




## Research Article

# Quality Evaluation of Breakfast Cereal Meal Produced from Finger Millet (*Eleusine coracana*) and Roasted African Yam Beans (*Sphenostylis stenocarpa*) Flour Blends

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**Abstract:** This study was carried out to evaluate the qualities of breakfast cereal meals produced from blends of finger millet and toasted African yam beans flour. Flour samples of processed finger millet were blended with roasted African yam beans flour at substitution levels of 0, 10, 20, 30, and 40%. The blended flours were processed into breakfast cereal. The breakfast cereal products were subjected to proximate, vitamin, mineral, and microbial analyses (mould count and total viable count) and sensory evaluation. The result showed that there was a significant increase in the protein, moisture, carbohydrate, and energy content of the breakfast cereals with a corresponding decrease in the ash and fiber content as the level of African yam bean flour increased in the blends. The proximate composition result of the breakfast cereal product ranged from 11.65-37.78% for protein, 13.70-4.91% for ash, 3.00-7.20% for fiber, 2.88-3.88% for moisture, 0.74-1.00% for fat, 46.41-76.77% for carbohydrate and 360.98-380.36% for energy. Vitamin composition of the products ranged from 43.17-72.14 UI for vitamin A, 0.058-0.184 mg/100 g for vitamin B<sub>1</sub>, 0.058-0.184 mg/100 g for vitamin B<sub>2</sub>, 0.006-0.015 mg/100 g for vitamin B<sub>3</sub>, 0.289-0.516 mg/100 g. Mineral composition ranged from 6.50-10.01 mg/100 g for iron, 355.53-454.37 mg/100 g for calcium, and 27.65-28.75 mg/100 g for phosphorus content. The total viable count ranged from  $2.7 \times 10^2$  to  $2.8 \times 10^2$  cfu/g while the mould was not detected in any of the samples. Results of sensory evaluation showed that FAY60 was the most acceptable breakfast cereal meal.

**Keywords:** breakfast cereal meals, proximate, vitamin, mineral

## 1. Introduction

The first meal of the day, breakfast lays the dietary groundwork for the rest of the day. Breakfast meals for both adults and babies are often centered on the local staple diet of cereals, legumes, and a few tubers in underdeveloped nations, especially in sub-Saharan Africa. Cereals, on the other hand, are by far the most popular choice for breakfast [1].

Cereals that have been swelled, ground, rolled, or flaked are considered breakfast cereals for legal purposes [2]. Cereals like Cornflakes, golden More, Quaker oats, and rice crisps are widely available in Nigeria.

Finger millet (*Eleusine coracana*) represents a staple food for a large segment of the population. It is one of the ancient millet crops cultivated in several regions of India. It ranks sixth in production after wheat, rice, maize, sorghum, and bajra in India. Finger millet contains 72% carbohydrate, 7.30% protein, 4.30% fat, 8.0% crude fiber, and 3.30% minerals [3].

One of the lesser-known edible grain legumes, the African yam bean (*Sphenostylis stenocarpa*) is widely farmed and used in Africa. Over 32% of its protein is made up of essential amino acids, with lysine and leucine being the most prevalent types, according to [4]. When its genetic resources are preserved for breeding and enhancement, it may help ensure food security, despite being of the “neglected crops” [5].

Cereals are limiting in some essential amino acids especially threonine and tryptophan [6]. Finger millet, like other cereals, is limited in these amino acids however, a combination of this cereal with legumes will complement each other in the amount of amino acids to improve nutritional quality, develop a new product that will benefit hungry and malnourish individuals, and improve the utilization of finger millet.

The aim of the study was to develop and evaluate breakfast cereal meals produced from blends of finger millet and African yam bean to evaluate the nutritional and sensory qualities of the resulting products.

## **2. Materials and methods**

### **2.1 Sources of materials**

The Finger millet (*Eleusine coracana*) grains were purchased from Jos, Plateau State, Nigeria while the African yam beans (*Sphenostylis stenocarpa*) were obtained in Ayinga market, Kogi State, Nigeria.

### **2.2 Production of finger millet flour**

Five kg of finger millet grains were sorted to remove chaff and dirt. It was then washed in clean water, oven dried (Techmel and Techmel, USA, TT-9053) at 60 °C for 6 h after which the dried millet was milled into flour and properly packaged in zip-lock polyethylene sample bags and stored till used [7].

### **2.3 Production of roasted African yam bean flour**

In order to make roasted African yam beans, the procedure described by [8]. A total of two (2) kilograms of beans were cleaned, rinsed, and dried in a hot air oven at 80 °C for 60 hours. The seeds were roasted at 120 °C for 45 min in a big frying pan. Throughout the process of heating and cooling the seeds, they were mixed on a regular basis to ensure even cooking. For further analysis, the seeds were ground into flour and kept in sealed plastic sachets.

### **2.4 Formulation of breakfast cereal meal**

Finger millet flour and roasted African yam bean flour were blended to produce composite flour. Five samples were generated by mixing the composite flour in different proportions (100:0, 90:10, 80:20, 70:30 and 60:40). Table 1 shows the composite flour proportions for the five samples

### **2.5 Production of breakfast cereal meal**

The process for making breakfast cereal meals was based on that reported by [9], with some modifications. The composite flour was mixed together with water to serve as a binding effect. 1 g of salt and 5 g of sugar were added to improve the taste, the mixture was partially heat treated for 10 min to gelatinize the starch. The dough was then cut into small shapes with a table knife and toasted in an oven (Century, COV-8320-B) at 120 °C for 1 h after which the toasted breakfast cereals were allowed to cool under room temperature and packed in air-tight polyethylene bags, sealed and stored for further analysis.

**Table 1.** Composite flour for the formulation of breakfast cereal meal made from finger millet and roasted African yam beans flour

Sample code	Finger millet	Roasted African yam beans
FAY100	100	0
FAY90	90	10
FAY80	80	20
FAY70	70	30
FAY60	60	40

Key  
FAY100- 100% Finger millet  
FAY90- 90% Finger millet:10% Roasted African yam beans  
FAY80- 80% Finger millet:20% Roasted African yam beans  
FAY70- 70% Finger millet:30% Roasted African yam beans  
FAY60- 60% Finger millet:40% Roasted African yam beans

## **2.6 Determination of the proximate composition of the breakfast cereal meal**

Proximate analysis including: moisture content, ash, crude fiber, crude protein, crude fat, carbohydrate, and energy was carried out on the ground breakfast cereal samples using standard methods described by [10].

## **2.7 Determination of vitamin content of breakfast cereal meal**

Vitamin B<sub>1</sub>, B<sub>2</sub>, and B<sub>3</sub> was determined following the standard method [10].

## **2.8 Determination of mineral compositions of breakfast cereal meal**

Phosphorus (P) was measured using the Vanadium-molybdate technique, while calcium (Ca) and iron (Fe) were measured using an Atomic Absorption Spectrophotometer (AAS Model SP9), both in accordance with the methodology described by [11].

## **2.9 Determination of microbial count of breakfast cereal meal**

The total viable count was determined by the pour plate count method as described by [12] while the mould count was determined using potato dextrose agar as described by [13].

## **2.10 Sensory evaluation of breakfast cereal meal**

Twenty untrained panelists from the Department of Food Science and Technology at Delta State University of Science and Technology were selected to assess the samples for a wide range of sensory qualities (appearance, aroma, texture, taste, consistency and overall acceptability). A 9-point Hedonic scale was used where '9' represents extremely like and '1' represents extremely dislike [14].

## **3. Experimental design and data analysis**

The experiment was conducted in a Completely Randomized Design (CRD). Data obtained were subjected to one-way Analysis of Variance (ANOVA) and mean separation was done by Duncan multiple range test, using Statistical Product for Service Solution (SPSS) version 20 and significant difference was accepted at  $p < 0.05$ .

## 4. Results and discussion

### 4.1 Proximate of composite breakfast cereal meal

The proximate composition of the breakfast meal is presented in Table 2. The protein content ranged from 11.65% in FAY60 to 37.78% in FAY60. The protein content of the samples was found to increase significantly ( $P \leq 0.05$ ) with an increase in addition of roasted African yam beans seed flour.

**Table 2.** Proximate Composition (%) of Breakfast Cereal Meal

Sample code	Protein	Ash	Fibre	Moisture	Fats	Carbohydrate	Kcal/100 g
FAY100	11.65 <sup>c</sup> ± 0.43	3.70 <sup>e</sup> ± 0.33	3.00 <sup>e</sup> ± 0.73	3.88 <sup>a</sup> ± 0.13	1.00 <sup>a</sup> ± 0.01	76.77 <sup>a</sup> ± 1.12	380.36 <sup>a</sup>
FAY90	11.78 <sup>d</sup> ± 0.33	4.67 <sup>d</sup> ± 0.06	3.60 <sup>d</sup> ± 1.10	3.63 <sup>b</sup> ± 0.45	0.86 <sup>b</sup> ± 0.01	75.46 <sup>b</sup> ± 1.20	374.15 <sup>d</sup>
FAY80	14.25 <sup>c</sup> ± 0.06	4.85 <sup>c</sup> ± 0.10	3.40 <sup>e</sup> ± 0.30	3.29 <sup>c</sup> ± 0.33	1.00 <sup>a</sup> ± 0.01	73.21 <sup>c</sup> ± 1.12	376.33 <sup>b</sup>
FAY70	24.82 <sup>b</sup> ± 0.45	4.88 <sup>b</sup> ± 0.30	4.80 <sup>b</sup> ± 0.33	3.05 <sup>d</sup> ± 0.21	0.74 <sup>d</sup> ± 0.02	61.71 <sup>d</sup> ± 0.56	370.08 <sup>c</sup>
FAY60	37.78 <sup>a</sup> ± 0.35	4.91 <sup>a</sup> ± 0.31	7.20 <sup>a</sup> ± 0.11	2.88 <sup>e</sup> ± 0.13	0.82 <sup>c</sup> ± 0.01	46.41 <sup>e</sup> ± 1.02	360.98 <sup>e</sup>

Values are means ± standard deviation of triplicates determinations. Values having different superscripts are significantly ( $p < 0.05$ ) different.

Key

FAY100- 100% Finger millet

FAY90- 90% Finger millet:10% Roasted African yam beans

FAY80- 80% Finger millet:20% Roasted African yam beans

FAY70- 70% Finger millet:30% Roasted African yam beans

FAY60- 60% Finger millet:40% Roasted African yam beans

The increased protein content may be attributed to the addition of roasted African yam bean to the finger millet. The crude protein content was substantially ( $P > 0.05$ ) higher than the FAO/WHO-recommended value ( $> 16.00$ ). [15] found that adding legumes to breakfast cereal increased the protein content. This result is in agreement with the report of [16] who reported an increase in the protein content of breakfast cereal due to the inclusion of legumes. Hence, developed breakfast cereal may promote growth and development as well as repairs of worn-out tissues. Differences in the ash content of the breakfast cereal were statistically significant ( $p \leq 0.05$ ), with values ranging from 3.70% in FAY100 to 4.91% in FAY60. A food's ash level may be used as a proxy for the presence or absence of essential minerals [17]. The increased mineral content of roasted African yam beans may explain their higher ash content. This result is in line with the findings of [18] who reported values in the range of 1.5-2.5% [19]. The present result is consistent with the result reported by [20], who developed a breakfast cereal by combining the African yam bean with maize and the defatted coconut. The crude fiber content of the samples ranged from 5.8% in FAY100 to 7.38% in FAY60. An increase in fiber content was observed as the proportion of African yam beans increased. The increase may be attributed to the presence of higher-level fiber in African yam beans. Studies have shown that consumption of fiber helps to improve digestive functions [21] and this fact is very necessary for a healthy breakfast. Studies have shown that the consumption of fiber helps to improve digestive functions [22]. The moisture content of the breakfast cereal ranged from 2.88% in FAY100 to 3.88% in FAY60. There was a significant ( $p < 0.05$ ) difference in the moisture content of the samples. The moisture content of the breakfast cereal decreased as the blending level of sample African yam beans increased. This is in agreement with [23] who stated that the increased addition of orange-fleshed sweet potato flour increased the moisture content of the bread produced from wheat and orange-fleshed sweet potato flour. It was observed that the moisture content of the breakfast cereal was significantly lower than the recommended value (10.00%) by FAO/WHO (1991). Therefore, breakfast cereal may exhibit longer shelf life as food samples with higher moisture content above 10.00% tend to deteriorate faster [21]. Fat content ranged from 0.74% in FAY70 to 1.00% in FAY100 and FAY80. A

gradual increase in fat content was observed as the level of roasted African yam beans increased. The fat contents of all the samples were found to be generally low. The relatively low-fat content of the food blends could contribute to the extension of the shelf-life of ready-to-eat breakfast cereals by retarding the onset of rancidity. The low-fat content of all the blends could also make the product an excellent food for diabetic and obese patients [24]. The carbohydrate content ranged from 46.41% in FAY60 to 76.77% in FAY100. The carbohydrate content was found to have decreased significantly ( $P \leq 0.05$ ) with an increase in roasted African yam beans flour substitution. The high value of carbohydrates in the breakfast cereal may be attributed to the high proportion of African yam beans as the principal ingredient in the formulations. The energy content ranged from 360.98% in FAY60 to 380.36% in FAY100. There was a significant decrease ( $P \leq 0.05$ ) in the energy content with an increasing addition of roasted African yam bean flour. This could be because African yam beans is a poor source of carbohydrate. Energy value represents the amount of energy in the food that can be supplied to the body for the maintenance of basic body functions.

#### 4.2 Mineral composition of breakfast cereal meal

The mineral composition of the breakfast cereal meal is presented in Table 3. A significant increase ( $p < 0.05$ ) was observed among the samples for iron, calcium, and phosphorus as the level of African yam beans increased. The mineral contents ranged from 6.50-8.96 mg/100 g: 355.53-418.52 mg/100 g and 27.65-28.75 mg/100 g for iron, calcium and phosphorous respectively. This finding is in line with the report of [25] who examined the nutritional value of breakfast cereals made from a flour mix of maize (*Zea mays*) and jackfruit (*Artocarpu sheterophyllus Lam.*) seeds. Anemia is common in people with diabetes, and iron deficiency is one of the complications that might arise. Deficits in calcium, one of the most essential elements, are more common than deficiencies in any other mineral [21]. Phosphorus is a mineral crucial for cellular and tissue development and repair [19]. The mineral content of the breakfast cereal meal tends to grow as the blending ratio with the roasted African yam beans flour increases. The iron, calcium, and phosphorus content of the finger millet flour was improved by the addition of African yam beans flour.

**Table 3.** Vitamins composition (mg/100 g) of Breakfast Cereal Meal

Sample code	A(IU)	B <sub>1</sub> mg/100 g	B <sub>2</sub> mg/100 g	B <sub>3</sub> mg/100 g
FAY100	72.14 <sup>a</sup> ± 0.45	0.06 <sup>c</sup> ± 0.04	0.01 <sup>d</sup> ± 0.00	0.28 <sup>e</sup> ± 0.08
FAY90	32.93 <sup>c</sup> ± 0.32	0.18 <sup>a</sup> ± 0.02	0.02 <sup>a</sup> ± 0.01	0.52 <sup>b</sup> ± 0.10
FAY80	58.90 <sup>b</sup> ± 0.12	0.05 <sup>d</sup> ± 0.00	0.01 <sup>c</sup> ± 0.00	0.31 <sup>c</sup> ± 0.05
FAY70	46.00 <sup>c</sup> ± 0.11	0.065 <sup>b</sup> ± 0.02	0.014 <sup>b</sup> ± 0.01	0.698 <sup>a</sup> ± 0.11
FAY60	43.17 <sup>d</sup> ± 0.21	0.058 <sup>c</sup> ± 0.02	0.006 <sup>e</sup> ± 0.00	0.289 <sup>d</sup> ± 0.15

Values are means ± standard deviation of triplicates determinations. Values having different superscripts are significantly ( $p < 0.05$ ) different.

Key

FAY100- 100% Finger millet

FAY90- 90% Finger millet:10% Roasted African yam beans

FAY80- 80% Finger millet:20% Roasted African yam beans

FAY70- 70% Finger millet:30% Roasted African yam beans

FAY60- 60% Finger millet:40% Roasted African yam beans

#### 4.3 Vitamin composition of breakfast cereal meal

The vitamin composition of the breakfast cereal meal is presented in Table 4. The composition of vitamins A, B<sub>1</sub>, B<sub>2</sub>, and B<sub>3</sub> were as follows: 72.14 mg/100 g-32.93 IU, 0.058 mg/100 g-0.184 mg/100 g, 0.006 mg/100 g-0.015 mg/100 g, and 0.28 mg/100 g-0.52 mg/100 g. Roasted African yam bean flour inclusion was shown to boost vitamin content.

The result was within the safe daily intake range (30-60 mg/100 g) established by the United States Department of Agriculture for males and females, respectively. Keratomalacia, often known as night blindness, results from a lack of vitamin A in the body [26]. The Recommended Daily Allowance (RDA) for vitamin A is 5,000 international units (I.U.) per day. The vitamin B complex is a group of related micronutrients that each have a role in supporting human health. Many third-world nations, particularly those in Africa, have a vitamin B<sub>2</sub> deficiency problem [26].

**Table 4.** Minerals Composition (mg/100 g) of Breakfast Cereal Meal

Samples code	Fe	Ca	P
FAY100	8.96 <sup>b</sup> ± 1.66	418.52 <sup>b</sup> ± 1.79	27.65 <sup>c</sup> ± 1.1
FAY90	10.01 <sup>a</sup> ± 0.32	353.27 <sup>c</sup> ± 1.88	27.21 <sup>c</sup> ± 0.98
FAY80	8.93 <sup>b</sup> ± 0.68	454.37 <sup>a</sup> ± 1.43	27.84 <sup>b</sup> ± 0.66
FAY70	6.21 <sup>d</sup> ± 0.22	348.08 <sup>c</sup> ± 1.24	27.38 <sup>d</sup> ± 0.76
FAY60	6.50 <sup>c</sup> ± 0.16	355.53 <sup>d</sup> ± 1.33	28.75 <sup>a</sup> ± 0.84

Values are means ± standard deviation of triplicates determinations. Values having different superscripts are significantly (p < 0.05) different.

Key

FAY100- 100% Finger millet

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FAY80- 80% Finger millet:20% Roasted African yam beans

FAY70- 70% Finger millet:30% Roasted African yam beans

FAY60- 60% Finger millet:40% Roasted African yam beans

#### 4.4 Microbial count of the breakfast cereal meal after 24 h of production

**Table 5.** Microbial count (cfu/g) of breakfast meal

Samples	TVC	Mould
FAY100	2.7 × 10 <sup>2</sup>	ND
FAY90	2.6 × 10 <sup>2</sup>	ND
FAY80	2.3 × 10 <sup>2</sup>	ND
FAY70	2.1 × 10 <sup>2</sup>	ND
FAY60	2.8 × 10 <sup>2</sup>	ND

Values are means of triplicates determinations

Key

FAY100- 100% Finger millet

FAY90- 90% Finger millet:10% Roasted African yam beans

FAY80- 80% Finger millet:20% Roasted African yam beans

FAY70- 70% Finger millet:30% Roasted African yam beans

FAY60- 60% Finger millet:40% Roasted African yam beans

The microbial load of the breakfast cereal meal is presented in Table 5. The total viable count of the breakfast cereal meal ranges between  $2.7 \times 10^2$  and  $2.8 \times 10^2$  cfu/g. The results of this investigation are consistent with the value of  $1.51 \times 10^5$  reported by [27]. According to the guidelines for the microbiological quality of ready-to-eat foods [28], the total viable counts of microorganisms in the food samples were not high. These guidelines state that ( $10^4$  cfu/g) is the threshold for satisfactory quality, ( $10^4$  to  $10^5$  cfu/g) is the threshold for acceptable quality and ( $10^6$  cfu/g) is the threshold for unsatisfactory quality ( $10^5$  cfu/g). The mold did not develop on any of the breakfast cereals meal, which may be due to the low moisture level of the samples. This means that the product's shelf life would be significantly extended. Hence the microbial load of the breakfast cereal product is accepted and within tolerable limits. Microorganisms play a significant role in the determination of the shelf life of food products. They are usually responsible for the spoilage of many food items.

#### 4.5 Sensory evaluation of the breakfast cereal meal

The results of the sensory evaluation are presented in Table 6. The result indicated that the breakfast cereal meal had appreciable scores for likeness for all parameters evaluated. Sample FAY90 was most preferred in terms of appearance with a mean sensory score of 7.30. The increase in the degree of likeness of the appearance may be a result of changes in the appearance that could be due to the increasing proportion of the toasted African yam bean flour. Sample FAY70 and FMY60 were the most preferred in terms of aroma. Sample FAY60 was the preferred in terms of texture with a mean sensory score of 8.60. Sample FAY70 was the most preferred in terms of consistency while sample FAY60 was the most preferred in terms of general acceptability. There were no significant ( $p < 0.05$ ) different in appearance, aroma, and general acceptability among the breakfast cereal. All the products had a good rating for all the sensory attributes since their scores were higher than the mean of 4.5. There was much acceptance of the newly formulated samples by the panelists. This showed that breakfast cereals meal produced from local raw materials was highly acceptable [29].

**Table 6.** Sensory Evaluation of Breakfast Cereal Meal

Samples	Appearance	Aroma	Texture	Taste	Consistency	Overall acceptability
FAY100	6.70 <sup>a</sup> ± 1.06	7.40 <sup>a</sup> ± 1.07	8.50 ± 0.97 <sup>a</sup>	7.60 <sup>ab</sup> ± 0.97	7.90 <sup>a</sup> ± 1.37	7.90 <sup>a</sup> ± 1.10
FAY90	7.30 <sup>a</sup> ± 0.67	7.30 <sup>a</sup> ± 1.06	8.00 ± 0.67 <sup>ab</sup>	7.10 <sup>ab</sup> ± 1.10	7.40 <sup>a</sup> ± 1.34	7.10 <sup>a</sup> ± 1.28
FAY80	7.00 <sup>a</sup> ± 1.15	7.10 <sup>a</sup> ± 1.52	7.10 ± 1.29 <sup>b</sup>	6.60 <sup>b</sup> ± 1.26	6.20 <sup>b</sup> ± 1.69	7.50 <sup>a</sup> ± 1.65
FAY70	7.20 <sup>a</sup> ± 1.69	7.80 <sup>a</sup> ± 1.69	7.90 ± 1.19 <sup>ab</sup>	7.80 <sup>a</sup> ± 1.32	8.40 <sup>a</sup> ± 0.69	7.80 <sup>a</sup> ± 1.62
FAY60	6.80 <sup>a</sup> ± 1.31	7.80 <sup>a</sup> ± 1.14	8.60 ± 0.69 <sup>a</sup>	8.10 <sup>a</sup> ± 1.10	7.70 <sup>a</sup> ± 1.34	8.10 <sup>a</sup> ± 1.19

Values having different superscripts are significantly ( $p < 0.05$ ) different.

Key

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FAY80- 80% Finger millet:20% Roasted African yam beans

FAY70- 70% Finger millet:30% Roasted African yam beans

FAY60- 60% Finger millet:40% Roasted African yam beans

## 5. Conclusion

The result of the study showed that the inclusion of roasted African yam beans flour to finger millet in the production of a breakfast cereal meal improved the protein, ash and fiber content of the breakfast cereal meal. The result also showed that vitamin and mineral content increased with an increase in the roasted African yam beans. The breakfast

cereals meal had a low bacterial count while no mould was detected. The sensory evaluation result showed that FAY60 was the most acceptable product. The production of breakfast cereal from the raw materials used in this study would contribute to the nutritional needs of individuals who are protein and B-group vitamin deficient.

## Authors' contributions

Joseph Oghenewogaga Owheruo: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing-Original Draft, Visualization.

Great Iruoghene Edo: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing-Original Draft, Visualization, Resources, Writing-Review & Editing, Supervision, Project administration.

Zubair Adeiza Bashir: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing-Original Draft, Visualization.

Patrick Othuke Akpogheli: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing-Original Draft, Visualization.

Joy Johnson Agbo: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing-Original Draft, Visualization.

## Conflict of interest

The authors declare no competing financial interest.

## References

- [1] Turck D, Castenmiller J, de Henauw S, Hirsch-Ernst K, Kearney J, Knutsen HK, et al. Dietary reference values for chloride. *EFSA Journal*. 2019; 17(9): e05779. Available from: <https://doi.org/10.2903/j.efsa.2019.5779>.
- [2] Williams PG. The benefits of breakfast cereal consumption: A systematic review of the evidence base. *Advances in Nutrition*. 2014; 5(5): 636S-673S. Available from: <https://doi.org/10.3945/an.114.006247>.
- [3] Devi PB, Vijayabharathi R, Sathyabama S, Malleshi NG, Priyadarisini VB. Health benefits of finger millet (*Eleusine coracana* L.) polyphenols and dietary fiber: A review. *Journal of Food Science and Technology*. 2014; 51: 1021-1040. Available from: <https://doi.org/10.1007/s13197-011-0584-9>.
- [4] George TT, Obilana AO, Oyeyinka SA. The prospects of African yam bean: Past and future importance. *Heliyon*. 2020; 6(11): e05458. Available from: <https://doi.org/10.1016/j.heliyon.2020.e05458>.
- [5] Great Iruoghene E, Favour Ogheneoruese O. Analysis of phytochemical constituents and antioxidant potential of bitter kola leaf extract towards bioactive food, nutrition and health resources. *Organic & Medicinal Chem IJ*. 2022; 11(5): 555823. Available from: <https://doi.org/10.19080/OMCIJ.2022.11.555823>.
- [6] Siminiuc R, Coşciug L. Effect of dehulling and hydrothermal treatment on the amino acid content of soriz (*Sorghum oryzoidum*). *Food and Nutrition Sciences*. 2021; 12: 1232-1242. Available from: <https://doi.org/10.4236/fns.2021.1212090>.
- [7] Maharajan T, Antony Ceasar S, Ajeesh Krishna TP, Ignacimuthu S. Finger millet [*Eleusine coracana* (L.) Gaertn]: An orphan crop with a potential to alleviate the calcium deficiency in the semi-arid tropics of Asia and Africa. *Front. Sustain. Food Syst*. 2021; 5: 684447. Available from: <https://doi.org/10.3389/fsufs.2021.684447>.
- [8] Suzzy Shitta N, Chukwudi Edemodu A, Gebreselassie Abteu W, Abebe Tesfaye A. A review on the cooking attributes of African yam bean (*Sphenostylis stenocarpa*). In: Jimenez-Lopez JC, Clemente A. (eds.) *Legumes Research-Volume 2*. IntechOpen; 2022. Available from: <https://doi.org/10.5772/intechopen.99674>.
- [9] Akinyede KA, Ekpo OE, Oguntibeju OO. Ethnopharmacology, therapeutic properties and nutritional potentials of carapobrotus edulis: A comprehensive review. *Sci. Pharm*. 2020; 88(3): 39 Available from: <https://doi.org/10.3390/scipharm88030039>.
- [10] Al-mentafji HN. *Official Methods of Analysis of AOAC INTERNATIONAL*. Aoac; 2006.
- [11] Wiczorek D, Źyszka-Haberecht B, Kafka A, Lipok J. Determination of phosphorus compounds in plant tissues: From colourimetry to advanced instrumental analytical chemistry. *Plant Methods*. 2022; 18: 22. Available from:



<https://doi.org/10.1186/s13007-022-00854-6>.

- [12] Sanders ER. Aseptic laboratory techniques: Plating methods. *J. Vis. Exp.* 2012; 63: e3064. Available from: <https://doi.org/10.3791/3064>.
- [13] Fernández-Canigia MV, Coyne MS. Low nutrient medium and spiral-plate system for enumerating heterotrophic bacteria in soil. *Commun. Soil Sci. Plant Anal.* 2001; 32(11-12): 1705-1717. Available from: <https://doi.org/10.1081/CSS-120000244>.
- [14] Frimpong TG, Wireko-Manu FD, Oduro I. Development and sensory assessment of ready-to-eat breakfast cereal. *International Journal of Food Science.* 2022; 2022: 1-7. Available from: <https://doi.org/10.1155/2022/4566482>.
- [15] Jideani IA, Jideani VA. Developments on the cereal grains *Digitaria exilis* (acha) and *Digitaria iburua* (iburu). *Journal of Food Science and Technology.* 2011; 48: 251-259. Available from: <https://doi.org/10.1007/s13197-010-0208-9>.
- [16] Usman GO, Okafor GI. Organoleptic properties and perception of maize, African yam bean, and defatted coconut flour-based breakfast cereals served in conventional forms. *Food Sci. Nutr.* 2016; 4: 716-722. Available from: <https://doi.org/10.1002/fsn3.336>.
- [17] Edo GI, Makinde MG, Nwosu LC, Ozgor E, Akhayere E. Physicochemical and pharmacological properties of palm oil: an approach for quality, safety, and nutrition evaluation of palm oil. *Food Analytical Methods.* 2022; 15: 2290-2305. Available from: <https://doi.org/10.1007/s12161-022-02293-4>.
- [18] Nwosu LC, Edo GI, Özgör E. The phytochemical, proximate, pharmacological, GC-MS analysis of *Cyperus esculentus* (Tiger nut): A fully validated approach in health, food and nutrition. *Food Biosci.* 2022; 46: 101551. Available from: <https://doi.org/10.1016/j.fbio.2022.101551>.
- [19] Akpogheli PO, Edo GI, Akhayere E. Proximate and nutritional composition of beer produced from malted sorghum blended with yellow cassava. *Biocatalysis and Agricultural Biotechnology.* 2022; 45: 102535. Available from: <https://doi.org/10.1016/j.bcab.2022.102535>.
- [20] Okafor GI, Usman GO. Production and evaluation of breakfast cereals from blends of African yam bean (*Sphenostylis stenocarpa*), maize (*Zea mays*) and defatted coconut (*Cocos nucifera*). *Journal of Food Processing and Preservation.* 2014; 38(3): 1037-1043. Available from: <https://doi.org/10.1111/jfpp.12060>.
- [21] Edo GI, Onoharigho FO, Akpogheli PO, Emakpor OL, Ozgor E, Akhayere E. Physicochemical, phytochemical, antioxidant, and inhibition properties of key enzymes linked to raw and regular honey. *Chemistry Africa.* 2022; 5: 1351-1364. Available from: <https://doi.org/10.1007/s42250-022-00401-9>.
- [22] Ogheneoruese Onoharigho F, Ahuose Ighede P, Edo GI, Othuke Akpogheli P, Oghenekome Akpogheli E. Isolation and identification of bacterial and fungal spoilage organisms in branded and unbranded milk; consumer perception of safety hazard for milk. *Applied Microbiology: Theory & Technology.* 2022; 3(2): 31-48. Available from: <https://doi.org/10.37256/amtt.3220221766>.
- [23] Edo GI, Ugbune U, Onoharigho FO, Ezekiel GO, Agbo JJ. Antioxidant activities of *reissantia indica* willd. (mopane paddle-pod) and nephroprotective effect on paracetamol-induced nephrotoxicity in male wistar rats. *Nutrire.* 2023; 48: 26. Available from: <https://doi.org/10.1186/s41110-023-00214-x>.
- [24] Edo GI, Nwosu LC. Association of alcohol use and dietary lifestyle of commercial drivers during the COVID-19 pandemic in Nigeria. *Bulletin of the National Research Centre.* 2022; 46: 197. Available from: <https://doi.org/10.1186/s42269-022-00885-y>.
- [25] Garg M, Sharma A, Vats S, Tiwari V, Kumari A, Mishra V, et al. Vitamins in cereals: A critical review of content, health effects, processing losses, bioaccessibility, fortification, and biofortification strategies for their improvement. *Front. Nutr.* 2021; 8: 586815. Available from: <https://doi.org/10.3389/fnut.2021.586815>.
- [26] Md Noh MF, Gunasegavan RD-N, Mustafa Khalid N, Balasubramaniam V, Mustar S, Abd Rashed A. Recent techniques in nutrient analysis for food composition database. *Molecules.* 2020; 25(19): 4567. Available from: <https://doi.org/10.3390/molecules25194567>.
- [27] Mbaeyi-Nwaoha IE, Uchendu NO. Production and evaluation of breakfast cereals from blends of acha and fermented soybean paste (okara). *Journal of Food Science and Technology.* 2016; 53: 50-70. Available from: <https://doi.org/10.1007/s13197-015-2032-8>.
- [28] Edo GI, Makinde MG, Nwosu LC, Ozgor E, Akhayere E. Physicochemical and pharmacological properties of palm oil: An approach for quality, safety, and nutrition evaluation of palm oil. *Food Analytical Methods.* 2022; 15: 2290-2305. Available from: <https://doi.org/10.1007/s12161-022-02293-4>.
- [29] Zlatanović S, Kalušević A, Micić D, Laličić-Petronijević J, Tomić N, Ostojić S, et al. Functionality and storability of cookies fortified at the industrial scale with up to 75% of apple pomace flour produced by dehydration. *Foods.* 2019; 8(11): 561. Available from: <https://doi.org/10.3390/foods8110561>.