



Proximate, Antinutrient and Mineral Contents of *Aframomum danielli* (Ataiko) Seed

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Authors' contributions

This work was carried out in collaboration between both authors. Author PDE designed the study, wrote the protocol, read and approved the final manuscript. Author KS performed the statistical analysis wrote the first draft of the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

Background: Plant seeds are rich in nutrients and antinutrients which interfere with bioavailability of minerals.

Objective: This research was aimed at evaluating the proximate, anti-nutrients and minerals compositions and estimation of relative mineral bioavailability of *Aframomum danielli* seed (Ataiko).

Methods: Proximate composition was assessed by AOAC methods, minerals by atomic absorption spectrophotometry and anti-nutrients by titrimetric methods.

Results: Proximate compositions in percentage revealed carbohydrate with (51.95±0.15), crude fibre (16.00±0.10) and fat (2.35±0.15) was least. Caloric value (kcal 100 g) was 286.55±2.75 Phytate (1.98±0.03%) was higher than oxalate (0.06±0.00%). Major mineral percentage included phosphorus (7401.43 ± 318.24) and sulphur (1926.58 ± 21.49), minor minerals were in trace amounts. Molar ratios of phytate: Fe, Zn and Ca and oxalate:Ca were above their critical values.

Conclusion: *A. daneilli* seed is rich in nutrients, has high caloric value. High intake could lead to micronutrient malnutrition.

Keywords: *Aframomum*; *daneilli*; antinutrients; bioavailability; proximate.

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1. INTRODUCTION

Relentless search for new sources of food nutrients especially from plants becomes imperative because 30% of the population in developing countries is currently suffering from one or more multiple forms of nutritional deficiencies, especially micro-nutrients [1]. Industrially processed fortified food items are usually not affordable for half of the world's population [2]. The major nutritional problems in these countries are insufficient food intake, consequently upon high prices of food and unbalanced food intake [3]. Hence the need to resort to plants as major sources of nutrients by most of the population living in these low income countries.

Spices refer to all of the edible parts of a plant used for flavouring or colouring foods, including fruit, seed, root, bark or vegetable substance [4]. Plants used as spices are usually aromatic and pungent [5]. Iwu [6] had reported that these plants owe these properties to the presence of varying types of essential oils. Specific uses of spices tend to vary considerably among cultures and countries: Medicine, religious rituals, cosmetics, perfumery, and foods. As food, they have been shown to play an important role in health partially as sources of nutrients [7,8]. Researches on spices have given rise to our knowledge of the volatile oils and vitamin and mineral contents [9,10]. Spices possess essential nutrients (minerals and vitamins inclusive) required for growth of the body and its maintenance and may therefore help alleviate the effects of some of these nutrient deficiencies.

Spices and herbs are revered for their potential health attributes. They are reported to have positive effects in the treatment of numerous diseases, especially chronic ones such as cancer, diabetes, and cardiovascular diseases [11]. It is a well-established fact that relationship exist between nutrition, health and the ability of nutrition, in this case, nutrients from spices to reduce the occurrence of diseases, has engaged the attention of researchers and nutritionist alike in recent times [12,13,14]. Spices are functional foods; these are foods that can be demonstrated to have a beneficial effect on certain target functions in the body beyond basic nutritional requirements [15]. Spices contribute a wide range of nutrients to foods [16].

The spice of interest in this study *Aframomum danielli* seeds are smooth, shining olive-brown

with a turpentine-like taste and are used medicinally. The genus *Aframomum* (family: Zingiberaceae) contains almost fifty species in West and Central Africa. The distinguishing feature of this genus is the attribute of highly pungent and aromatic seeds. All the plant parts also exude a strong aroma when pulverized [17]. *Aframomum danielli* is a herb with a creeping rhizome found in the region of Niger Delta. The plant is used as spices in traditional dishes. It is also commonly known as Ataiko, a local spice commonly used to enhance flavour, aroma and palatability in 'Banga' soup in the southern part of Nigeria, particularly by the Urhobos, Itsekiris and Isoko of Delta State. The nutritional profile of *A. danielli* had been reported by [18,19]. Furthermore, several researchers have also reported on the nutritional profile of different plant parts of other *Aframomum* species [20,21, 22,23,24]. There is high caloric value and hence could contribute essential nutrients in diet to alleviate nutrient deficiencies. However, improving the nutritional value of a diet with spices without estimating relative nutrient bioavailability may not necessarily solve the malnutrition challenge.

Micronutrient malnutrition affects more than half of the world population, particularly in developing countries. Iron, zinc and vitamin A deficiencies are the most serious health constraints worldwide [2]. In developing countries plants are the major source of food. Plants are major sources of numerous bioactive compounds collectively termed as phytochemicals, which are reported to be key to good health [25,26]. It is worth noting that while there are many groups of chemical compounds that have health benefits, others can be very toxic and fatal to humans when consumed. As such phytochemicals can be broadly classified as nutritional e.g. essential fatty acids, proteins, vitamins, minerals and phenolic compounds, and examples of anti-nutritional are oxalates, tannins, nitrate chemical compounds. Anti-nutrients are chemicals which have been evolved by plants for their own defence, among other biological functions and reduce the maximum utilization of nutrients especially proteins, vitamins, and minerals, thus preventing optimal exploitation of the nutrients present in food and decreasing the nutritive value. Anti-nutrients such as phytates, oxalates, polyphenols, tannins and alkaloids present in spices [27,28] interfere with the bioavailability of minerals and vitamins. Hence the present study evaluates proximate composition, mineral and anti-nutrient contents and inhibitory effects of

anti-nutrients on the bioavailability of minerals in *A. danielli* seed. Among the anti-nutritional compounds, two of great importance: Phytate and oxalate which interfere with the bioavailability of minerals were considered in this study.

Phytate [inositol hexaphosphate (IP6)] is widely present in plant-based foods. IP6 chelates with divalent metal ions and hereby interferes with the absorption or utilisation of important minerals, especially iron, zinc and calcium. It is well documented that even small amounts of phytate in food will significantly reduce iron absorption [29,30]. Phytate is widely present in plant-based foods. Phytate content is evaluated as molar ratios to iron, zinc and calcium. To efficiently minimize mineral absorption inhibition, the molar ratios for phytate: Fe should be less than 1.0 [30], phytate: Zn molar ratio less than 15 [31] and phytate: Ca molar ratio less than 0.17 [32].

Oxalic acid [(COOH)₂] in combination with its salts or minerals form oxalates. Oxalic acid is present in the cell sap of many of the green leafy vegetable [33]. Depending on plant species, oxalates can occur as insoluble salts of calcium, magnesium and iron, and soluble salts of potassium and sodium or as a combination of these two forms [34]. However, oxalic acid does not interfere with zinc absorption and metabolism [35]. Insoluble oxalates are excreted in faeces. Whereas, soluble oxalates affect the human body by forming a strong chelate with dietary calcium and other minerals rendering the complex unavailable for absorption and assimilation. This insoluble calcium oxalate in the crystal form is stored in the kidney causing serious health-related problem called kidney stone [36]. Oxalate content is evaluated as molar ratios to calcium. To efficiently minimize mineral absorption inhibition, the molar ratios for oxalate: Ca should be less than 1.0 (Ox:Ca) > 1 [37,38,39].

2. MATERIALS AND METHODS

2.1 Proximate Analysis

Proximate chemical composition *Aframomum danielli* spice was determined using the Association of Official Analytical Chemists AOAC [40] method. The micro-Kjeldahl method was employed to determine the total nitrogen and the crude protein was obtained by multiplying the nitrogen value obtained by 6.25. The weight difference method was used to determine

moisture and ash levels while crude lipids were extracted with petroleum ether, using a Soxhlet apparatus following methods outlined in AOAC [41]. The carbohydrate content was determined by calculation using the difference method using Equation 1

$$\% \text{ Carbohydrate} = [100 - \%(\text{protein} + \text{fat} + \text{moisture} + \text{ash} + \text{fibre})] \quad (1)$$

Gross energy was calculated using the Atwater factors for protein (4), fat (9) and carbohydrate (4) following the method of Zou et al., [42]. (Equation 2)

$$\text{Gross energy} = 4 (\text{crude protein } \%) + 9 (\text{crude fat } \%) + 4 (\text{carbohydrate } \%) \quad (2)$$

2.2 Mineral Analysis

Mineral constituents of *Ataiko* were determined by atomic absorption spectrophotometry.

2.2.1 Wet digestion of the sample (Ashed *Ataiko* Seeds)

Accurately weighed 0.1 g of the ash sample was put into the pre cleaned borosilicate 250 ml capacity beaker for digestion. A volume of 20 ml of the nitric acid was added into the weighed sample in the beaker. The sample with the digesting solvent was placed on the hot plate for digestion in the fume cupboard. The beaker and its contents after the digestion were allowed to cool. Another volume of 20 ml of the digesting solvent was added and digested further in the fume cupboard and the mixture was allowed to cool to room temperature. The mixture was filtered into the 250 ml volumetric capacity borosilicate container. The filtrate was made up to the mark with de-ionised water. All the digested samples were sub-sampled into pre-cleaned borosilicate glass containers for Atomic Absorption Spectrophotometer analysis.

Standards of iron, zinc, calcium, magnesium, potassium, sodium, selenium, cobalt, sulphur, chlorine, iodine and copper solutions of 0.2, 0.4, 0.6, 0.8 and 1.0 mg/l were made from each of the heavy metals stock solutions of 1000 mg/l analytes. The set of standard solutions and the filtrate of the digested samples were analysed by Atomic Absorption Spectrophotometry. The detection limit of the metals in the sample was 0.0001 mg/l by means of the UNICAM 929 London, Atomic Absorption Spectrophotometer powered by the SOLAR software. Iron, zinc,

calcium, magnesium, potassium, sodium, selenium, cobalt, sulphur, chlorine, iodine and copper cathode lamps were used for the analysis of the respective mineral ions in the standards and the filtrate of the samples. Gas mixtures of compressed air and acetylene were used in the generation of the flame. The concentration of each metal was determined by the use of a calibration curve.

2.2.2 Determination of phosphorus

Procedure: Accurately weighed 25 mg of the sample was put into the Schoniger flask and burnt in excess of oxygen gas. The product was digested with nitric acid. The content was boiled for a minute to ensure complete conversion of phosphorus pentoxide to orthophosphate.

The solution was passed through a 10 cm long resin column, and the filtrate was collected. In a 10 ml pyrex test tube, 2 ml of the colour development reagent was added for the absorbance reading at wavelength 650 nm for both the standards and the sample filtrate.

Calculation of phosphorus: The calculations for the total mineral intake involve the same procedure as given in Atomic Absorption Spectrophotometry.

2.3 Determination of Anti-Nutrients in *Aframomum Danielli* (Ataiko) Seed

2.3.1 Oxalate

The modified method of Day and Underwood [43] was employed for the analysis of oxalate. 1.00 g of the sample was weighed into 100 ml borosilicate glass flask, 75 ml of 3M H₂SO₄ was added and the solution was intermittently stirred carefully with magnetic stirrer for about hrs and latter filtered with Whatman No. 1 filter paper. 25 ml of the filtrate was collected and then titrated at hot condition of 80°C-90°C against 0.1M KMnO₄ solution to the end point. The oxalate content was estimated using Equation

$$\text{Oxalate} = (\text{Titre value} \times 0.9004) \text{ mg/g}$$

2.3.2 Phytate

Phytate was determined according to the method of Wheeler and Ferrel [44]. Weight of 4.0 g of the sample was soaked in 100 ml of 2% HCl for 3 hrs and latter filtered through Whatman No. 2 filter paper. 25 ml of the filtrate was placed in conical flask and 5 ml of 0.3% ammonium thiocyanate solution was added, after which 53.5% of distilled water was added and titrated against standard Fe (III) chloride solution to end point. Phytate content was expressed as the percentage of phytate in sample. Phytate content was estimated from Equation 3

$$\% \text{ Phytic acid} = \frac{8.24t \times 100}{1000 \times \text{sample mass}} \quad (3)$$

Where t = titre value.

2.3.3 Estimation of relative mineral bioavailability

The molar ratios of phytate to zinc, iron and calcium and that of oxalate to calcium were calculated using Equation 4. The molar masses of phytate and oxalate used were 660 g/mol and 88 g/mol respectively.

$$\text{Molar ratio} = \frac{\text{Moles of antinutrient}}{\text{Moles of mineral}} \quad (4)$$

3. RESULTS

Result from Table 1 shows the proximate percentage compositions of *A. danielli* seeds (ataiko). Result from Table 2 shows the anti-nutrients contents of *A. danielli* seeds. Table 3 shows the result of the mineral contents of *A. danielli* seeds. Result from Table 4 represents estimation of relative mineral bioavailability with respect to molar ratios of anti nutrient to minerals.

Table 1. Proximate composition of *Aframomum daneilli* seeds

Parameters (%)	Dry weight	Energy value (kcal/100 g)
Carbohydrate	51.95±0.15	207.8±0.60
Crude Protein	14.40±0.20	57.60±0.80
Crude Fat	2.35±0.15	21.15±1.35
Crude Fiber	16.00±0.10	
Ash	3.95±0.05	
Moisture	11.35±0.15	
Total metabolizable energy		286.55±2.75

Data were represented in mean ± standard deviation (M±SD) in triplicate determination (n=3)

Table 2. Anti-nutrient contents of *Aframomum daneilli* seeds

Anti-Nutrients	Concentration (%)
Oxalate	0.06±0.00
Phytate	1.98±0.03

Data were represented in mean ± standard deviation (M±SD) in triplicate determination (n=3)

Table 3. Mineral constituents of *afmomom danielli* seeds (ataiko)

Mineral	Concentration (ppm)	*Recommended dietary allowance (RDA) in mg/day
Sodium (Na)	240.29 ± 30.71	120 ^a , 1500 ^{b,c}
Calcium (Ca)	12.70 ± 0.01	210–800 ^a , 800 ^b , 1200 ^c
Magnesium (Mg)	3.62 ± 0.01	30–130 ^a , 240–360 ^b , 320–340 ^c
Potassium (K)	5.22 ± 0.04	400–3000 ^a , 4700 ^{b,c}
Iron (Fe)	0.80 ± 0.01	0.27–11 ^a , 8–15 ^b , 10 ^c
Zinc (Zn)	0.66 ± 0.06	2–5 ^a , 11 ^b , 15 ^c
Selenium(Se)	0.13 ± 0.00	
Phosphorus (P)	7401.43 ± 318.24	100–500 ^a , 1250 ^b , 700 ^c
Iodine (I)	0.16 ± 0.00	
Sulphur (S)	1926.58 ± 21.49	
Chlorine (Cl)	89.51 ± 0.57	
Cobalt (Co)	0.02 ± 0.00	
Copper (Cu)	0.28 ± 0.00	0.20-0.44 ^a , 0.7–0.89 ^b , 0.9 ^c

Data were represented in mean ± standard deviation (M±SD) in triplicate determination (n=3).

*Culled from the United States Department of Agriculture (USDA) and may be assessed via <http://www.nap.edu/>.

^aInfants; ^bchildren; ^cadults

Table 4. Comparism of antinutrients to minerals mole ratio with recommended critical values

Antinutrients: Minerals	Mole ratios	Critical values
Phytate:Zinc	2,951.72	15
Phytate:Iron	2,096.57	1
Phytate:Calcium	94.51	0.1
Oxalate:Calcium	21.45	1

Data were represented in mean ± standard deviation (M±SD) in triplicate determinations (n=3)

4. DISCUSSION

Result from Table 1 showed the proximate percentage compositions of *A. danielli* seeds (ataiko) as carbohydrate (51.95±0.15), crude fibre (16.00±0.10), crude protein (14.40±0.20), moisture (11.35±0.15), ash (3.95±0.05) and crude fat (2.35±0.15). The highest proximate constituent was carbohydrate followed by crude fibre while crude fat had the least composition. The trend in proximate composition in this study is consistent with previous study by Adegoke and Skura [18] on nutritional profile and antimicrobial spectrum of the spice *A. danielli*. This result was in variance with that reported by Bouba et al. [19] on proximate composition, mineral and vitamin contents of *A. danielli* fruit with predominant compositions identified as crude fat (23.1 ± 0.61 g/100 g) and carbohydrate (11.9 ± 0.1 g/100 g) with high ash content (9.3 ± 0.1 g/100 g) as against (3.95±0.05%) in the present study. The

nutrients composition pattern of the two most abundant constituents compare favourably with those data obtained in previous research for different species of *Aframomum seed* [20,22,23,24,45]. Carbohydrate provides necessary energy required to drive cellular metabolism, muscular work, and maintenance of body temperature [46].

Fiber constitutes the second most abundant in *A. danielli* seed. The % composition (16.00±0.10) in this study is above NAFDAC minimum requirement of 3 g /100 g for fibre and the EU/WHO recommended limit of 2.5 g/ 100 g. Crude fibre, which represents the amount of indigestible sugar present in the sample, decreases the risks of many disorders such as constipation, colon cancer, cardiovascular diseases (CVD), diverticulosis and obesity [47]. Also, they inhibit absorption of glucose and cholesterol from the gastrointestinal tract, thus

are helpful in diabetes and heart disease control [48].

Result revealed crude protein content of the seed to be $14.40 \pm 0.20\%$. This result is far higher than the work reported by Adegoke and Skura, [18] on this spice and the studies reported by Ibekwe and Orok [20]; Alaje et al. [22]; Nwachoko et al. [23] and Borquaye et al. [45] on different species of *Aframomum* seeds. However, the amount of crude protein in the present study is lower than that reported by Borquaye et al. [45] and Asemave and Ode, [24] on studies done on different species of *Aframomum* seeds. Proteins play critical roles in cellular functions, structure and regulations of metabolic activities in all living organisms hence *A. danielli* seed could serve as sufficient alternatives to the very scarce meat protein in the developing countries.

Percentage moisture content was observed to be 11.35 ± 0.15 which is higher than the amount reported by Adegoke and Skura [18] on the same spice and those of Ibekwe and Orok [20] and Bouba et al. 2012 of different species of *Aframomum* seeds and fruit respectively. The amount is however lower than reports by Borquaye et al. [45] and Asemave and Ode [24] on seeds of different *Aframomum* species. High moisture content will encourage microbial growth, increase the rate of enzymatic reaction and hence deterioration while low moisture content are indicative of their high dry matter content and possible long shelf-life.

The gross caloric value in the present study was 286.55 ± 2.75 kcal/100 g, a little above half of the gross caloric value of 469.7 kcal/100 g reported by Adegoke and Skura [18] of *A. danielli* seed. Borquaye et al. [45] reported 243.17 kcal as gross caloric value for the seed of *Aframomum melegueta*. Factors that could cause differences in proximate compositions are differences in soil characteristics, climatic conditions at the areas where they were cultivated, growth conditions, genetic variations and differences in analytical procedures [49,50,51,52].

Result from Table 2. represents Anti-Nutrient contents of *Aframomum daneilli* seeds. The two anti-nutrients considered were oxalate with concentration $0.06 \pm 0.00\%$ and phytate with $1.98 \pm 0.03\%$. Concentration of phytate was much higher in this study than that of oxalate. Borquaye et al. [45] reported higher phytate and oxalate levels in their work on nutritional and

anti-nutrient profiles of the seed of *Aframomum melegueta* from Ghana.

Phytate, the salt form of phytic acid, is primarily present as a salt of the mono- and divalent cations K^+ , Mg^{2+} , and Ca^{2+} and accumulates in the seeds during the ripening period. Phytate is ubiquitous among plant seeds and grains, comprising 0.5 to 5 percent (w/w) [52]. Phytic acid is reported to chelate metal ions such as calcium, magnesium, zinc, copper, iron and molybdenum to form insoluble complexes that are not readily absorbed from gastrointestinal tract leading to mineral deficiency.

Oxalates can occur as insoluble salts of calcium, magnesium and iron, and soluble salts of potassium and sodium or as a combination of these two forms [53]. However, oxalic acid does not interfere with zinc absorption and metabolism [54]. Soluble oxalates affect the human body by forming a strong chelate with dietary calcium and other minerals rendering the complex unavailable for absorption and assimilation. This insoluble calcium oxalate in the crystal form is stored in the kidney causing serious health-related problem called kidney stone [36].

Table 3 present result of mineral contents of *A. danielli* seed. The most abundant macrominerals were phosphorus (7401.43 ± 3188.24), Sulphur (1926 ± 21.00), Sodium (240.29 ± 30.771), chlorine (89.51 ± 0.57) and calcium (12.0 ± 0.01). All the micronutrients were found in trace amounts in the range of 0.02 ± 0.00 - 0.80 ± 0.01 mg/kg. This result was in variance with works done by Bouba et al. [19] on the mineral content of *A. danielli* fruit in Cameroon and that reported by Borquaye et al. [45] on mineral contents of *A. melegueta* seed in Ghana. These differences may be due to differences in soil characteristics at the areas where they were cultivated, the plant part analyzed, genetic variations and type of fertilizer used during cultivation. The concentrations of copper, iron, phosphorus, and sodium in the spice met the Recommended Dietary Allowance (RDA) of these minerals in infants. However, only phosphorus met the RDA for infants, children, and adults. Metal ions are important to the normal functioning and wellbeing of humankind as they serve as cofactors in enzymatic reactions, maintain protein structures, donate or accept electrons in redox reactions facilitate the binding of molecules to receptor sites on cell membranes, alters the structure or ionic nature of membranes to control permeability, and inducing gene expression.

Result from Table 4. represents estimation of relative mineral bioavailability with respect to molar ratios of antinutrient to minerals. Molar ratios of Phytate:Zinc, Fe, Ca and Oxalate: Ca were 2,951.72, 2,096.57, 94.51 and 21.45 respectively. All the molar ratios were above their respect critical values. Borquaye et al. [45] in their work on mineral contents of *A. melegeta* seed in Ghana reported molar ratios far lower than what was observed in the present study for Phytate: Zinc, Fe, Ca and Oxalate: Ca. The molar ratios of antinutrients to mineral nutrients estimate the relative bioavailability of minerals in the presence of antinutrients. These molar ratios also give an indication of the inhibitory effects of the antinutrients on the bioavailability of these minerals in spices. The high levels of antinutrients to low mineral levels in this spice resulted to high molar ratios far above the recommended critical values. The implication of this is inhibitory effect of the antinutrients on the bioavailability of these minerals in the spice which could result to deficiencies of these minerals.

More than one third of the world's population suffers from anemia, half of it caused by iron deficiency. Iron deficiency adversely affects cognitive development, resistance to infection, work capacity, productivity and pregnancy. Zinc is involved in cellular growth and differentiation. While mild to moderate zinc deficiency is common throughout the world [55] one third of world's population at high risk live in low income countries. Zinc deficiency causes impaired growth, immune dysfunction, increased morbidity and mortality, adverse pregnancy outcomes and abnormal neurobehavioral development. Processing techniques such as boiling and cooking have no effect in reducing the level of phytic acid as the phytate is relatively heat stable [56]. However, evidence showed that although food preparation techniques help in reducing the phytic acid level, the most effective methods are lactic acid fermentation and soaking in acid medium [57].

5. CONCLUSION

The present study evaluated the proximate, antinutrients and minerals compositions and estimation of relative mineral bioavailability of *Aframomum danielli* seed (Ataiko). The result revealed the spice was high in carbohydrate, moisture, dietary fibre, and caloric values adequate to meet nutritional need of consumers. Most abundant macrominerals were phosphorus, sulphur, sodium, chlorine and calcium. All the

micronutrients were found in trace amounts. Cu, Fe, P and Na met RDA of these minerals in infants while phosphorus met the RDA for infants, children and adults. High phytate to micromineral ratios and low calcium to oxalate ratio showed inhibitory effects of antinutrients on mineral bioavailability that could lead to antinutrient malnutrition. Though spices are used in small amounts, it should be used along with other components rich in essential macro and micro minerals in diets. Also proper and most effective food preparatory method required to reduce the amount of anti-nutrients should be adopted.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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