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# Comparative Nutritional and Anti-Nutritional Assessment of Raw and Processed Varieties of Granulated Sorghum (*Sorghum Bicolor* and *Sorghum Arundinaceum*) and Acha (*Digitaria Exilis*) Dumpling

**Ogungbemiro Festus Oladayo[1*], Ode Rikko John[2], Fatima Amin Adamude[2], Adeoye Ismail[3], Abu Yusuf Uwello[1], Ikebuiro Joshua Onyeka[2], Akpomie Timothy[1], Amos Idzi Ambo[1], Douglas Ernest Tanko[1], Ogbuji Joshua Chigozie[1], Yohanna Garba Enwongulu[1]**

[1]*Department of Chemistry, Federal University of Lafia, Nasarawa State, Nigeria*

[2]*Department of Biochemistry, Federal University of Lafia, Nasarawa State, Nigeria*

[3]*Interim Joint Matriculation Board Unit, Federal Polytechnic, Nasarawa State, Nigeria*

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***Corresponding author:** Ogungbemiro Festus Oladayo, Department of Chemistry, Faculty of Science, Federal University of Lafia, Nigeria, E-mail: ogungbemirofestusoladayo@gmail.com*

## Abstract

**Background**: In view of the importance of improving human nutrition, especially among Nigerian resource poor families living in the north, by using local and easily accessible ingredients, it is important to assess and evaluate the nutritional and anti-nutritional properties of raw and processed cereal based *dambu* produced using different compositions of pepper, ginger, soya beans, fried groundnut, moringa and other ingredients.

**Aim of this work**: To comparatively assess the nutritional and anti-nutritional composition of processed varieties of granulated sorghum (*Sorghum bicolor* and *Sorghum arundinaceum*) and acha (*Digitaria exilis*) dumpling.

**Methodology**: Our study utilized two types of cereals (sorghum and acha) of different varieties (popularly consumed in Northern Nigeria. Standard analytical protocols were strictly adhered to.

**Results**: Findings from the proximate analysis revealed that the moisture content ranged from (17.90 – 18.64 %), ash contents (1.96 – 3.08 %), crude protein contents (6.50 – 10.19 %), crude fiber contents (2.12 -3.08 %), crude fat content (2.12 – 5.41 %), carbohydrates (60.76 -79.89 %) and calorific value (296.10 – 348.60 %). Mineral elements analysis showed concentration that ranged thus: sodium (46.00 - 52.62 mg/100g), potassium (307.37 – 411.60 mg/100g), calcium (114.82 – 122.72 mg/100g) and phosphorus (169.09 – 218.15 mg/100g) were found to be high in the processed dambu from two varieties of sorghum (*bicolor* and *arundinacuem*). The levels of anti-nutrients: tannins (0.48 – 0.54 %), phytate (1.34 – 1.46 %) and hydrogen cyanide (1.27 – 1.36 %) showed little interference with protein and carbohydrate digestion and mineral bioavailability in the samples analyzed. Vitamins analysis confirmed that all samples analyzed were rich in vitamins A (24.16 – 26.99 mg/100g), vitamin E (2.06 – 2.17 mg/100g), thiamine (0.16 – 0.28 mg/100g) and riboflavin (0.24 – 0.36 mg/100g).

**Conclusion**: The result obtained from the proximate analysis showed how the raw variety of Sorghum arundinaceum significantly contained sufficient quantity of ash which confirmed its high minerals (Na, Ca, P and K) levels, while low moisture contents in all the samples suggests minimal antimicrobial susceptibility. Availability of vitamin A, E, thiamine and riboflavin in the raw and processed samples indicates that they are good plant vitamin source. Low level of the anti- nutritional factors; phytate, tannins and HCN within consumption rate will barely interfere protein, carbohydrate and minerals component.

**Keywords**: Dambu; Food Dumpling; Proximate Composition; Anti-Nutrient Composition; Vitamins; Anti- Nutrient; Nasarawa.

## Introduction

Cereal grains are very important crops especially in the developing world where sorghum (*Sorghum bicolor*) and acha (*Digitaria exilis*), forms part of the stable food [1]. Seeds from cereal grains contain a large centrally located starchy endosperm that is rich in protein, with a protective outer coat consisting of two to three layers of fibrous tissues and an embryo or germ usually located near the bottom of the seed [2]. Most cereals contain vitamins and minerals with all the essential amino acids required by man except for lysine and tryptophan and when consumed with other food items, these can supplement for the low nutrients or even those lacking in the cereals [3]. However, deficiency in essential nutrients is not confined to cereals alone because most food consumed in developing countries either lack these nutrients or the information about their nutrient contents are lacking [4].

There is an increasing rate of population growth in northern Nigeria states (118.6 million) as reported by the Nigeria National

Population Commission [5], coupled with economic crisis and inflation in prices of some commonly consumed imported cereal food items which calls for an in-depth research into local whole cereal grains, reported to be major source of nutrient vital for human health in Nigeria, especially in Nasarawa state, (northern Nigeria), where this cereals are used now by the populace to produce different kind of food (dumpling) [6].

Cereals flour are among the major staple foods in Nasarawa State, due to the importance of their grain nutritional components; dumpling sorghum, and acha fortified with ingredients like; pepper, onions, moringa will promote its consumer's health. Even though the word dambu refers to a cereal based granulated dumpling made from cereal flour, small quantity of onions, leaves and some herbs, there are various types of *dambu* depending on the types of raw materials and methods of production. The various other types include *dambun* nama, those produced from either beef, mutton or poultry [7], *dambun kifi*, prepared from flesh of fish and those prepared from cereal grains. *Dambun nama* and *dambun* kifi are described as boiled, spiced, shredded, stirred and fried meat and fish products, respectively. On the other hand, *dambu* produced from cereal grains is a granulated dumpling generally produced from moistened acha, sorghum and maize flours or any suitable cereal flour blended with spices and steamed for about 30 minutes [8].

In view of the importance of improving human nutrition, especially among Nigerian resource poor families living in the north, by using local and easily accessible ingredients, it is important to assess and evaluate the nutritional and anti-nutritional properties of raw and processed cereal based *dambu* produced using different compositions of pepper, ginger, soya beans, fried groundnut, moringa and other ingredients, hence, the aim of this study.

## Materials and Methods

All reagents/chemical used were of analytical grade and were used throughout.

## Study Design

### Sample collection and identification

Two varieties of sorghum (*Sorhum bicolor* and *Sorghum arundinaceum*) and acha (*Digitaria exilis*) were purchased from Lafia Modern market, Lafia Local Government Area, Nasarawa State, and were identified at the Faculty of Science, Department of Botany, Federal University of Lafia. The samples were stored in seed bags and kept in a dry laboratory cupboard.

### Preparation of raw varieties of cereals

All the grains were cleaned from impurities, broken and damaged seeds, milled into fine flour using a laboratory miller to pass a 0.4 mm mesh screen and kept in polythene bags and stored in cupboard for further analysis.

### Preparation of processed varieties of cereals (dumpling)

To each type of flour (acha and sorghum), 150 g was added to 0.7 g pepper, 1.5 g of ginger, 10 g of ground powdered soya beans flour, 10 g of fried groundnut, 3.5 g moringa leaves, and 60 mL of water. The mixtures were mixed separately using spoon and steamed using a two-fold system, having a perforated plate containing the product and placed on a pot containing boiling water. The preparation was cooked for 30 minutes, allowed to cool and dished into plastic plates for sensory evaluation.

### Proximate Analysis

Determination of moisture content, ash content, crude fibre, crude protein, and crude fat of both raw and processed samples was carried out according to AOAC (2010) standard methods of analysis, while carbohydrate was determined as described by Agu [1].

### Minerals Analysis

The selected mineral elements (Na, Ca, P and K) were determined following standard procedure described be AACC (2000).

### Vitamins Analysis

The AOAC (2010) method using the colorimeter was adopted for determination of vitamin A and riboflavin concentration. Vitamin E was determined as outlined by FAO (2002). The scalar analyser method was used to determine thiamine content.

### Antinutrients Analysis

Tannin content was determined by the Folis – Denis colorimetric method described by AOAC (2010). Phytate content was determined using spectrophotometric method as described by FAO (2002) and alkaline picrate colorimetric method of Oduro [16] was used to determine the concentration of hydrogen cyanide.

### Statistical Analysis

Result of each determination were obtained in triplicates. All data were statistically analysed. The means and standard deviations (SD) were calculated using Microsoft Excel 2019. One-way analysis of variance (ANOVA) was carried out with MiniTab 19 statistical software.

## Results

The results of the nutritional (proximate composition: moisture content, ash content, crude fibre, crude protein, crude fat, carbohydrate and calorific value), minerals (Na, Ca, P and K), vitamins (A and E, thiamine and riboflavin) and antinutritional composition (tannin, phytate and hydrogen cyanide) are presented in Table 1 – 4.

**Table 1: Proximate Composition of Raw and Processed *Sorghum bicolor, Sorghum arundinaceumand Digitariaexilis***

| Samples | Ash | Moisture | Crude Protein | Crude Fibre | Crude Fat | Carbohydrate | Calorific Value |
|---|---|---|---|---|---|---|---|
| Raw *Sorghum bicolor* | 1.96± 0.02$^{e}$ | 8.18±0.02$^{d}$ | 7.98±0.05$^{d}$ | 3.41±0.08$^{d}$ | 2.15±0.05$^{e}$ | 76.33±0.14$^{c}$ | 337.45±0.39$^{c}$ |
| Raw *Sorghum arundinaceum* | 3.08 ± 0.04$^{a}$ | 7.15±0.02$^{e}$ | 6.54±0.03$^{f}$ | 2.95±0.05$^{f}$ | 2.19±0.01$^{d}$ | 78.09±0.02$^{b}$ | 338.73±0.05$^{b}$ |
| Raw *Digitariaexilis* | 2.26 ±0.04$^{b}$ | 5.07±0.04$^{f}$ | 7.49±0.46$^{e}$ | 3.18±0.04$^{e}$ | 2.12±0.06$^{f}$ | 79.89±0.42$^{a}$ | 348.60±0.44$^{a}$ |
| Processed *Sorghum bicolor* | 2.00± 0.02$^{d}$ | 18.23±0.23$^{b}$ | 10.10±0.11$^{b}$ | 5.41±0.05$^{a}$ | 3.08±0.03$^{a}$ | 61.30±0.90$^{e}$ | 298.02±1.63$^{e}$ |
| Processed *Sorghum arundinaceum* | 2.12±0.03$^{c}$ | 18.64±0.34$^{a}$ | 10.19±0.01$^{a}$ | 5.24±0.09$^{b}$ | 3.05±0.03$^{b}$ | 60.76±0.34$^{f}$ | 296.10±1.55$^{f}$ |
| Processed *Digitariaexilis* | 2.00±0.01$^{d}$ | 17.9±0.24$^{c}$ | 9.95±0.08$^{c}$ | 5.06±0.07$^{c}$ | 3.03±0.04$^{c}$ | 62.06±0.40$^{d}$ | 299.80±105$^{d}$ |

**Table 2: Vitamins Composition of Raw and Processed Sorghum bicolor, Sorghum arundinaceum and Digitariaexilis**

| Samples | Vitamin A (mg/100g) | Vitamin E (mg/100g) | Thiamine (mg/100g) | Riboflavin (mg/100g) |
|---|---|---|---|---|
| Raw *Sorghum bicolor* | 24.81±0.61$^{d}$ | 2.06±0.02$^{d}$ | 0.19±0.01$^{d}$ | 0.24±0.03$^{f}$ |
| Raw *Sorghum arundinaceum* | 24.16±0.14$^{b}$ | 2.06±0.03$^{d}$ | 0.18±0.02$^{e}$ | 0.26±0.01$^{d}$ |
| Raw *Digitariaexilis* | 24.68±0.30$^{e}$ | 2.07±0.03$^{c}$ | 0.16±0.01$^{f}$ | 0.25±0.01$^{e}$ |
| Processed *Sorghum bicolor* | 26.73±062$^{a}$ | 2.17±0.02$^{a}$ | 0.24±0.04$^{c}$ | 0.33±0.04$^{c}$ |
| Processed *Sorghum arundinaceum* | 26.62±0.44$^{c}$ | 2.15±0.02$^{b}$ | 0.26±0.02$^{b}$ | 0.37±0.01$^{a}$ |
| Processed *Digitariaexilis* | 26.99±0.14$^{b}$ | 2.17±0.03$^{a}$ | 0.28±0.02$^{a}$ | 0.36±0.02$^{b}$ |

**Table 3: Anti-nutrient Composition of Raw and Processed Sorghum bicolor, Sorghum arundinaceum and Digitariaexilis**

| Samples | Tanin (%) | Phytate (mg/100g) | Hydrogen Cyanide (mg/kg) |
|---|---|---|---|
| Raw *Sorghum bicolor* | 0.48±0.02$^{d}$ | 1.34±0.03$^{e}$ | 1.27±0.01$^{c}$ |
| Raw *Sorghum arundinaceum* | 0.38±0.01$^{f}$ | 1.34±0.02$^{e}$ | 1.24±0.01$^{d}$ |
| Raw *Digitariaexilis* | 0.45±0.02$^{e}$ | 1.37±0.02$^{d}$ | 1.27±0.01$^{c}$ |
| Processed *Sorghum bicolor* | 0.52±0.02$^{b}$ | 1.45±0.02$^{b}$ | 1.36±0.02$^{a}$ |
| Processed *Sorghum arundinaceum* | 0.51±0.02$^{c}$ | 1.44±0.02$^{c}$ | 1.34±0.02$^{b}$ |
| Processed *Digitariaexilis* | 0.54±0.01$^{a}$ | 1.46±0.02$^{a}$ | 1.36±0.02$^{a}$ |

**Table 4: Mineral Composition of Raw and Processed Sorghum bicolor, Sorghum arundinaceum and Digitariaexilis (mg/100g)**

| Samples | Sodium | Calcium | Phosphorus | Potassium |
|---|---|---|---|---|
| Raw *Sorghum bicolor* | 46.00±2.87$^{c}$ | 114.82±5.94$^{f}$ | 180.24±7.34$^{d}$ | 307.37±8.18$^{f}$ |
| Raw *Sorghum arundinaceum* | 44.99±1.36$^{a}$ | 121.56±3.38$^{c}$ | 175.51±6.92$^{e}$ | 348.88±45.22$^{d}$ |
| Raw *Digitariaexilis* | 48.85±1.68$^{b}$ | 115.53±6.18$^{e}$ | 169.09±2.454$^{f}$ | 332.48±16.04$^{e}$ |
| Processed *Sorghum bicolor* | 48.97±0.98$^{b}$ | 121.61±1.36$^{b}$ | 205.52±6.81$^{c}$ | 411.6±4.00$^{a}$ |
| Processed *Sorghum arundinaceum* | 52.62±1.31$^{a}$ | 118.51±1.57$^{d}$ | 207.16±4.21$^{b}$ | 411.25±7.74$^{b}$ |
| Processed *Digitariaexilis* | 48.70±1.1$^{c}$ | 122.73±1.94$^{a}$ | 218.15±1.88$^{a}$ | 399.13±4.17$^{c}$ |

## Discussion

Moisture, ash, crude protein, crude fiber, crude fat and carbohydrates were determined in the raw and process granulated varieties of sorghum and acha dumplings were reported in Table 3.1.

The moisture content of the raw samples ranged from 5.07 – 8.18 % with *Sorghum bicolor* having the highest value, while the dambu samples had moisture content from 17.90 – 18.64 %. Highest moisture content recorded for the dambu was observed in *Sorghum arundinaceum*. The analysis of variance showed that there were highly significant differences ($p>0.05$), among the samples. The results obtained were in agreement with the findings of Anjorin [12].

The ash contents of the samples investigated ranged between 1.96 – 3.08 %. It was significantly greater than other values obtained in the other raw cereals (*Sorghum bicolor* and *Digitaria exilis*, while the lowest ash content (1.96 %) was scored in the raw *Sorghum bicolor* sample. *Sorghum bicolor* and *Sorghum arundinaceum* had same ash content percentage (2.00 %) (Figure 1).

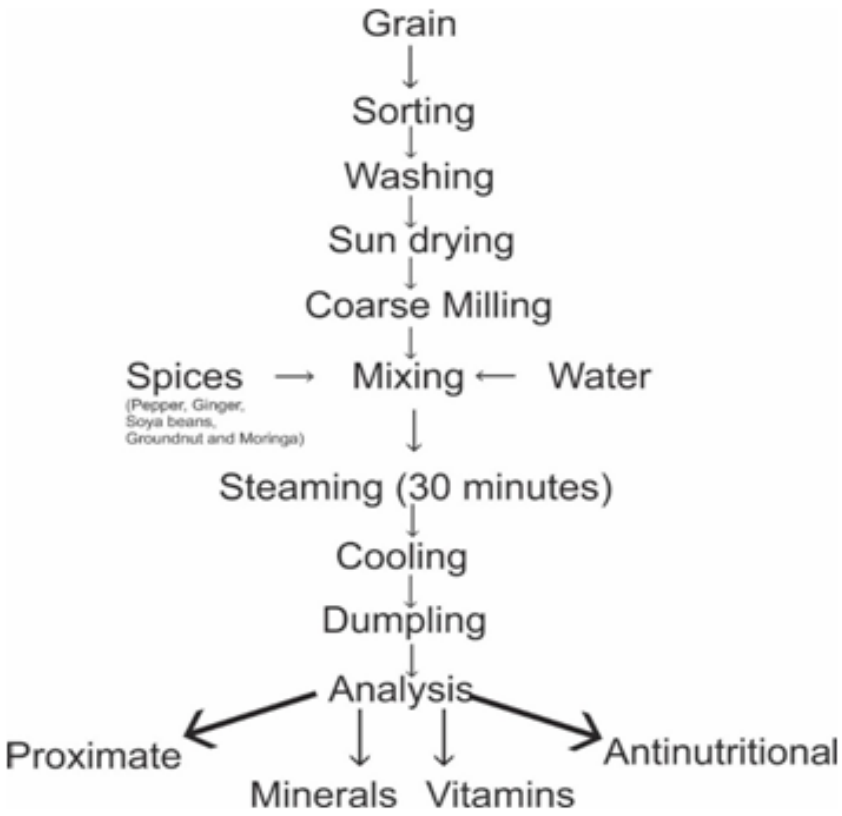


**Figure 1:** Study design chart for sorghum and acha dumpling

Protein contents in the samples ranged from 6.5 – 10.19 %. All the dambu samples showed high protein content; 10.10 %, 10.19 % and 9.95 % for Sorghum bicolor, *Sorghum arundinaceum* and Digitaria exilis respectively. On the othe hand, the lowest protein content (6.54 %) was recorded in raw *Sorghum arundinaceum* variety of sorghum. The results obtained for protein were in agreement with Asibuo [13]. Increase in protein content of the dambu compared with their cereal flour could be as a result of the added spices (moringa, groundnut, soya bean, seasoning). This suggests that the dambu contain slightly higher protein, therefore giving them nutritional advantage over their cereal flours.

Fiber contents of the raw and processed samples ranged from 2.12 -3.08 %. The highest fat content (3.05 %) was recorded in processed *Sorghum arundinaceum* sample and was significantly greater than the other values obtained from the other two dambu. Raw *Digitaria exilis* had the lowest fat content (2.12 %). The fat contents of the raw and processed sampled ranged 2.95 – 5.41 %. The highest fat content (5.41 %) was reported in the *Sorghum arundinaceum* which was significantly greater than the other values obtained in the study. The lowest fat content (2.12 %) was obtained in *Digitaria exilis*. These results are in accordance with findings of Nweke [14] whose fat content in different sorghum varieties and acha dambu ranged from 1.5 - 6.0 %. The carbohydrates of the samples under study showed values that ranged from 60.76 -79.89 %. *Digitaria exilis* had the highest carbohydrate content (79.89 %) while the lowest carbohydrate content (60.76 %) was recorded in *Sorghum arundinaceum*. Calorific values obtained from the samples ranged from 296.10 –

348.60 %. All the raw samples had high concentrations compared to their respective dambu.

The result from this research agreed with the findings of Agu [1] which revealed that that dambu being a cereal-based product contains substantial amount of energy (calorific value) due to high carbohydrate content. The carbohydrate and energy values of the products were far lower than their cereal flours because of the high moisture content of the products. The ash, protein, fat, and crude fibre content values of the processed cereals varieties (sorghum and acha) and the flours are within the range for their cereal grains as reported by Ogunshina [17]. The sodium contents obtained were 46.00, 44.99, 48.85, 48.97, 52.62, 48.70 mg/100g for raw *Sorghum bicolor, Sorghum arundinaceum*, *Digitaria exilis* and their processed dambu respectively. The highest sodium content (44.99 mg/100g) was recorded in processed *Sorghum arundinaceum* and was significantly greater than the other values. The lowest sodium content (44.99 mg /100g) was recorded in raw Sorghum. These values are higher than those found by Oduro and Iken [15,16] that reported sodium content in different sorghum and acha varieties which range from 3.07 to 6.18 mg/100g. Table 4 also revealed that the potassium concentration in the samples ranged from 307.37 - 411.60. The highest potassium content (411.60 mg/100g) was obtained in processed *Sorghum bicolor.* The lowest potassium content (307.37 mg/100g) was observed in raw *Sorghum bicolor*. Previous work, recorded that potassium content in sorghum grains varied from 225.23 to 423.66 mg/100g. Agu also obtained values for sorghum, acha and maize dambu in the range of 50.22 - 51.82 mg/100g.

The calcium contents ranged from 114.82 – 122.73 mg/100g. Raw and processed (dambu) *Sorghum arundinaceum* had the highest calcium contents, which imply that the variety is a good calcium source. Phosphorus concentration generally ranged from 169.09 - 218.15 mg/100g. The highest phosphorus content (218.15 mg/100g) was obtained in processed *Digitaria exilis* which was significantly greater than the other samples. Raw *Digitaria exilis* also recorded lowest mean concentration of Phosphorus (169.09 mg/100g). This indicates that the evaluated varieties of sorghum and acha are rich in phosphorus. These results are in agreement with the findings, that reported phosphorus content between 263.3 and 423.7 mg/100g in different sorghum and acha sample. Generally variable amounts of the elements P and K in the three cereals and their respective dambu were found to contain higher levels of Na and Ca as compared to other findings.

The levels of anti-nutrients: tannins (%) and phytate (mg/100g) and hydrogen cyanide (HCN) (mg/kg) results of the two are shown in Table 3. The presence of anti-nutrients such as phytate and tannin affects the nutritional quality of sorghum. The presence of the anti-nutritional factors, such as phytate, tannins and HCN. These compounds are known to interfere with protein and carbohydrate digestion and mineral bioavailability. Reduction or elimination of these undesirable components is essential for improving the nutritional quality of the cereals under consideration, effectively utilizing their full potential as human food [12]. Tannin contents in the sample showed values that ranged from 0.38 – 0.54 %. The results showed that there were highly significant differences ($p>0.05$) among the raw and processed samples. The highest tannin content (0.54 %) was reported in processed (dambu) Digitaria exilis. Phytate concentration was highest in *Digitaria exilis* (1.34 mg/100g). ANOVA showed that the concentration was significantly greater compared to the means obtained from the remaining raw and processed cereals. However, all the processed cereals (*Sorghum bicolor*, *Sorghum arundinaceum* and *Digitaria exilis*) had higher phytate contents compared to their respective raw cereals. HCN showed values that ranged from 1.24 – 1.36 mg/kg. This value was highest as observed in all the processed (dambu) cereals varieties, while Sorghum bicolor and *Digitaria exilis* had same concentration of 1.36 mg/kg. Also, in the raw cereals, *Sorghum bicolor* and *Digitaria exilis* had same concentration (1.27 mg/kg).

The vitamin result reported in Table 3 showed that all samples analyzed were rich in vitamins A, E, thiamine (B1) and riboflavin (B2). Vitamin A showed mean concentrations that ranged from 24.11 – 27.12 mg/100g with significant difference ($p>0.05$). However, the processed (dambu) samples had higher vitamin A content 26.32 – 27.12 mg/100g. This suggests that the processed samples are better source of vitamin A compared to the raw cereals. In Table 3, vitamin E, concentration of vitamin E ranged from 2.06 -2.17 mg/100g. Lowest concentration was obtained in the two raw Sorghum varieties; bicolor, arundinaceum and *Digitaria exilis* while highest vitamin E was obtained processed (dambu) *Sorghum bicolor* and *Digitaria exilis*.

Thiamine and riboflavin contents ranged from 0.15 – 0.29 mg/100g and 0.24 – 0.38 respectively. Digitaria exilis had least thiamine concentration (0.16 mg/100g) among the raw cereals and the highest among the processed samples (0.28 mg/100g) while riboflavin recorded highest mean concentration in *Sorghum arundinaceum* (0.37 mg/100g) and lowest concentration in *Sorghum bicolor* (0.24 mg/100g).

The vitamins content obtained for vitamin A and E agreed. The bio-chemical and physiological functions of vitamins include vision, growth, and differentiation of epithelial cells, nervous tissue activity, bone and immunity, non specific reducing agents as antioxidants (vitamin E) which may protect against some forms of cancer. The presence of vitamins in both raw and processed samples analyzed will contribute anti-infective properties, promotes wound healing, may boost the immune system and may help ward off infections [13].

## Conclusion

Both varieties of Sorghum (*bicolor* and *arundinaceum*) and acha were found to possess high nutritive values, which implies they will be of immense importance in daily diet. Mineral composition report confirmed that Na level was highest in processed *Sorghum arundinaceum*, while processed *Digitaria exilis* contained high Ca and P. The vitamins analysis, vitamin A, E, thiamine and riboflavin were all available in the raw and processed samples analyzed and their presence indicates that they are good plant vitamin source either in raw and processed form. Low level of the anti-nutritional factors; phytate, tannins and HCN within consumption rate will barely interfere protein,

carbohydrate and minerals component.

There is an urgent need to increase awareness of *Sorghum bicolor*, *Sorghum arundinaceum* and *Digitaria exilis* dumpling and its nutrient potentials while, increased efforts should be made to encourage the cultivation of Sorghum bicolor, Sorghum arundinaceum and *Digitaria exilis* dumpling as well as their consumption and efforts should be made to incorporate *Sorghum bicolor*, *Sorghum arundinaceum* and *Digitaria exilis* in convenient foods as well as a complement to wheat flour in the preparation of composite products, baked products etc.

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