Bio-Science Research Bulletin
Volume 40, Number 2
July-December 2024: P.124-135
Original Research Article

Print version ISSN 0970 0889
Online version ISSN 2320 3161

http://www.bpasjournals.com

Phytochemical Composition, Nutritional Content and Mineral Bioavailability in Dry Leaf of *Colocasia esculenta* (L.) Schott

[1]Oyeyemi Sunday Dele and [2]Arowosegbe Sunday*

Author's Affiliation:
[1,2]Department of Plant Science and Biotechnology, Ekiti State University, Ado-Ekiti 36001, Nigeria

***Corresponding Author:**
Arowosegbe Sunday,
Department of Plant Science and Biotechnology, Ekiti State University, Ado-Ekiti 36001, Nigeria
E-mail:
sunday.arowosegbe@eksu.edu.ng

ABSTRACT

Consumption of local vegetables is common in Africa and more importantly among the local populace in Nigeria. These vegetables are characterized by high nutritional values and therapeutic properties. This present study was done to assess active phytochemical and nutritional content of the dry red cocoyam leaves collected from a location in Ekiti State, Nigeria using standard procedures. The mineral bioavailability was predicted using antinutrient mineral molar ratios. The proximate result revealed the following: moisture content (6.36%), ash (7.98%), crude fat (0.71%), crude protein (8.16%), crude fiber (1.74%), and available carbohydrate (75.06%). The dry leaf contained saponins, alkaloids, flavonoids, phenols and terpenoids which are important active secondary metabolites. Mineral content investigation revealed that the plant contained some vital elements like K, Na, P, Ca, and Mg, which occurred in high proportion, Fe and Zn in moderate proportion, while Cu and Zn contents were low. Phytate, oxalate and cyanide levels were also low, while the calculated Phytate/Zn, Phytate/Ca and Oxalate/Ca were not up to the threshold levels hence, will not inhibit absorption and bioavailability of Zn and Ca in the sample. This plant as a vegetable is cheap, can be sourced locally as cocoyam waste. It was found to be nutritionally rich in protein, mineral, low crude fat with various groups of phytochemicals in the leaf. All these could make it good for the body's health and development. The low antinutrient discovered in this sample makes it safe for human consumption. Its consumption can help in food security in Nigeria especially now that there is dearth of protein rich foods among low income earners.

KEYWORDS: *Vegetable, cocoyam, antinutrient, protein, food security, Nigeria*

Received on 15.08.2024, Revised on 21.09.2024, Accepted on 30.11.2024

How to cite this article: Oyeyemi, S.D. and Arowosegbe, S. (2024). Phytochemical Composition, Nutritional Content and Mineral Bioavailability in Dry Leaf of *Colocasia esculenta* (L.) Schott. *Bio-Science Research Bulletin*, 40(2), 124-135

INTRODUCTION

Nutritionally, man needs a good diet for proper growth and development (Sha'a *et al*., 2019). Vegetables are essential food component in human diet. They serve as good sources of fibres, micro and macro mineral elements as well as vitamins to the majority of rural dwellers. Iyaka (2007) reported that vegetables are usually eaten in comparatively small quantities as dish or relish with staple food. Many traditional African vegetables are nutrient-dense and have much potential to reduce malnutrition. Consumption of less known vegetables are common in Africa and they are noted for their high nutritional and medicinal values (Schmidt, 1994). Traditional vegetable is considered as nutritious and popular among certain tribes or population in specific locations. In some tribe or area, local vegetable is regarded as favourite food while in another region it might be considered a weed. This might be as a result of lack of adequate information or knowledge on the extent of their uses. These underutilized vegetables are cheap and generally consumed by poor farmers. Shavan *et al*. (2009) reported that local vegetables are often regarded as being lower in rank, status or quality and being treated as insignificant by the urban populate.

However, these local vegetables are under-researched and underutilized across the vegetable value chain. There is the need to evaluate and document relevant information on the nutritional and phytonutrients profiles of *Colocasia esculenta* leaf, an underutilized vegetable, in order to promote its cultivation and encourage its utilization. The screening and estimation of the amount of phytochemical of *C. esculenta* leaf would in turns help to give credence to or validate its acclaimed medicinal importance, thereby promoting its consumption.

MATERIAL AND METHODS

Plant collection

Pink cocoyam (*Colocasia esculenta*) leaves were collected from Iyin - Ekiti, Ekiti State, Nigeria. The sample was identified and authenticated by the Curator in the Herbarium of the Department of Plant Science and Biotechnology, Ekiti State University Ado-Ekiti. The leaves were rinsed with distilled water, air dried at room temperature (25-30 ^{0}C) for fourteen (14) days, then pulverized before being used for the chemical analyses.

Qualitative Phytochemical analysis

The methods of Harborne (1973), Trease and Evans (1998) and Sofowora (2008) were adopted for qualitative phytochemical screening of the plant sample. The sample was screened for the presence of important phytochemical such as alkaloids, tannins, saponins, phenols, flavonoids, terpenoids, cardiac glycosides, phlobatanins and reducing sugar.

Qualitative Phytochemical Screening

Test for flavonoids

To test for Flavonoids, one (1) g of the extract was dissolved in 1% Aluminium chloride in methanol. This was followed by the addition of few drops of concentrated HCl, magnesium turnings and potassium hydroxide solution. Colour change of orange to pink showed the presence of flavonoids.

Test for Alkaloids

One (1) gram of the pulverised sample was taken and mixed with 5ml of 1% HCl on a steam bath and then filtered. Few drops of Dragendorff's reagent (Bismut nitrate + conc. HCl) was added to 1 ml of the filtrate. A dark colour change of the sample indicated the presence of alkaloids (Oyeyemi *et al*., 2019)

Test for Saponins

A portion (2 g) of the pulverised sample was taken and boiled in 20 cm^3 of distilled water in a water bath and then, filtered. The filtrate (5 cm^3) was added to 5 cm^3 of distilled water and shaken vigorously. Stable foam formation was taken as to mean the presence of saponins (Banso and Adeyemo, 2007).

Test for Cardiac glycosides

The samples' Cardiac glycosides was tested using Killer Killani Test. Portion of the powdered leaf sample (1 g) was dissolved in 5cm^3 of distilled water and 2 cm^3 of glacial acetic acid solution containing one drop of ferric chloride solution. This was under played with 1cm^3 of concentrated H_2SO_4. A brown ring formation at the interface indicated the presence of deoxy sugar characteristics of cardenolides.

Test for Phenols
For phenol detection, 2 ml of ferric chloride ($FeCl_3$) solution was added to 2 ml of the sample extract in a test tube. Formation of deep bluish green solution showed the presence of phenol.

Test for the presence of Phlobatannins
Aqueous extract of the leaf sample (2 ml) was added to 2 ml of 1% HCl and allowed to boil in a water bath. A red precipitate deposits confirmed phlobatannins presence in the sample.

Test for Terpenoids
One gram of the plant ground sample was mixed with 2 ml of chloroform and 3 ml of conc. H_2SO_4 was carefully added to form layer. A reddish-brown colouration of the interface indicated the presence of terpenoids.

Determination of Phytochemical constituents

The quantity of the phytochemicals presence in the sample were estimated using the method of AOAC (2006).

Proximate analysis

The procedure of Association of Official Analytical Chemist (AOAC, 1990) was used to determine the moisture content, carbohydrate, crude protein, crude fat, crude fibre and ash contents of the sample. To determine the moisture content, 5 g of the sample was heated in a crucible inside an oven at temperature of 105 ^{0}C to a constant weight. Total ash was estimated by measuring 5 g of the sample in a crucible and ignited in a muffle furnace at 550 ^{0}C for 6 h, allowed to cool down and the weight taken again (AOAC, 1990). Crude protein was extrapolated by multiplying the nitrogen content of the sample by 6.25 (AOAC, 2006).

Determination of the Crude fat content was done by measuring 5 g of the powdered sample and digested with H_2SO_4 and NaOH. The residue was put into a crucible and then placed in a muffle furnace at about 550 ^{0}C for 5 h.

The available Carbohydrate in the sample was estimated according to Onwuka (2005) method thus; % Available carbohydrate = 100 – (% moisture + % ash + % protein + % fibre)

Mineral Content Determination

To determine the mineral content, wet digestion of the sample was carried out in line with the method of Alpodogan *et al.* (2002). Atomic Absorption Spectrophotometer was used to determine Zinc, Manganese, Magnesium and Iron contents, while Sodium, Potassium and Calcium were determined calorimetrically (State *et al*., 2011).

Determination of Mineral Ratios
The ratios of Na/K, Ca/P, Ca/Mg, Na/Mg, Ca/K, Zn/Cu, Fe/Cu and the milliequivalent ratio [K/(Ca + Mg)] were all calculated by adopting Hathcock (1985) method. Mineral Safety Index (MSI) of Na, P, Ca, Mg, Fe, Zn and Cu were also calculated using the formula:
Calculated MSI = MSI/RAI x Research data result
where;
MSI = mineral safety index table (standard)
RAI = recommended adult intake

Determination of some Anti-Nutrient factors

The oxalate content was determined using high pressure liquid chromatograph (HPLC) methods described by Wilson *et al*. (1982). Phytate and cyanide were determined according to the methods described Wheeler (1971) and AOAC (2010) respectively.

Determination of Energy

Atwater factor method as described by Osborne and Voogt (1978) was adopted to determine the energy value.The estimated energy value in the samples in Kilocalories (Kcal/100g) was determined by adding the multiplied values for crude fat, crude protein and carbohydrate using the factor (9Kcal, 4Kcal and 4Kcal) in that order. The energy value in Kilojoules was estimated by adding the multiplied values for crude fat, crude protein and carbohydrate using the factor 37Kcal, 17Kcal and 17Kcal respectively.

Statistical Analysis

The statistical analyses carried out were the mean and standard Error (SE).

RESULTS

Phytochemical Composition

The phytochemical screening results of the dry leaf of red *C. esculenta* showed the presence of saponins, phenols, alkaloids, flavonoids and terpenoids (Table 1). Quantitative phytochemical estimation (mg/100g) is presented in Table 2. The results indicated values for alkaloids (0.59 ±6.36), phenols (0.085± 4.24), saponins (1.55±9.19), flavonoids (0.92± 4.94) and terpenoids (0.041 ± 5.65).

Proximate Composition of dry leaf of red C. esculenta

The results for the proximate content (%) revealed that the *C. esculenta* leaf had low moisture content (6.36 ± 0.014), crude fat (0.71 ± 5.65), crude fibre (1.74±7.07), moderate ash (7.98± 0.012), crude protein (8.16± 0.014) and high carbohydrate content (75.06± 0.021) and Energy value (344.98 kcal/100g) (Table 3).

Mineral contents of dry leaf of red C. esculenta

The mineral composition (mg/100g) data for the dry *C. esculenta* leaf revealed that it contained high levels of K (778.55), P (157.29), Ca (89.15). Mg (57.14) and moderate levels of Na, Fe, with low levels of Zn, Cu, and very low content of toxic metals (Cd, Ni and Cr) (Table 4).

Mineral Ratios of C. esculenta dry leaf

Table 5. depicts the mineral ratios of Ca/ K(0.032), K/Na (31.71), Ca/Mg (1.56), Ca/ K (0.115), Zn/Cu (3.32), Fe/Cu (5.70) Ca/P (0.566), (K/[Ca + Mg]) milliequivalent (5.32) for *C. esculenta* leaf. The mineral ratios for Ca/Pb, Fe/Pb were not determined since Pb was not detected in the leaf sample.

Vitamin contents of C. esculenta dry leaf

The result of vitamin compositions was found to be at low value of 0.011 ±1.44 mg/100g for Vitamin A and 0.97 ±7.07µg /100g for Vitamin D (Table 6)

Table 1: Qualitative phytochemical screening of *C. esculenta* dry leaf

Phytochemical	*C. esculenta*
Saponins	++
Alkaloids	+
Flavonoids	++
Phenols	+
Cardiac glycosides	-
Terpenoids	+
Phlobatanins	-

+ = presence, - = absent

Table 2: Quantitative phytochemical estimate of *C. esculenta* dry leaf

Phytochemical	***C. esculenta*** (mg/100g)
Saponins	1.55±9.19
Alkaloids	0.59±6.63
Flavonoids	0.92±4.94
Phenols	0.085±4.24
Terpenoids	0.041±5.65

Mean ± SD of duplicate determinations

Table 3: Proximate composition of *C. esculenta* dry leaf

Parameter	**Concentration (%)**
Moisture content	6.36±0.014
Ash	7.98±0.012
Crude fat	0.71±5.65
Crude protein	8.16±0.014
Crude fibre	1.74±7.07
Carbohydrate	75.06±0.021
Energy (Kcal/100g)	345.04±0.08

Mean± SD of duplicate values

Table 4: Mineral Content of *C. esculenta* dry leaf

Parameter	**Concentration (mg/100g)**
Na	24.55±0.21
K	778.55±0.07
P	157.29±0.03
Ca	89.15±0.21
Mg	57.14±0.03
Fe	4.50±0.07
Zn	2.62±4.24
Cu	0.79±3.54
Cd	0.003±7.07
Ni	0.013±2.12
Cr	0.229±2.83
Pb	0.00±0.00

Mean± SD of duplicate values

Table 5: Calculated mineral ratios of *C. esculenta* dry leaf

Parameter	**Ratios**	**Standard**
Na/K	0.0058	0.06
K/Na	3.19	5.0
Ca/P	0.59	≥0.5
Ca/Mg	1.56	6.67
Na/Mg	0.43	4.17
Ca/K	0.115	4.0
[K/(Ca+Mg)]	1.08	2.2

Zn/Cu	3.32	4.75
Fe/Cu	5.70	5.59
Ca/Pb	0.00	0.9
Fe/Pb	0.00	84
Zn/Cd	873.3	500

Table 6: Anti-nutrient Composition (mg/100g) and Calculated antinutrient-mineral ratios of C. esculenta dry leaf

Parameter	*C. esculenta*	Ideal value
Phytate	63.13	-
Oxalate	24.36	-
Hydrocyanide	12.65	-
Ca	89.15	-
Fe	4.50	-
Zn	2.62	-
[Phy]/[Zn]	2.39	>15
[Phy]/[Ca]	0.043	<6
[Phy][Ca]/[Zn]	5.33	>0.5
[Phy]/[Fe]	1.187	>1
[Oxa][Ca]	0.123	1

Table 7: Vitamin composition of *C. esculenta* dry leaf

Parameter	Concentration
Vitamin A	0.011±1.41 (mg/100g)
Vitamin D	0.97±7.07 (µg/100g)

Mean± SD of duplicate determinations

DISCUSSION

Phytochemicals are groups of naturally occurring compounds found in plants and are believed to be responsible for the protective health benefits in man. These active secondary metabolites play various important roles in alleviating several ailments in the traditional medicine and folklore. Past research works revealed that the various active phytochemical such as phenols, tannins, flavonoids, alkanoids and terpenoids are noted for a variety of therapeutic actions in humans (Mutha *et al*., 2021). The phytochemical screening and determination of *C. esculenta* leaf is very important in order to know the presence and actual amount of these phytonutrients in this local leafy vegetable. This would in turn help to give credence or validate the therapeutic benefits and also promote the uses of the vegetable. The phytochemical found in the leaf of *C. esculenta* were saponins, phenols alkanoids, flavonoids and terpenoids while cardiac glycosides and phlobatanins were absent.

The phytochemical result discovered in this present study compared favourably to the findings of Tudu and Sinha (2017) who reported the presence of alkanoids, phenols, saponins and flavonoids in *C. esculenta*. Saponins have been reported to have exhibited a diverse pharmacological activity which include antiviral, anti-fungal, anti-inflammatory, anti-cancer, antioxidant and antimicrobial effects (Juang and Liang, 2020). Phenols remains one of the most valuable and diverse groups of secondary metabolites in plants (Zhang *et al*., 2022). Phenols are known to be strong antioxidants that make impossible oxidative damage to biomolecules such as DNA, lipids, and proteins (Muller *et al*., 2019). Several authors have reported the therapeutic properties of phenols as anticancer, inflammation prevention and immune system busting (Chen *et al*., 2015; Andre *et a*l., 2018). Many edible plant species such as various fruits and vegetables contains flavonoids which form an important human dietary constituent (Verri *et al*., 2012). It has been reported that constant consumption of dietary foods rich in flavonoids proved to sufficiently protect against the development of diabetes and its management, cancer, cardiovascular diseases and osteoporosis diseases (Mutha *et al*., 2012). Flavonoids have antioxidant properties which help in the treatment of anaemia and can as well cause inhibition of the oxidative modification of the human lipoproteins (Swapana *et a*l., 2012).

The presence of the active secondary metabolites add credence to the acclaimed medicinal uses of the cocoyam leaf in promoting healthy skin, prevention of cancer and boost immune system. The consumption of C. *esculenta* leaf is desirable to make man live healthy and fight against undesirable diseases.

Moisture content is the amount of water in food and equally forms an essential part of proximate composition analysis of food (Gemede *et a*l., 2015). The moisture content for the investigated leaf is lower than 30.90% and 23.60% reported for *Brassica oleracea* and *Hibiscus sabdariffa* respectively (Yunus and Abdullahi, 2020). High moisture content indicates susceptibility to microbial attack leading to spoilage (Nnamani *et a*l., 2009). Low moisture content recorded for *C. esculenta* in this study might support the local practice of storing the studied vegetable in dry forms. Anita *et a*l. (2006) reported that ash content of any food sample gives a reflection of its mineral contents. The ash content of 7.98% obtained in this study is lower than 16.40% for *Telfairia occidentalis* and 11.17% for *Brassica oleracea* as recorded by Iyaka *et al*. (2014). However, the ash content is higher than the ash value of 4.0% discovered by Azubuike *et al*. (2018) for boiled leaves of *Colocasia esculenta*. The results of our findings compared favourably with the value (7.39%) found in *Gnetum africanum* (Okezie *et al*., 2017). The crude fat value (0.71%) for *C. esculenta* dry leaf in this work is lower compared to 5.65% crude fat previously reported for *Corchorus olitorus* (Sha'a *et al*., 2019). The result of our finding is in line with the general norm that leafy vegetables contain very low lipid hence, positioning them a preferred food for obese (Linta, 1992). Excess consumption of fats in human is undesirable. It may leads to hearth related diseases, ageing and cancer (Kris-Etherton et al., 2002). Low crude fat in the leaf of *C. esculeta* in this study indicated that the consumption of the vegetable is safe.

The content of crude fibre (1.74%) obtained for the *C. esculenta* dry leaf sample in this present study is lower than 10.51% and 12.48% recorded for *Emilia coccinea* and *Hibiscus sabdariffa* respectively (Simon *et al.,* 2015). However, this value compared favourably with the report of Akachukwu and Fawesi (1995) for *Colossia argentea* (1.8%). Fibre in human diet is noted to aid digestion. Olujobi, (2015) reported that fibre plays an important role in cleansing digestive tract and promote regular bowel movement. The crude protein content of the investigated *C. esculenta* dry leaf (8.16%) is lower than the value (16.84%) recorded for *Agerantum conyzoides* leaf (Oyeyemi *et al*., 2019). Interestingly, the protein content in this present study is higher than 0.066% crude protein documented by Alinnor and Akelezi (2010). On the other hand, the result of our finding is in tandem with the crude protein content of 8.80% reported for *Annona senegalensis* (Yisa *et al*., 2010). Proteins are essential component of human diet that supports the growth and maintenance of body tissues (Sudahakararao *et al*., 2019). Sufficient consumption of protein is necessary for keeping the muscles, bones and tissues healthy. Proteins help in constant replacement of worn out tissues (Obahiagbon and Erhabor, 2010). The value reported in this present study is cheering and the plant leaf could be a good source of crude protein in human and animal foods.

Carbohydrates provide energy needed for physical effectiveness and regulate nerve cells (Whitney and Rolfes, 2005). The carbohydrate content of the studied vegetable is comparatively higher than the previous reports of Yunus and Abdullahi *et a*l. (2020) for some indigenous leafy vegetables. The carbohydrate value compared favourably with the report of Akinola *et al*. (2021) for Bay leaf but slightly lower than the one discovered by MAlcantra *et al*. (2013) for raw taro (*C. esculenta*). The high carbohydrate content in *C. esculenta* in this present study propose that this underutilized vegetable could be considered as a good carbohydrate food for man and supplement feeds for the domestic animals.

The mineral value obtained in this present study for dried cocoyam leaves suggests that the underutilized vegetable is moderately rich in nutritionally important minerals. The importance of minerals in the nutritional development of man cannot be underestimated.

Some nutrients have a beneficial inter-relationship to each other hence, human body must have them in a certain proportion for the body to operate at its optimal level. Mineral ratios are usually more important in finding out nutritional deficiencies and excesses than mineral alone (Oyeyemi and Raymond, 2023). The selected mineral ratios showed important balance between these elements as well as give information on the likely factors that could come up as a result of disruption of their relationships. Such disruption could affect the state of disease, physiological and developmental factors, the effects of diet and drugs (Watt, 2010). The Na/K ratio in this study conform to the standard value of 0.6. High amont of salt in the body can raise blood pressure hence increase the risk of cardiovascular attack and stroke. However, eating food that contains more K can help to reduce these health risks.

The K/Na ratio is probably the most important nutrient ratio in the body. The ratio is very fundamental for our energy production and fluid balance. The ideal value for potassium to sodium ratio is 5:1 but has been reported in typical American diet to be close to 1:1 (Sebastian *et a*l., 2018). An imbalance in the ratio may lead to a wide range of health challenges like hypertension and high blood pressure. The Ca/P ratio value obtained in this local vegetable is in tandem with the standard value ≥ 0.5. Phosphorus is needed for strong bones and teeth as well as proper renal function.

Ca and Mg regulate one another in the body. Mg supports calcium absorption and utilization in the body. When there is deficiency in Mg, this can lead to poor absorption in Ca and vice versa (Zhang and Attura, 1999). Previous report showed that a ratio above 2:1 has been linked to increased risk of metabolic, inflammatory and cardiovascular disorder (DeLuccia *et al*., 2019). The Ca/Mg ratios in this present study could not pose any health risk to the consumer. Zn and Cu are essential micronutrients that the body needs in small quantities. Albeit, the Zn:Cu ratio should be kept in balance. Zn/Cu ratio may serve as reliable predictive indicator for poor health in elderly population (Andrea *et a*l., 1998). High Zn/Cu ratio has harmful health effect in the body (Malavolta *et al*., 2016). Zn has antioxidant properties which can help in ageing and also promote wound healing (Fabris, and Mocchegian, 2016). Zn equally boosts immunity and promote cellular metabolism (Sandstead, 1994). Cu is important in many metabolic activities. It helps in mental and cognitive function, bone and tissue maintenance, antioxidant defence, and immune function (Uriu-Adams and Keen, 2005). Consumption of Cu in high amount with low Zn may lead to depression, fatigue, constipation as well as copper toxicity.

The body needs iron to synthesize red blood cells and transport oxygen into cells, healthy immune activity as well as enzyme production. A high ratio shows possible iron toxicity while a lower ratio indicates a possible copper toxicity. The two minerals work in tandem. The Fe/Cu ratio value reported for *C. esculenta* falls within standard value 5.59.

Anti-nutritional factors are compounds that lower the maximum use of nutrient and/or food intake of plants or plant products used as foods and hence decreasing the nutritive value. However, if the diet is not varied, some of these toxins build up in the body to harmful levels (Abhishek *et al*., 2019).The results of the antinutrient factors in the cocoyam leaf revealed that the Phy:Ca, Phy: Zn, Phy:Fe and Oxa:Ca ratios were below the critical values. The Phy:Ca ratio was lower than the ideal vale of <6 an indicative of low phytate concentration. High phytate concentration in the diet can lead to reduced mineral absorption (Walter *et al*., 2002). It was reported in the previous report of Kies *et al*. (2006) that phytic acid could suppress the activity of enzymes needed for the degradation of protein in the stomach as well as the small intestine. Generally, phytic acids have affects on the bioavailability of minerals. It also has a strong influence on infants, pregnant and lactating women that eat large portions of cereal-based foods (Al Hasan *et al*., 2016).

Oxalate has been reported to inhibit Ca and Mg absorption which in turns affects peptic digestion. Human poising has been reported as a result of intake of leaves of certain plants that contain high amounts of oxalates (Veer *et al*., 2021). Oxa/Ca ratio was less than the critical value of 1 indicative of bioavailability of calcium in the leaf. Arowosegbe *et* al. (2020) was able to establish variations in the phytochemical, nutritional and mineral compositions of the same plant species planted under different environments, hence the differences in the results recorded in this present study and other similar studies on *C. esculenta.*

CONCLUSION

The results of the nutritional investigation of *C. esculenta* dry leaf pointed to the fact that the vegetable contained medicinally rich phytonutrients. The results establish the presence of active secondary metabolites that have been reported to promote good well-being hence, make it desirable for human consumption. The report of the proximate composition with low crude fat, moderate ash content, crude protein as well as high carbohydrate and essential minerals are very cheering and suggest that the vegetable is rich in nutritionally important nutrients. Antinutrient contents are low and make it safe for consumption. Antinutrient to mineral ratios as well as calculated mineral ratios are also in right proportions. The vegetable could be ranked among health promoting and nutritious local vegetable. Its uses, consumption and cultivation should be encouraged to fill the gap of foods that are poor in nutritional and energy sources among the low income earners.

REFERENCES

Abhishek, T., Vishal, S. and Aayushee, T. (2019). An overview of anti-nutritional factors in food. *International Journal of Chemical Studies.* 7(1): 2472-2479.

Akachukwu, C.O. and Fawusi, M.O.A. (1995). Growth characteristics yield and nutritive values of waterleaf, *Discovery and Innovations,* 7(2): 163-172.

Al Hasan, S. M., Hassan, M., Saha, S., Islam, M., Billah, M. and Islam, S. (2016). Dietary phytate intake inhibits the bioavailability of iron and calcium in the diets of pregnant women in rural Bangladesh: A cross-sectional study. *BMC Nutrition*, 2(1):2-24.

Alpdogan, G., Karbina, K. and Surgur, S. (2002). Derivative Spectrophotometer for Analysis. Chapman A and Hall, London, pp. 279.

Alinnor, I.J. and Akalezi, C.O. (2010). Proximate and mineral compositions of *Dioscorea rotundata* (White Yam) and *Colocasia esculenta* (White Cocoyam). *Pak. J. Nutr*., 9: 998-1001.

Andrea, M., Sante, D., Fabrizio, C., Ferdinando, R., Domeni co, De.C., Franco, C., Tiziana, I., Giuseppe, R., Franco, D., Giovanni, Z. and Renato, F. (1998). Copper/zinc ratio and systemic oxidant load: effect of aging and aging-related degenerative diseases. *Free Radical Biology and Medicine***.** 25 (6): 676-681.

Andreu, L., Muncio-Jauregui, N., Carbonell-Barrachina, A.A., Legua, P. and Harnandez, F. (2018). Antioxidant properties and chemical characterization of Spanish *Opuntia ficus-indica* Mill. Cladodes and fruits. *J.Sci. Food Agric*. 98:1566-1573.

Anita, B.S., Akpan, E.J., Okon, P.A. and Umoren, I.U. (2006). Nutritive and Antinutritive Evaluation of Sweet Potatoes (*Ipomoea batatas*) leaves. *Pakistian Journal of Nutrition*. 5(2): 166-168.

AOAC (1990). Association of Official Analytical Chemist.Official Method analytical Chemist, Washington.

AOAC (2006). Official Methods of Analysis of the AOAC (W. Horwitz Editor). 18th Ed.

Arowosegbe, S., Olanipekun, M.K and Olowoyeye, O.J. (2020). Influence of location on the phytochemical, Nutritional and Mineral Composition of the leaves of *Moringa oleifera* Grown in Ekiti-State, *Bulletin of Pure and Applied Sciences*. 39: 40-50.

Azubuike, N.C., Maduakor, U.C., Ikele, I.T., Onwukwe, O.S., Onyemelukwe, A.O., Nwanijiobi, D.U., Chukwu, I.J. and Achukwu, P.U. (2018). Nutritional profile, Proximate Composition Health Benefits of *Colocasia esculenta* Leaves: An Underutilized Leafy Vegetable in Nigeria. *Pak. J. Nutr.* 17: 689-695.

Banso, A. and Adeyemo, S.O. (2007). Evaluation of antibacterial properties of tannins isolated from *Dichrostachys cinerea*. *African Journal of Biotechnology***.** 6(15): 1785-1787.

Beard, J. (2006). Iron. In: Bowman BA, Russell RM,eds. Present knowledge in nutrition. Volume 1. Washington, D.C.: ILSI Press; 430-444.

Chen, X., Dang, T.T. and Facchini, P.J. (2015). Noscapine comes of Age. *Phythochemistry*. 111:7-13.

DeLucccia, R., Cheung, M., Ng, T., Ramadoss, R., Altasan, A. and Sukumar, D. (2019). Calcium to Magnesium Ratio Higher than Optimal Across Age Groups (P10 - 100-19). *Current Developments in Nutrition*, 3(1): issue supplement-1 pp 868-869.

Fabris, N. and Mocchegian, E. (2016), Zinc, human diseases and aging. *Europe PMC*, 7(2): 77-93.

Gemede, H.F. and Ratta, N. (2014). Antinutritional factors in plant foods:Potential health benefits and adverse effects. *Int. J. Nutri. Food Sci.* 3(4): 284-289.

Gqaza, B.M., Njume, C., Goduka, N.I. and George, G. (2013). The proximate composition of *S. nigrum* plant leaves consumed in the Eastern Cape Province of South Africa. *2nd International Conference on Nutrition and Food Sciences, IPCBEE.* 53.20 pp1-4.

Harbone, J.B. (1973). Phytochemical Methods. A guide to Modern Techniques of Plant Analysis. Chapman A and Hall, London, pp. 279.

Hathcock J.N. (1985). Quantitative evaluation of vitamin safety. *Pharmacy Times*, Pp.104-113.

Iyaka, Y.A., Idris, S., Alawode, R.A. and Bagudo, B.U. (2014). Nutrient content of selected edible leafy vegetables. *American Journal Applied Chemisty*. 2(3): 42-45

Juang, Y. and Liang, P. (2020). Biological and Pharmacological Effect of Synthetic Saponins. *Molecules*. 25(21): 4974.

Kies, A. K., De Jonge, L. H., Kemme, P. A. and Jongbloed, A. W. (2006). Interaction between protein, phytate, and microbial phytase. In vitro studies. *Journal of Agricultural and Food Chemistry,* 54(5):1753– 1758.

Kris-Etherton, P.M., Harris, W.S. and Appel, L.J. (2002). Fish consumption, fish oil, omega-3 fatty acids and cardiovascular diseases. *Circulation*. 106: 2747-2757.

Lambert, J.D., Hong, J., Yang, G.Y., Liao, J. and Yang, C.S. (2005). Inhibition of carcinogenesis by polyphenols; evidence from laboratory investigations. *Am. J. Clin. Nutr.* 81:284S-91S

Linta, C. (1992), Nutritional aspects of fruit and vegetable consumption. *Opt. Mediterr.* 19: 79-87.

Malavolta, M., Giacconi, R., Piacenza, F., Santarelli, L., Cipriano, C., Costarelli, L., Tesei, S., Pierpaoli, S., Basso, A., Galeazzi, R., Lattanzio, F.and Mocchegiani, E. (2016). Plasma copper/zinc ratio: an inflammatory/nutritional biomarker as predictor of all-cause mortality in elderly population. *Biogerontology,* 11(3):309-19.

MAlcantara, R., Hurtada, W. A. and Dizon, E. (2013), The nutritional value and phytochemical components of Taro (*Colocasia esculenta* (L.) Schott) powder and its selected processed foods. *Journal of Nutrition and Food Science*. 3(3): 1-7.

Muller, A.G., Saiker, S.D., Saleem, M. and Hutcheon, G.A. (2019). Delivery of natural phenolic compounds for the potential treatment of lung cancer. *Dury-J Phar. Sci.* 27(1): 433-449

Mutha, R.E., Tatiya, A.U. and Surana, S.J. (2021). Flavonoids as natural phenolic compounds and their role in therapeutics: an overview. *Future Journal of Pharmaceutical Sciences*.(2021) 7- 25

Nnamani, C.V., Oselebe, H.O. and Agbatutu, A. (2009), Assessment of nutritional value of three underutilized indigenous leafy vegetables of Ebonyi State, Nigeria. *African Journal of Biotechnology*. 8(9): 2321-2324.

Obahiagbon, F.J. and Erhabor, J.O. (2010). The health implications of dietary nutrients detection in the vegetable leaves intercropped with *Raphia hookeri* palms. *Afr. J. Food Sci*., 4:440-443.

Olujobi, O.J. (2015). Evaluation of the Nutritive Composition of Five Indigeneous Tree Leaves used as vegetable in Ekiti State, Nigeria**.** *Int. J. Agric. Environ. Sci*., 4: 185-197

Onwuka, G.I. (2005). Food Analysis and Instrumentation Theory and Practical, 1st Edition,

Osborne, D.R & Voorgt, P. 1978. Calculation of Caloric value. In: "Analysis of Nutrients in Foods". Academics Press, New York, pp, 23-34.

Oyeyemi, S.D., Kayode, J. and Olawumi, J. (2019). Nutritional and phytochemical evaluation of *Agerantum conyzoides*: A neglected edible wild vegetable in Ekiti State, Nigeria. *Singapore Journal of Scientific Research*. 9:69-76.

Oyeyemi, S.D. and Raymond, O. (2023). Phytochemical and Nutritional Profile, Mineral Ratio and Mineral Safety Index of Young and Matured Corn Silk Collected from Ekiti State, Nigeria. *Asian Plant Research Journal*. 11(5): 3041.

Oyeyemi, SD, Adebiyi, AO, and Ojo, VI, (2019). Phytochemical and Nutritional Evaluation of *Nephrolepis cordifolia* (L) C Presl, a Tropical Edible Fern, *East African Scholars J. Biotechnol Genet*., 1(4): 91-98.

Sha'a, K. K., Clarkson, G. P. and Artimas, S. P. (2019). Phytochemical analysis, proximate composition and antinutritional factors of *Corchorus oliterius* plant. *International Journal of Biological and Chemical Sciences*. 13(4): 2147-2157.

Sandstead, H.H. (1994). Understanding zinc: recent observations and interpretations. *J. Lab. Clin. Med.*, 124: 322-7.

Schmidt, D.R. (1994). Comparative yield and consumption of eight tropical leafy vegetables grown at two soil fertility levels. *Agronomy Journal*, 63: 559.

Sebastian, A., Cordain, L., Frassetto, L., Banerjee, T. and Morris, R.C. (2018). Postulating the major environmental condition resulting in the expression of essential hypertension and its associated cardiovascular diseases: Dietary imprudence in daily selection of foods in respect of their potassium and sodium content resulting in oxidative stress-induced dysfunction of the vascular endothelium, vascular smooth muscle, and perivascular tissues. *Med Hypotheses* 119:110–9.

Shava, S.O., Donoghve, R., Krasny, M.F. and Zazu, C. (2009). Traditional food crops as a source of community resilience in Zimbabwe. *Int. J. Afr. Renaiss*, 4(1): 31-48.

Simon, T.U., Raymond, L.T.,Barnabas, A.O. and Qrisstuberg, M.A. (2015). Proximate and Mineral Analysis of some wild leafy vegetables common in Benue State, Middle Belt-Nigeria. *International Journal of Sciences*. 4(05): 26-29.

Sofowora, E.A. (2008). Medicinal Plants and Traditional Medicine in Africa. John Wiley and Sons Ltd. Pp. 1-10.

State, G., Popescu, I.V., Gheboianu, A., Radulescu, C., Dulama, I., Bancuta, I. and Stribescu, I. (2011). Identification of air pollution elements in Lichens used as bio-indicators by the XFR and AAS methods. *Romanian Journal of Physics*. 56: 240-249.

Sudhakararao, G., Priyadarsini, K.A., Kiran, G., Karunakar and Chegu, K. (2019). Physiological Role of Proteins and their Functions in Human Body. *International Journal of Pharma Research and Health Sciences*. 7(1): 2874-2878.

Swapana, N., Jotinkumar, T., Devi, C.B., Singh, M.S. and Singh, S.B.. (2012): Total phenolic, total flavonoid contents and antioxidant activity of a few indigenous fruit grown in Manipur. *The Bio.scan* 7:73-76.

Trease, G.E. and W.C. Evans, (1998). Pharmacognosy. 15th Ed., Saunders, London, pp 53-56, 2002.41.Codex Alimentarius Commission. Draft revised for honey at step 6 of the Codex Procedure. CX 5/10.2, CL1998/12-S.

Tudu, D. and Sinha, V. S. (2017). Qualitative Phytochemical Analysis of some Leafy Vegetables used to Cure Anemia in west Singhbhum, Jharkhand, India. *Int. J. Recent Sci. Res*., 8(5): 17137-17140.

Uriu-Adams, J.Y. & Keen, C.L. (2005). Copper, Oxidative Stress and Human Health. Molecular Aspects of Medicine, 26, 268-298. https://doi.org/10.1016/j.mam.2005.07.015

Veer, S.J., Pawar, V.S. and Kambale, R.E. (2021). Antinutritional factors in foods. *The Pharma Innovation Journal*, 10(7): 01-04.

Verri, V.A., Vicentini, FTMC., Baracat, M.M., Georgett, S.R., Cardoso, R.D.R., Cunha, T.M.,Ferreira,S.H., Cunha, F.Q., Funseca Maria, J.V. and Casagrande, R. (2012). Flavonoids as anti-inflammatory and analgesic drugs: mechanisms of action and perspectives in the development of pharmaceutical forms. Studies in Natural Products Chemistry, Elsevier, In. pp. 297-330.

Walter, H.L., Fanny, L., Charles, C. & Christian, R. (2002). Minerals and phytic acid interaction: is it a real problem for human nutrition. *International Journal of Food Science and Technology*. 37:727-739.

Watts, D.L. (2010). HTMA mineral ratios: A brief discussion of their clinical importance. *Trace Elements Newsletter*, 21(1): 1-3.

Wheeler, E. and Ferrel, R.E. (1971). Evaluation of African Vegetables for their Nutritive Values. *J. Sci. Food Agric.*, 32: 273-278.

Wilson, C.W., Philip, E.S. and Robert, J.K. Jr. (1982). Analysis of Oxalic acid in *Averrboa carambola* I and spinach by high pressure liquid chromatography (HPCL). *Journal of Agriculture Food Chemistry*. 30(6): 1106-1108.

Whitney EN and Rolfes SR. (2005). Understanding Nutrition. 10th Edn.,Thomson/Wadsworth Publishing Company, Belmont, CA., pp: 132-137.

Yisa, J., Egila, J.N.and Dalinton, A.O. (2010). Chemical composition of *Annona senegalensis* from, Nupe land, Nigeria, *Afr. J. Biotechnol.* 9(26): 4106-4109.

Yunus, M.M. and Abdullahi, L. (2020). Nutritive composition and essential elements evaluation of some leafy vegetables grown in Gubi, Fadama Land, Bauchi, Nigeria.*African Journal of Pure and Applied Science*.

Zhang, A., Cheng, T.P.O. and Altura, B.M. (1992). Magnesium regulates intracellular free ionized calcium concentration and cell geometry in vascular smooth muscle cells. Biochimica Et Biophysica Acta Bba – *Mol. Res*.,1134:259.

Zhang, Y., Cai, P., Cheng, G. and Zhang, Y. (2022). A brief review of Phenolic compounds identified from plants: Their extraction, analysis and biological activity. *Natural Product Communication*. 17(1): 1-14.

****