, reverse cell damage (antioxidant) and increase cellular immunity in persons living with HIV/AIDS [8]. In South Western Nigeria, the extract has been used for many generations to treat sickle cell anaemia, leukaemia, multiple myelomas, headaches, heart and other blood-related disorders. Consumption of fermented drink from sorghum bicolor seeds alone for seven days is reported to serve as good anti-sick ling drugs [9]. The stem of *Sorghum bicolor* has also been reported to be used as an anti-malaria and anthelmintic [10]. Higher consumption of food of plant origin such as *Sorghum bicolor* stem extract rich in natural antioxidants that can

scavenge free radicals has been reported to fight against degenerative diseases (cyclophosphamide-induced oxidative stress) thereby improving the body's antioxidant status [11].

Antioxidant properties of spices have been recognized about six decades ago when it was demonstrated that spices effectively increased the antioxidant capacity of foods and that their effects depended on food matrices [12]. Studies on culinary and medicinal herbs identified the superiority of spices in antioxidant capacity to berries, other fruits, vegetables and nuts [13]. The use of local spices to control the activities of micro-organisms in food has been reported [14]. Apart from antimicrobial activities, spices are believed to have medicinal value (especially in African settings) and have desirable determinative influences on the overall organoleptic analysis when used. It is desirable therefore that further exploitation of locally available spices in the formulation of acceptable non- alcoholic beverage be encouraged for the benefit of the local people and the nation at large. This study therefore, seeks through intensive investigation to develop an acceptable non-alcoholic beverage from *Sorghum bicolor* stem sheath in combination with alligator pepper. The objective of this study is to formulate an acceptable beverage from sorghum stems heath in combination with alligator pepper and to evaluate the nutritional content of the spiced beverage.

## **2. MATERIALS AND METHODS**

### **2.1 Materials**

Mature reddish-purple *Sorghum bicolor* L. Moench stem sheath locally known as *poporo*, alligator pepper (*Aframomum melegueta*) and food grade sucrose. Sorghum stem sheath in dry form and alligator pepper were purchased from a local market in Oshogbo, Osun State, Nigeria.

### **2.2 Preparation of Sorghum Stem Sheath Flour**

The sorghum stem sheath was dry cleaned and further dried in an air oven at 50°C for 6hrs for moisture uniformity. The dried samples were milled separately into flour using a coffee mill and sieved through 450µm aperture sieve. The flour samples were packed in air tight containers until utilized.

### **2.3 Preparation of Poporo Extract**

The stem sheath flour was soaked for 30mins at ambient temperature before boiling for 30mins. The extract was then filtered with clean muslin cloth to obtain clear filtrate. The filtrate was sweetened with food grade sucrose to a brix level of 10°. The sweetened beverage was then dispensed into previously sterilized bottles before pasteurization at 75°C for 15mins [15].

### **2.4 Preparation of Liquid Extract of Alligator Pepper**

The method described by [16] was adapted. The alligator seeds were sorted and cleaned from extraneous materials. It was further dried in an oven at 50°C for 48hrs only. It was further pulverized in a hammer mill and sieved to obtain the powdered form. The powdered spice was then packed in an air tight container.

Moreover, the dry crude extract of alligator pepper (*Aframomum melegueta*) was weighed differently and mixed with distilled water at (50:100, 100:100, 150:100, 200:100, 250:100) w/v to make 0.5%, 1.0%, 1.5%, 2.0% and 2.5% concentrations. Each mixture was then pasteurized at 75°C for 15 minutes and the liquid extracts were kept in previously sterilized bottles and cooled at ambient temperature before storage in a refrigerator (8 ± 2°C) until used.

## 2.5 Preliminary Investigations on the Stem Sheath Beverage Preparation

Some preliminary tests were conducted to establish the method to be adopted for the beverage preparation: the brix levels of some non-alcoholic beverages like zobo and soya milk were checked using a handheld refractometer so as to ascertain the best suitable brix level for the beverage preparation. The most appropriate proportion of stem sheath flour to water was investigated for the beverage preparation. Varying proportions of the stem sheath flour to water were tested (1:10, 1:20; 1:30, 1:50 and 1:70w/v) for the infusion. The soaking and boiling time necessary for the beverage preparation was also investigated using the same ratio of the stem sheath to water in order to ascertain the best formulation. The method described by [15] was adapted. The stem sheath flour was soaked for 30 mins at ambient temperature before boiling for 30 mins. The most appropriate ratio of 1:30 (w/v) stem sheath flour to water was used for the beverage preparation. The filtrate obtained was mixed with the extracts of alligator pepper (*Aframomum melegueta*) as described in section 2.4. This implies a total of 6 samples including beverage without spice (control). The extract was then filtered with clean muslin cloth to obtain clear filtrate. The mixture was sweetened and pasteurized as described in section 2.3 to obtain a ready to drink beverage. The beverage samples were then subjected to further investigations.

## 2.6 Proximate Composition of the Stem Sheath Beverage

### 2.6.1 Determination of crude protein

About 1ml of the samples was measured into micro Kjeldhal digestion flask and one tablet of Selenium catalyst was added. The mixture was digested on an electro thermal heater until clear solution was obtained. The flask was allowed to cool after which the solution was diluted with distilled water to 50ml and 5ml of this was transferred into the distillation apparatus. 5ml of 2% boric acid was pipetted into a 100ml conical flask (the receiver flask) and four drops of screened methyl red indicator were added. About 50% NaOH was continually added to the digested sample until the solution turned cloudy which indicated that the solution had become alkaline. Then distillation was carried out into the boric acid solution in the receiver flask with the delivery tube below the acid level. As the distillation was going on, the pink colour solution of the receiver flask turned blue indicating the presence of ammonia. Distillation was continued until the content of the flask was about 50ml after which the delivery of the condenser was rinsed with distilled water. The resulting solution in the conical flask was then titrated with 0.1M HCl [17].

Calculation:

$$\% \text{ Nitrogen} = \frac{\text{Titre value} \times 0.1 \text{ HCl} \times 0.014 \times 100}{\text{Original weight of sample}} \times \frac{50}{5} \text{ -----(1)}$$

**2.6.2 Determination of dry matter and moisture content**

About 2ml of each sample was measured into a previously weighed crucible, dried over water for sometimes. The crucible plus sample taken was transferred into the oven set at 100°C to dry to a content weight for 24hours overnight. At the end of 24 hours, the crucible plus sample was removed from the oven and transfer to the dessicator, cooled for 10 minutes and weighed [17]. The weight of empty crucible plus sample was taken as  $W_1$  while the weight of crucible plus oven dried sample was  $W_3$  [17].

$$\% \text{ Dry matter} = \frac{W_3 - W_0}{W_1 - W_0} \times 100 \text{ ----- (2)}$$

$$\% \text{ Moisture content} = \frac{W_1 - W_3}{W_1 - W_0} \times 100 \text{ ----- (3)}$$

$$\% \text{ Moisture content} = 100 - \% \text{Dm} \text{ ----- (4)}$$

**2.6.3 Fat determination**

This was carried out using the method of [17]. Clean and dried thimble was weighed ( $W_1$ ) and 5ml of the dried sample was measured and weighed ( $W_2$ ). Round bottom flask was filled with petroleum ether (40-60) °C up to  $\frac{3}{4}$  of the flask. Soxhlet extractor was fixed with a reflux condenser to adjust the heat sources so that the solvent boils gently, the samples were put inside the thimble and inserted into the Soxhlet apparatus and extraction under reflux was carried out with petroleum ether for 6 hours. After the barrel of the extractor is empty, the condenser was removed and the thimble also removed, taken into the oven at 100°C for 1 hour and later cooled in the dessicator and weighed again ( $W_3$ ).

$$\% \text{ Fat} = \frac{\text{Weight loss of sample (extracted fat)}}{\text{Original weight of sample}} \times 100 =$$

$$\frac{W_2 - W_3}{W_2 - W_1} \times 100 \text{ ----- (5)}$$

**2.7 Chemical Analysis**

**2.7.1 pH measurement**

The pH was measured using a pH meter, digital model EA 513-055, ELE, England standardized with buffer solution of 4.0 and 7.0 [17]. The glass electrode of pH meter was dipped in 30mls of the beverage sample measured into a Curvette at ambient temperature and was allowed to stabilize for sometimes after which the reading was taken.

**2.7.2 Titratable acidity**

About 4 ml of the sample was measured into a 250ml conical flask and 200ml of carbon dioxide with distilled water added. The flask was allowed to stand in a water bath at 40°C for 1hr. It was swirled occasionally to ensure complete mixing before filtration. Phenolphthalein was added after filtration and then titrated against 0.1m NaOH solution [17]. The result was expressed as % lactic acid equivalent present in the beverage.

$$\text{Acidity (\% lactic acid)} = \frac{\text{Volume of 0.1M NaOH Used} \times 0.09}{\text{Weight of the sample}} \times 100 \text{ ----- (6)}$$

### **2.7.3 Determination of mineral contents**

The method described by [17] using Atomic Absorption Spectrophotometer (AAS), Buck Scientific East Norwalk, CT, USA was used for mineral contents determination. The minerals determined were potassium, sodium, calcium, iron, magnesium, copper, manganese, lead and zinc. The wavelengths used ranged between 190-900nm with accuracy of  $\pm 0.25\text{nm}$  as specified for each mineral [17]. The baseline stability was 0.004A/30min and the D2 lamp background correction capability was at 1A. The S-H background correction capability was at 1.8A. Lamp current was automatically adjusted and displayed with wide pulse current being 0~25mA, and the narrow pulse current was 0~10mA. Lamp power supply mode was 100Hz and narrow square wave pulse (+400Hz). Czerny-Turner design grating monochromatic was used. Grating was 1800 l/mm, focal length (277mm) and blazed wavelength (250nm). Spectral Bandwidth of 0.1nm, 0.2nm, 0.4nm and 1.2nm were used. Graphite furnace at a temperature of 3000°C, the heating rate being 2000°C/s was used. The graphite tube dimension is 28 mm (L) x 8mm (OD). The standard used was RS-232 serial port communication, characteristic Air-C H flame Cu: characteristic concentration  $\leq 0.025\text{mg/L}$  and the detection limit was  $\leq 0.006\text{mg/L}$ . The concentrations of the various metallic mineral elements were determined in triplicates.

### **2.8 Sensory Evaluation**

The beverage samples were presented as coded samples to 10 semi -trained panellists according to the method reported by [18]. The panellists were asked to indicate their observations using a 9- point hedonic scale for taste, after taste, flavour/aroma, colour, consistency and overall acceptability. The coded samples were served in clean transparent bottles at room temperature (25°C).

### **2.9 Statistical Analysis**

This was done using Statistical Analysis Software [19] package (version 8.2 of SAS Institute, Inc.). The sensory scores from the ratings were subjected to analysis of variance (ANOVA) and means were separated using Duncan multiple range test [20] and the significance was accepted at  $p < 0.05$ . Samples were presented to the panellist at random and one at a time. The panellists were given clean water to rinse their mouths between each sample. Like extremely and dislikes extremely were ranked 9 and 1 respectively.

## **3. RESULTS AND DISCUSSION**

### **3.1 Proximate Composition, pH and Titratable Acidity of Sorghum Stem Sheath Beverage**

The proximate composition of sorghum stem sheath beverage is presented in Table 1. The moisture content of the beverages ranged from 87.7-88.2% showing significant difference ( $p < 0.05$ ) among treatments. It was observed that all the spiced samples had higher moisture contents than the Control. (i.e. without spice). A decreasing trend in the moisture content with increasing concentration of alligator pepper in the samples was observed. High

moisture content makes beverage suitable as a refreshing and thirst-quenching drink, which is characteristic of good beverage.

Alligator pepper (*Aframomum melegueta*) spiced samples had higher protein content than the plain beverage. The plain beverage had a protein content of 0.005% while a range of 0.005 to 0.047% was recorded for samples containing alligator pepper extracts at varying concentrations respectively. The observation shows a progressive significant decrease in the protein content with increasing alligator pepper concentration in the sample. This may be attributed to the effect of heat process involved in the extraction which might have destroyed some amino acids with consequent reduction in total nitrogen content of the resulting beverage [21]. However, the protein contents of the alligator pepper spiced samples (0.052 – 0.092) % were found to be higher than that of the zobo drink (0.046)% produced from *Hibiscus sabdariffa* calyxes.

**Table 1. Chemical and proximate composition (%) of poporo beverage**

Level of addition (%)	Samples	Moisture	Protein	Crude fat
Control	XK	87.9b	0.005d	0.009c
0.5	XA	88.2a	0.047a	0.140a
1.0	XB	88.0bc	0.033b	0.130ab
1.5	XC	87.9b	0.029b	0.120ab
2.0	XD	87.8bc	0.018c	0.110b
2.5	XE	87.7c	0.009d	0.110b

**Key:** XA: 0.5% alligator pepper (A.P.) XB: 1.0% alligator pepper XC: 1.5% alligator pepper XD: 2.0% alligator pepper XE: 2.5% alligator pepper XK: control (without spice). Values are means of 4 determinations. Values with the same letter along the column are not significantly different at  $p > 0.05$ .

The spiced samples had higher crude fat content than the plain beverage sample. The ether content of alligator pepper (11.00%) has contributed significantly at  $p < 0.05$  to the increase in fat content of beverage though the beverage is not a good source of fat [22]. Plain beverage had a crude fat content of 0.005% while a range of 0.009 to 0.140% was recorded for samples containing alligator pepper extracts at the varying concentrations. The result showed a progressive significant decrease in the moisture, protein and fat contents as the level of alligator pepper concentration exceeds 1.5% in the sample. Hence, its inclusion beyond this level may not be advisable.

The pH of the freshly prepared beverage samples with spice was found to be 7 which were neutral while the titratable acidity was found to be 4% which remained fairly constant. The pH of the stem sheath (7.0) is higher than that of pre-treated tiger nut juice as reported by [23]. This is also an indication that the beverage is less acidic which may be advantageous to patients with stomach and peptic ulcer and other related problems. The observation reveals that the extract is neutral suggesting the need for inclusion of preservative to extend its shelf-life.

### 3.2 Mineral Composition of the Non-Alcoholic Beverage

The mineral composition of poporo is presented in Table 2. The plain beverage (Control) had a magnesium content of 145.00mg/100ml while a range of 159.10-200.42mg/100ml was recorded for samples containing alligator pepper extracts at varying concentrations respectively. Alligator pepper spiced beverage samples significantly ( $p < 0.05$ ) had higher magnesium content than the Unspiced samples. A significant ( $p < 0.05$ ) decreasing trend in

the magnesium content with increasing concentration of alligator pepper in the samples was observed. Control sample had the least magnesium content in the beverage indicating the advantage of spicing the beverage with alligator pepper. However, the magnesium content of Zobo (30.03mg/100ml) was lower than that of the stem sheath beverage [24].

The plain beverage had a sodium content of 25.00mg/100ml while that samples spiced with alligator extract were found to vary from 25.20 - 25.33 mg/100ml. There was a decreasing trend ( $p < 0.5$ ) in the sodium content with increasing concentration of alligator pepper in the beverage. However, the sodium content of the Zobo drink (5.90mg/100ml) was found to be lower than that of the stem sheath beverage [25].

**Table 2. Mineral Composition (mg/100ml) of the non-alcoholic Beverage**

Sample code	Mg	Na	K	Ca	Fe	Zn	Mn	Cu
XK	145.00 <sup>c</sup>	25.00 <sup>c</sup>	23.03 <sup>c</sup>	50.00 <sup>d</sup>	4.00 <sup>e</sup>	2.50 <sup>f</sup>	0.380 <sup>d</sup>	0.06 <sup>a</sup>
XA	200.40 <sup>a</sup>	25.20 <sup>a</sup>	28.68 <sup>a</sup>	54.54 <sup>a</sup>	5.91 <sup>a</sup>	3.51 <sup>a</sup>	0.89 <sup>a</sup>	0.06 <sup>a</sup>
XB	190.20 <sup>a</sup>	25.18 <sup>ab</sup>	26.55 <sup>ab</sup>	54.41 <sup>ab</sup>	5.75 <sup>b</sup>	3.30 <sup>b</sup>	0.76 <sup>b</sup>	0.07 <sup>a</sup>
XC	181.10 <sup>ab</sup>	25.15 <sup>b</sup>	25.48 <sup>b</sup>	54.39 <sup>b</sup>	5.52 <sup>c</sup>	3.10 <sup>c</sup>	0.64 <sup>c</sup>	0.07 <sup>a</sup>
XD	170.20 <sup>b</sup>	25.13 <sup>bc</sup>	25.31 <sup>bc</sup>	54.35 <sup>bc</sup>	5.37 <sup>d</sup>	2.90 <sup>d</sup>	0.50 <sup>d</sup>	0.07 <sup>a</sup>
XE	159.10 <sup>c</sup>	25.10 <sup>c</sup>	23.24 <sup>c</sup>	54.28 <sup>bc</sup>	5.20 <sup>d</sup>	2.70 <sup>e</sup>	0.42 <sup>d</sup>	0.07 <sup>a</sup>

**Key:** XA: 0.5% alligator pepper (A.P.) XB: 1.0% alligator pepper XC: 1.5% alligator pepper XD: 2.0% alligator pepper XE: 2.5% alligator pepper XK: control (without spice). Values are means  $\pm$  S.D. of 4 determinations. Values with the same superscript along the column are not significantly different at  $p > 0.05$

The potassium content of Control was 23.02mg/100g while that of the spiced samples were higher (23.71-28.18mg/100g). Alligator pepper spiced beverage samples significantly ( $p < 0.05$ ) had higher potassium content than the Unspiced samples. A decreasing trend ( $p < 0.5$ ) in potassium content with increasing concentration of alligator pepper were also observed. Nevertheless, it could be seen from Table 2 that the addition of spice significantly enhanced the potassium content of the beverage samples.

Calcium content of Control (50.00mg/100ml) is also observed to be lower than the spiced samples (50.18-54.54mg/100ml). However, [25, 26] reported the calcium content of Zobo drink (6.00mg /100ml) to be lower than that of the stem sheath beverage. This mineral was also observed to decrease with increasing concentration of the alligator pepper.

The sorghum stem sheath beverage is rich in iron content. The control with iron content of 4.00mg/100ml is higher than that found in Zobo (2.40mg/100ml) while higher values (5.20-5.91mg/100ml) are recorded for the spiced samples. The spiced samples had significantly ( $p < 0.05$ ) lower zinc content than the plain beverage (Control) while in the contrary; the manganese contents were higher in the spiced samples (Table 2).

### 3.3 Sensory Attributes of the Beverage Samples

The sensory attributes of the formulated beverage samples are presented in Table 3. Beverage spiced with 0.5% alligator pepper (*Aframomum melegueta*) had the best ratings in all sensory attributes evaluated. Unspiced beverage (control) had the least ratings in all the sensory attributes indicating the potential of the spices in producing acceptable beverage from sorghum stem sheath. Interestingly, this observation agrees with the results of the chemical analyses in which 0.5% alligator pepper showed better results. Varying the



concentration of alligator pepper in the beverage did not result in significant ( $p < 0.05$ ) changes in almost all the studied sensory attributes. From the result in Table 3, beverage formulated with 0.5% alligator pepper was best preferred by the panellists.

**Table 3. Mean sensory quality attributes of the formulated sorghum stem sheath beverage**

Sample code	Colour	Taste	After taste	Consistency	Flavour	Overall acceptability
XK	5.00c	3.17d	3.50d	3.33d	3.00c	4.83c
XA	6.40a	5.00a	4.83a	5.00a	5.20a	5.83a
XB	5.67ab	4.80a	4.80ab	4.80b	4.83ab	5.80a
XC	5.33b	4.50b	4.60b	4.80b	4.33b	5.40b
XD	5.17bc	4.50b	4.50b	4.33c	4.30b	5.33b
XE	5.17bc	4.20c	4.00c	4.33c	4.28b	5.30b

**Key:** XA: 0.5% alligator pepper (A.P.) XB: 1.0% alligator pepper XC: 1.5% alligator pepper XD: 2.0% alligator pepper XE: 2.5% alligator pepper XK: control (without spice). Values are means of 4 determinations. Values with the same letter along the column are not significantly different at  $p > 0.05$ .

#### 4. CONCLUSIONS

This study has drawn attention to the potential of sorghum stem sheath and local spices in formulating nutritious and health promoting non-alcoholic beverage for the consumption of the Nigerian populace. From the foregoing, it can be concluded that sorghum stem sheath is a promising rich plant material that could be used in the formulation of functional foods as evidenced in its nutritional profile recorded in this study. Protein, fat and mineral contents increased significantly in all the spiced samples. The most abundant minerals in the drink were magnesium followed by calcium, potassium, sodium, iron, manganese, copper and zinc. However, progressive decrease in the nutrient was observed with increasing concentrations of the spices beyond 1.5%. This could possibly be attributed to the dilution influence of the components in the spices at higher levels of inclusion. The result of this study reveals that nutritious non-alcoholic beverage could be produced from sorghum stem sheath with local spice.

#### RECOMMENDATIONS

The following recommendation could be made from this study:

The formulated beverage could serve as a refreshing drink to people of all social classes thereby replacing synthetic drinks which are detrimental to human health. Industrial production of this beverage should therefore be encouraged, which would not only alleviate the longing for fluid intake in warm tropical climate but could also provide a cheaper and more nutritive drink than the sugar laden fizzy drinks in the market. Further studies are needed on the synergetic effect of the local spice used. Studies on other spices are also recommended to generate more data which could assist in the commercial production of the product.

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## CONSENT

Not applicable.

## ETHICAL APPROVAL

Not applicable.

## COMPETING INTERESTS

Authors hereby declare that no competing interests exist.

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