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Research Article
Nutritional Profile, Proximate Composition and Health Benefits of *Colocasia esculenta* Leaves: An Underutilized Leafy Vegetable in Nigeria

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Abstract

Background and Objective: *Colocasia esculenta* L. Schott, commonly known as Cocoyam, is commonly grown for its edible tubers but the leaves have been underutilized. This study was conducted to compare the proximate and mineral values of fresh, sun-dried and boiled *C. esculenta* leaves collected in Enugu State, Nigeria. **Methodology:** Proximate analysis was performed according to the standard AOAC methods while the mineral content was determined using atomic absorption spectrometry. The effect of no treatment, sun-drying and boiling of the leaves were investigated. **Results:** Proximate analysis showed that the sun dried leaves had higher carbohydrate, protein, fat and ash content than the fresh and boiled leaves. However, boiling decreased the ash, protein and fat contents of the leaves. Mineral content determination revealed that calcium, magnesium, potassium, sodium, iron and manganese contents were increased by sun drying whereas copper, phosphorus and zinc contents were decreased compared to the fresh leaves. **Conclusion:** This study revealed that sun-dried *Colocasia esculenta* leaves retained more of the nutrients than the fresh and boiled leaves. The leaves of *C. esculenta* may be a potential source of nutrients as leafy vegetables.

Key words: *Colocasia esculenta*, african leafy vegetable, cocoyam, proximate analysis, mineral content, sun-drying, boiling

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Nigeria is a country with multi-cultural diversities where indigenous vegetables, especially leafy vegetables, have been used as indispensable ingredients in diets. In most tropical countries of Africa, vegetables have served as important components in traditional sauces and soups that accompany carbohydrate staples[1]. They are the cheapest sources of essential nutrients[2] and hence provide nutritional balance and food security which are mutually important for humans both in rural and urban set ups[3]. However, due to inadequate scientific knowledge of the nutritional potentials of many local vegetables, they are under-utilized. There is an increasing interest in the study of nutrition and health benefits of indigenous and under-utilized vegetables in Africa. Many reports abound in literature documenting on the nutritional composition of various edible plant materials but much still need to be done.

Colocasia esculenta L. Schott belongs to the family of Araceae. The common name of the plant is Cocoyam and the leaves are known as Mpoto ede (Igbo language) in the Eastern part of Nigeria. It is cultivated mainly for its edible corms/tubers and serves as food throughout sub-tropical and tropical regions of the world. The plant is a succulent herb with leaves appearing in clusters of long arrowhead shapes pointing earthwards[4] and the plant grows a few meters high on erect stems. The leaves may be consumed[5], however, its consumption among the urban dwellers in Nigeria is uncommon unlike the tubers. The leaves hold an important place in the diet of few rural people especially in some areas in South Eastern and South Western States of Nigeria and it is the fourteenth most consumed vegetable worldwide[6,7]. The fresh leaves may be boiled and utilized as a vegetable to supplement carbohydrate meals or in soups. They may also be harvested and sun-dried to make them available during periods of shortages in dry seasons.

In Nigeria, *C. esculenta* leaves is underutilized as a leafy vegetable especially among the urban dwellers. Fear of its safety for consumption and inadequate information on the nutritional potentials may seem as the reasons for its underutilization. A previous study on acute toxicity testing of the leaves in rats showed an oral LD_{50} of >5 g kg^{-1} body weight[8] suggesting the non-toxic nature of the leaves for consumption according to OECD-423 testing guidelines. Lewu *et al.*[9] have documented the mineral content and anti-nutritional factors of accessions of the plant material growing in South Africa. There is, however, paucity of scientific literature on the nutrient and mineral composition of *C. esculenta* leaves growing in Nigeria. It is therefore, imperative to provide scientific information on the nutritional status of *C. esculenta* leaves as part of the practical ways to mainstream African leafy vegetables in the global trends in food, health and nutrition. This study was, therefore, conducted to investigate its nutritive value, proximate composition and the changes due to processing by sun-drying and boiling on these parameters.

MATERIALS AND METHODS

Procurement and preparation of plant material: Fresh leaves of the *Colocasia esculenta* plant (Fig. 1) were obtained from a farm in Enugu metropolis, Enugu State, in Southeastern Nigeria. The leaves were identified and compared with the voucher specimen (UNH No.379[a]) deposited at the herbarium section of the Department of Plant Science and Biotechnology, University of Nigeria, Nsukka. The plant material was divided into three equal parts. One part was placed in boiling water for 5 mins and eventually strained with a sieve, while another part was sun-dried for 3 days. The remaining portion of the leaves received no treatment. The Fresh, Boiled and Sun-dried leaves (FL, BL and SDL respectively) samples were separately placed in polythene bags to prevent loss of moisture during transportation to Pymotech Research Centre and Laboratories, Abakpa Nike, Enugu, Enugu State, Nigeria for analyses.

Proximate analyses: The recommended methods of the Association of Official Analytical Chemists[10] were used for the determination of moisture, ash, crude fat, crude fibre and nitrogen contents in the fresh, boiled and sun-dried samples. Crude protein was obtained by determining the organic nitrogen content of the sample using micro-Kjeldahl method

Fig. 1: *Colocasia esculenta* plant in a farm site

and multiplying the nitrogen by a protein conversion factor of 6.25. The carbohydrate content was determined using estimation by difference.

Energy value estimation: The calorific values of the samples were estimated (in kcal) by multiplying the percentage crude protein, carbohydrate and crude fat by the recommended factors (2.44, 3.57 and 8.37) used in vegetable analysis as documented by Asibey-Berko and Tayie[11].

Analysis of mineral elements: The mineral contents namely calcium, magnesium, copper, manganese, phosphorus, iron sodium, potassium, zinc in homogenized samples were estimated using standard techniques[12].

RESULTS AND DISCUSSION

Proximate composition: As shown in Table 1, the comparison of the fresh leaves with the boiled leaves revealed that boiling reduced the ash, protein, fat and fibre contents while the moisture, carbohydrate and caloric contents increased. Upon sun-drying, all the parameters were increased except fibre and moisture contents which showed mild and marked decrease, respectively.

The moisture content of the FL which gave a value of 83.0% agreed with the fact that high content of moisture is usually found in leafy vegetables. This is indicative of freshness, low shelf life or easy perishability as high amount of moisture in vegetables make them vulnerable to microbial attack leading to spoilage[13]. Increased water absorption occurs during boiling and this may explain the increased moisture content observed in BL, thus enhancing perishability. However, the markedly reduced value of 6.0% by sun-drying may support the practice of storage of vegetables in dry forms by consumers.

Ash content of any sample is an index of the total mineral content[14]. A value of 9.0% obtained in the FL suggests that the leaf is a good source of mineral elements. The decrease in ash content of 4.0% observed in the BL may be due to water absorption during boiling which results in dilution as previously documented[15]. This finding suggests a reduction in the potential ability of the boiled leaves to supply essential minerals. Lewu *et al*.,[9] documented a range of mineral contents after cooking (7.02-9.43%) and before cooking (11.58-12.78%) accessions of *C. esculenta* leaves harvested in South Africa. These values are slightly higher than those obtained in the present study. However, the SDL gave a value of 23% and was shown to have highest mineral content (Fig. 1).

Table 1: Proximate composition of fresh, boiled and sun-dried cocoyam (*Colocasia esculenta* (L.) schott) leaves

	Concentration (%) DW		
Parameters	FL	BL	SDL
Moisture content[a]	83.0	88.0	6.0
Ash content	9.0	4.0	23.0
Crude protein	2.9	2.7	3.2
Crude fat	0.6	0.4	1.0
Crude fibre	2.2	1.2	2.0
Carbohydrate	2.3	3.7	64.8
Calorific value (kcal 100 g^{-1})	20.3	23.1	247.5

[a]Value expressed as wet weight (%)

The results of the crude protein content revealed that similar values were obtained for FL (2.9%) and BL (2.7%), however, slightly higher value was noted for the SDL (3.2%) when compared to FL. Previous studies have reported on similarity of protein content in fresh and blanched leafy vegetables[16,17]. These values are about 1.3% (SDL), 11.7% (FL) and 14.3% (BL) of their calorific values, respectively. Proteins contain amino acids which are required for cell function and to furnish energy[18]. Alinnor and Akalezi[19] documented a low crude protein content (0.066%) in *C. esculenta* tuber. This further implies that both the leaves and tubers of this plant are poor sources of protein. To achieve the daily requirement of protein for adults and children[20], dietary supplementation from other protein sources such as legumes and cereals would be required.

Fat is known to supply most of the energy needed by man[21]. The fat content of 0.6, 0.4 and 1.0% were obtained for the FL, BL and SDL respectively. These findings showed that the leaves of *Colocasia esculenta* are poor sources of plant fat which agrees with the general observation that leafy vegetables have low lipid content making them valuable food sources in avoiding obesity[22]. The content of crude fibre (1.2-2.2%) in the leaf samples investigated in the present study are lower than those values reported in previous studies on *C. esculenta* and *X. sagittifolium* leaves which were greater than 12%[15,23,24]. However, a low value of crude fibre (1.0%) was also recorded for the tubers[19]. Fibre intake helps in digestion and reduces serum cholesterol levels, colon cancer, hypertension, diabetes and the risk of cardiovascular diseases[25,26].

The present study revealed the carbohydrate content of the SDL (64.8%) which is higher than those obtained for the FL and BL (2.3 and 3.7%, respectively). Previous reports have shown that leaves processed by different drying techniques including sun-drying, have higher carbohydrate content than

fresh leaves[27,28]. Carbohydrates are the key energy source to human beings and generally add to the bulk of the diet. The high calorific (energy) value obtained for the SDL (247.5 kcal 100^{-1} g) may be attributed to the high carbohydrate content when compared to values obtained for the FL and BL (20.3 and 23.1 kcal 100^{-1} g, respectively).

Mineral content: The mineral compositions are shown in Fig. 2(a-b). Higher values of all minerals analyzed were observed in SDL than in FL and BL except for copper, phosphorus and zinc. It is well known that sun-drying processing improves the nutritional value of vegetables.

The highest values for calcium content was observed in the SDL (19.25 mg kg^{-1}). Previous studies have shown significantly higher calcium content in dried vegetables than in fresh vegetables[29,30]. It is well known that calcium is necessary for the formation of bones and teeth and is vital for blood clotting. Low intake in the body would lead to a deficiency called osteoporosis in adults while in children, development of rickets occurs as a result. Hence, calcium intake is essential for human body and demands sufficient intake.

Low levels of magnesium (Mg) were found in the samples of *C. esculenta* leaves with values of 1.21, 1.12 and 2.22 mg kg^{-1} for FL, BL and SDL, respectively indicating that the leaves of this plant is a poor source of Mg. Mg is a constituent of teeth and bones, serves as an enzyme activator and participates in functioning of nucleic acids[31,32]. Potassium in combination with sodium is required for the maintenance of proper acid-base balance in the cells. Potassium was found to be the most abundant mineral element in the FL (4.24 mg kg^{-1}), however, boiling and sun-drying decreased and increased its content (2.30 and 17.25 mg kg^{-1}, respectively). Sodium content was found to be 1.50 and 10.50 mg kg^{-1} for FL and BL respectively whereas SDL gave the highest value (22.50 mg kg^{-1}).

Iron (Fe) is needed in the body for the formation of the oxygen carrying protein molecule in the red blood cells, haemoglobin and the deficiency of iron is a common

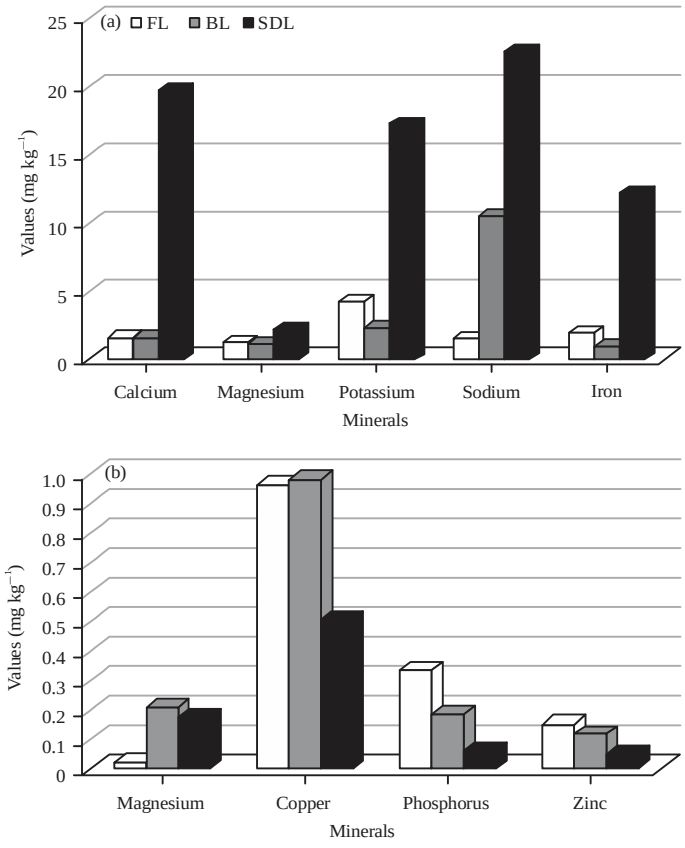

Fig. 2(a-b): Mineral composition of Fresh, Boiled and Sun-dried *Colocasia esculenta* (L.) Schott leaves: (a) Amounts (mg kg^{-1}) detected for calcium, magnesium, potassium, sodium and Iron, (b) Amounts (mg kg^{-1}) detected for manganese, copper, phosphorus and zinc

nutritional problem worldwide leading to anaemia[33]. Fe deficiency is associated with blood loss, intestinal malabsorption, folic acid deficiency, infections and inadequate amounts of iron in diet[34]. The iron content values of 1.93, 0.94 and 12.20 mg kg^{-1} were obtained for FL, BL and SDL, respectively. The range of iron content (0.19-4.22 mg kg^{-1}) have been documented for edible vegetables[35]. The markedly highest value observed with the SDL suggests that dehydration improved the iron content in *C. esculenta* leaves. It is known that green leafy vegetables become concentrated source of nutrients when dehydrated. Previous reports have documented markedly increased iron content of some green leafy vegetables after dehydration and as such have been used for enrichment of traditional recipes[36,37]. Children (7-10 years) and adult mail daily required 10mg of iron, adult female required 15 mg and pregnant and lactating mothers required 13 mg[38]. Copper (Cu), which plays a vital role in diet for the uptake of iron[39] was found in very low amounts (<1 mg kg^{-1}) in all the samples of *C. esculenta*. The Recommended Dietary Allowance (RDA) of Cu is 3.5 mg kg^{-1} [40] and its excess intake can result in Wilson's disease.

The concentration of manganese (Mn) was found to be the least present element in *C. esculenta* leaves with values falling within a range of 0.02-0.20 mg kg^{-1} [41]. The RDA of Mn is 2-5 mg day^{-1}. Mn is vital for proper food digestion, growth, nervous system and reproduction[42]. Its deficiency results in infertility, nervous irritability and bone malformation. More so, the levels of phosphorus (P) and zinc (Zn) were found to be <1 mg kg^{-1} in the three samples with SDL exhibiting the lowest value for both elements. The RDA for P and Zn are 4000 and 13 mg kg^{-1}, respectively. Phosphorus is essential for the development of strong bones and teeth, hence its deficiency results in osteomalacia, rickets and tooth decay[43]. Zinc, however, is required for the activation of different enzyme systems as a cofactor and is also involved in immune system function, wound healing and tissue repair. Excess Zn leads to gastrointestinal distress including abdominal pain, vomiting and diarrhea. *C. esculenta* leaves appears to be poor sources of P and Zn.

CONCLUSION

The present study has shown that boiling may decrease the protein, fat, fibre and ash content of *Colocasia esculenta* leaves. Specifically, sun-drying improved the carbohydrate, protein, fat and ash content of the leaves. The leafy vegetable can be recommended as a good source of calcium, potassium, sodium, iron and copper to help combat malnutrition in developing countries. The consumption of the leaves is therefore encouraged as supplementary source of nutrients to accompany carbohydrate staple diets of the indigenous people of Nigeria.

RECOMMENDATION

We recommend further studies to be carried out to explore the effect of other drying methods which would preserve the nutritional phyto-constituents of the plant material. More so, a study to ascertain the economic implications of consuming the leaves is encouraged.

SIGNIFICANCE STATEMENT

This study discovers the potential use of *Colocasia esculenta* (Cocoyam) leaves (especially sun-dried) for nutritional benefits. This study can help researchers to uncover a critical area of nutritional profile assessment which have not been explored by other researchers. Therefore, a new view on the utilization of cocoyam leaves may be arrived at.

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