American Journal of Food Science and Technology, 2020, Vol. 8, No. 2, 42-48
Available online at http://pubs.sciepub.com/ajfst/8/2/1
Published by Science and Education Publishing
DOI:10.12691/ajfst-8-2-1

Nutritive and Anti-Nutritive Evaluation of Cocoyam (*Colocasia Esculenta L. Schott*) Inflorescence

Kalu Emmanuel Okechukwu[1,*], Princewill-Ogbonna Ijeoma Lawretta[2], Azuka Chinenye Eberechukwu[1], Okocha Kalu Stanley[3], Kalu Chibuike Egbuta[4], Nweke Chijioke Joel[5]

[1]Department of Food Science and Technology, University of Nigeria Nsukka, Nigeria
[2]Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike, Nigeria
[3]Department of Food Science and Technology, Nnamdi Azikiwe Universit, Awka, Nigeria
[4]Department of Food Technology, Akanu Ibiam Federal Polytechnic Unwana, Nigeria
[5]Department of Mathematics and Statistics, Alex Ekwueme Federal University, Ndufu-Alike, Nigeria
*Corresponding author: emmajesus4i@gmail.com

Received December 27, 2019; Revised February 06, 2020; Accepted February 23, 2020

Abstract Levels of some nutrients and anti-nutrients of cocoyam (Colocasia esculenta (L.)Schott) inflorescence was determined using standard analytical methods. Crude protein, crude fat, crude fibre, ash, carbohydrate and moisture contents were 3.10%, 1.78%, 1.17%, 2.83%, 11.61% and 70.33% respectively. The vitamin composition was found to be at the levels of 348.91µg/dl for vitamin A and 27.21mg/100g for vitamin C. The elemental analysis of the inflorescence (in percentage) indicated that it contained appreciable levels of calcium (1.14), magnesium (4.80), manganese (5.49), zinc (60.70), iron (0.003), copper (0.04), sodium (22.92), potassium, (152.43), phosphorus (1.60) and iodine (18.13). The anti-nutrient composition (in percentages) for phytate, cyanide, oxalate and saponin were 32.27, trace, 36.07, 85.72 and tannin 17.15mg/100g respectively. These results revealed that cocoyam inflorescence can serve as good sources of nutrients, vitamins and mineral elements and contained low levels of toxicants and therefore, should be included in diets to supplement our daily allowance needed by the body.

Keywords: *cocoyam inflorescence, proximate analysis, anti-nutrients, minerals, vitamins*

Cite This Article: Kalu Emmanuel Okechukwu, Princewill-Ogbonna Ijeoma Lawretta, Azuka Chinenye Eberechukwu, Okocha Kalu Stanley, Kalu Chibuike Egbuta, and Nweke Chijioke Joel, “Nutritive and Anti-Nutritive Evaluation of Cocoyam (*Colocasia Esculenta L. Schott*) Inflorescence.” *American Journal of Food Science and Technology*, vol. 8, no. 2 (2020): 42-48. doi: 10.12691/ajfst-8-2-1.

1. Introduction

Cocoyam inflorescence is the flowered part of cocoyam plant. The inflorescence occur on a stout peduncle, shorter than leaf stalks, with pale yellow colored and about 20cm long [1]. The inflorescence is usually surrounded by stem leaves of the corm. It emergence or production during the season in the farm, marks the maturity of the cocoyam and therefore, ready for harvesting. Cocoyam inflorescence is an edible flower. In South America like Brazil and some part of Asia, it is used in dressing salad. It is consumed as delicacies in southern part of Nigeria. Cocoyam inflorescence is locally referred to as “Akpuru ede’” “Opere’, Efuru ede”, Ogbala ede” “Opi ede” Orim ede, and “Umu ede” by the Igbo tribes [1]. Traditionally, fresh cocoyam inflorescence is used as vegetable in soup and yam porridge. It is also dried, milled and used as spices in some communities in soup preparations to impact a peculiar color and flavor [1].

There are many species of *Colocasia esculenta* that produce inflorescence. Among all these, only NC_{E005} (Nigerian *Colocasia esculenta*) is commonly consumed in the southern parts of Nigeria and has the highest yield during their season. This research is only restricted to NC_{E005} species of cocoyam inflorescence.

Research on cocoyam (*Colocasia esculenta*) has reported that the leafy parts of cocoyam have high protein content that is highly degradable with good source of vitamins A and C [2]. Other research findings have reported that the leafy parts of cocoyam contains more proteins than the corm (tuber) [3]. Leafy vegetables are important items of diet in many Nigerian homes.Leafy vegetables are valuable sources of nutrients especially in rural areas where they contribute substantially in protein, mineral, vitamins, fiber and other nutrients which are usually in short supply in daily diets [4].

Besides, they add flavor, taste, color and aesthetic appeal to our food. Green leafy vegetables (wiled and cultivated) are important items of diets in many Nigerian homes as valuable sources of nutrients especially in rural areas where they contribute substantial micronutrients which are usually in short supply in most diets [5]. They are rich sources of carotene, ascorbic acid, riboflavin, folicacid and minerals like calcium, potassium, magnesium, sodium, iron and phosphorus [6]. They are also high in dietary fibre which helps in digestion and prevention of colon cancer [7]. In addition, they contain anti-nutrients such as oxalate and phytic acid which reduce the bioavailability of some essential minerals [8,9]. Green leafy vegetables also contain health promoting phytochemicals such as alkaloid, flavonoids, saponin and tannins and are associated with the reduction in the risk of cancer and other degenerative diseases [10,11].

Figure 1. Cocoyam Inflorescence in the farm.

However, use of fresh cocoyam inflorescence is usually associated with irritating sensation in the mouth and throat due to the presence of oxalate. The presence of anti-nutrients especially oxalate has been a limiting factor in the consumption of cocoyam inflorescence.Consumption of the majority of locally available vegetables in Nigeria is limited by insufficient information on their nutritive values. Researches have shown that there is no documentation on the chemical potency and nutritional composition of cocoyam inflorescence. Therefore, the purpose of this research is to evaluate the nutritive and anti-nutritive compositions of cocoyam inflorescence in a bid to determine its suitability as an edible vegetable or otherwise.

2. Material and Methods

2.1. Sample Collection

Fresh samples of cocoyam (*Colocasia esculenta (L.) schott*) inflorescence NCe005 used for this study were obtained from cocoyam section of National Root Crop Research Institute (NRCRI) Umudike, Abia State where it was as well identified.

2.2. Sample Preparation

Fresh cocoyam inflorescence were washed, drained and allowed to air dried for about 40 minutes at a room temperature. The fresh cocoyam inflorescence was sliced (2mm) and blended using Kenwood blender-BL300/BL350 series to obtain the wet milled fresh sample. It was packaged in a plastic container and stored in the freezer until used for analysis.

2.3. Analysis

2.3.1. Proximate Analysis

Proximate composition of the sample was determined using AOAC standard methods [12].

2.3.2. Vitamins and Minerals Determination

Calcium, magnesium, sodium, potassium, phosphorus, copper, manganese, iron and zinc were obtained when 1g of the sample was ashed in a furnace at 5500C for 7hrs.

The ash was dissolved in 10MHCl (hydrochloric acid) in a conical flask and filtered into a 100ml flat bottomed standard flask and made up to the mark with distilled water [12]. These individual minerals were measured from the solution using Atomic Absorption spectrophotometer (AAS) (UNICAM model 939 United Kingdom).Iodine was determined by the method described by Muir and Lamberts [13].

Vitamin A and C were determined using HPLC as described by Junaid *et al.* [14]. Samples were determined by reversed- phase high performance liquid chromatography technique using Agilent 1100 series Model HPLC system equipped with degasser, quaternary pump, auto-sampler, UV detector and column (zornax SB C8, 4.6 x 75mm, and 3.5 µm particle size or X bridge C18, 4.6 x150mm, and 5µ particle size) in an isoelectric elution mode and at a constant flow rate of 1ml/min using Agilent pump. Stable operating LC conditions were established before HPLC analysis by equilibrating for 30 min with mobile phase (ca 1 ml/ min). Standard blanks respectively were injected before analysis to confirm absence of chromatographic activity at retention time for the vitamins. The individual vitamin peaks in the samples was identified by comparison of retention times to the standards. The concentration of the vitamins in mg/100g edible weight was calculated.

2.3.3. Anti-Nutrient Determination

Saponin content was determined using AOAC standard method [12] and Oxalate content was determined by the method described by Iwuoha and Kalu [15]. Phytate content was determined by the method of Nkama and Gbenyi [16] while Tannin content was determined by the Folin-Denis colorimetric method as described by AOAC [12]. Hydrogen cyanide (HCN) was determined by alkaline picrate colorimetric method described by Bradbury *et al.* [17].

3. Results and Discussion

The results of proximate composition of cocoyam inflorescence are presented in Table 1. The values for ash content, fibre fat, protein, carbohydrate and moisture content were 2.83, 1.17, 1.78, 14.03, 11.61 and 70.33%

Table 1. Result of the Proximate Analysis of Fresh Cocoyam Inflorescence.

Parameter	Values in Dry bases (%)
Moisture content	70.33±0.45
Ash content	2.83±0.39
Crude fat	1.78 ±0.39
Crude protein	3.10±0.12
Crude fibre	1.17±0.39
Carbohydrate	19.84±0.11

Values are means ± standard deviation of triplicate determination

The ash content of the inflorescence was lower than that of some leafy vegetables commonly consumed in Nigeria such as *Telfairia occidentalis* (12.4%) [18], *Occimium graticimum* (8.00%) and *Hibiscus esculenta* (8.005) [9], 11.10% recorded for raw sweet potato leaves [20].

The 2.83% ash content of cocoyam inflorescence was however above 2.0% of cocoyam leaf, 2.2%% of *Amaranthus hydridus*, [21] but as well close to 2.52%) for *Moringa oleifera* [22] and 3.28% of raw Uckakoro leaf [23].

The ash content of the raw leaf, represent the amount of minerals present in a matter. The low level of ash content found in the fresh cocoyam inflorescence could be as a result of dilution factor caused by the high moisture content of the fresh sample. This value of the ash present in the sample reflected that cocoyam inflorescence could be a good source of minerals.

The crude fat (1.78%) is below 4.58, 5.9 and 4.8% for raw *Lasianthera africana* leaf, *Talinum triangulare* and *Amaranthus hydridus*respectively [9,24,25]. This value of the fat (1.78%) was similar to 1.10% raw Uchakoro [23], and 1.56% for raw *Moringa oleifera* [22] and quite higher when compared with 0.6% for *Solanum lycopersicum* leaf and 0.4% for *Solanum melanaema* leaf [26].

This showed that cocoyam inflorescence contains a low fat content and therefore could be shelf stable. Dietary fats function in the increase of palatability of food by absorbing and retaining flavors. A diet providing 1-2% of its caloric of energy as fat is said to be sufficient to human beings [20]. Excess fat consumption is implicated in certain cardiovascular disorders such as atherosclerosia, cancer and aging.

The crude protein of cocoyam inflorescence was quite higher when compared to fresh *Moringa oleifera* from Anambra (10.78%) and Nsukka (6.13%) [27], fresh cocoyam (*Colocasia esculenta*) leaves (3.1%) [21]. However, it was lower than 20.59% of fresh *Amaranthus caudatus* [28], 19.96% of fresh fluted pumpkin leaves [29], 24.85% of fresh sweet potato leaves [20].

The protein content (14.03%) cocoyam inflorescence agreed with 14.7% protein content of fresh *Heinsia crinita* [28]. The 14.03% of protein content of cocoyam inflorescence is moderate when compared with other protein content of most raw leaves in Nigeria. This flower having high moisture content could contribute to this low level of protein. The presence of tannins is known to inhibit the bioavailability of protein and minerals [30]. More so, Ihekoronye and Ngoddy (1985) noted that proteins in raw leafy vegetables are usually low, but they have high biological value [31].

The fibre content of the inflorescence was very low (1.17%). It was similar to the values for 1.4% of raw *Telfairia occidentalis,*1.3% for raw cocoyam leaf, 1.6% for raw *Amaranthus hybridus*, and 1.4% for raw tomato leaf [21]. The result was below 1.85% for raw Uchakoro leaf [23]. This low fibre content could be as a result of the high moisture content of the fresh sample which caused dilution effect. Non-starchy vegetables are the richest sources of dietary fibre [32] and are employed in the treatment of disease such as obesity, diabetes, cancer and gastrointestinal disorders [7].

The carbohydrate content of the fresh inflorescence was 11.61%. This value is similar to the work of Osum *et al.* (2013) who reported the carbohydrate of fresh Uchakoro to be 12.72% [23] but higher than 9.26% for fresh *Moringa oleifera* leaf [27]. This low level of carbohydrate exhibited by cocoyam inflorescence could be due to utilization by micro flora for the formation of carbon skeleton for the synthesis of nutrients. Carbohydrate provides heated energy for all forms of body activity. Deficiency of carbohydrate can cause the body to divert proteins and body fat to produce needed energy, thus leading to depletion of body tissues [33]. At the recommended daily allowance (RDA) of 3000kca for a normal adult human [34], fresh cocoyam inflorescence is not a good source of carbohydrate.

The moisture content of cocoyam inflorescence was 70.33%. This value is quite lower than that of fresh cocoyam leave (88.1%) [21], raw Uchakoro leaf (75%) [23], fresh *Moringa oleifera* (74.05) [22] but agreed with the work of Mbah et al (2012) who reported 70.33% of fresh *Moringa oleifera* at Nsukka in Nigeria [27].

This higher moisture content exhibited by cocoyam inflorescence could be as a result of the freshness of the sample. The moisture content of any food is an index of it water activities [35]; which is used as a measure of stability and susceptibility to microbial contamination [36]. Leaf vegetables are highly perishable and seasonal.

Table 2. Anti-nutrients Composition of Fresh Cocoyam Inflorescence

Anti-nutrients	Composition(mg/100g)
Cyanide	Trace
Oxalate	36.07±0.11
Phytate	32.27±0.15
Tannin	17.15±0.10
Saponin	85.72±0.11

Values are means ± standard deviation of triplicate determination

The results for anti-nutrient composition are presented in Table 2. The result revealed trace amount of cyanide, oxalate (36.07), saponin (85.72%), phytate (32.27) and tannins (17.15mg).

The trace level of cyanide in cocoyam inflorescence is very much interesting when compared to the value obtained by Akwaowo et al. (2000)for fluted pumpkin leaves (0.18mg) [18] and for cashew nut shell (0.009) [37]. This trace level of cyanide indicates that cocoyam inflorescence may not be threatening to human nutrition at any level and state of consumption. Hydrogen cyanide is known to be harmful to the body. According to IITA (1990), the safe limit of cyanide in garri as specified by the Nigerian Food and Drug Administration is 1mg HCN per 100g of garri [38]. Oke (1969) reported the toxic limit of hydrogen cyanide to be 35mg 100g DM [39], consumption of food with large amounts of cyanide can result in death or chronic neuropathy (TAN) [40].

The oxalate content of cocoyam inflorescence was 36.07mg. This value is quite low when compared to the oxalate content value for fresh *Gongronema latifolium* (132mg), *Occimium canum* (1246mg), *Talinium triangulare* (184mg) [41] and fresh *Telfaria occidentalis* (80.7mg) [42]. The oxalate content of Cocoyam inflorescence is also higher than 15.08mg for bitter leaf and 8.68mg for *Moringa oleifera* [22,43]. Oxalate causes irritation and scratching sensation in the mouth and throat when consumed. Therefore, Cocoyam inflorescence should be properly processed to reduce the oxalate level to tolerable level to avoid this discomfort. Interestingly, this 36.07mg oxalate content in Cocoyam is below the lethal dose of oxalate (15-30g) according to environmental Health and safety, U.S.A. Apart from causing irritation, oxalate forms insoluble complexes with some metals thus leading to reduced calcium availability/metabolism. Dietary oxalate has been known to complex with calcium, magnesium and iron leading to the formation of insoluble oxalate salts which the body cannot metabolize [44]. Proper cooking before consumption significantly reduces the total oxalate content of leaves or vegetables [18].

The phytate content of Cocoyam inflorescence was 32.27mg close to the value recorded in raw fluted pumpkin leaves (38.4mg) [18] but below 45.50mg recorded in raw cowpea leaves, 40.01mg of raw *Gongronema latifolium* [45] and 41.27mg of raw *Ocimium canum* [41]. It is also higher than 12.82mg recorded in fresh cassava leaves [46], 16.48mg recorded in raw *Moringa oleifera [22]*. The level of phytate in Cocoyam inflorescence in this work appeared less than most of the plant leaves commonly consumed as safe leaves like fluted pumpkin, cowpea leaves *Gongronema latifoluim* and *Ocimium canum* and therefore might be safer than these leaves as this study suggested. Kaayla (2010) indicated that phytate causes more calcium binding than oxalate [47]. Phytate block proper absorption of iron, zinc, calcium and other minerals. Phytate induced mineral deficiencies, facilitate displacement of needed minerals by toxic metals, for examples iron by lead and zinc by cadmium [48]. Phytates are the leading cause of poor growth, anemia, immune system incompetence and other health woes in the third world countries where plant based diets are the norm and are increasingly a problem in first world countries, where plant based and vegan diets are widely considered chic and healthy [47]. The smallest toxic dose of phytate in human is not known, it appears, that high doses are required for any appreciable effect. Tanninand phytate have been discovered to be heat stable [49].

The tannin content of the fresh Cocoyam inflorescence was 17.15mg. This is higher than 0.23mg recorded in fresh *Moringa oleifera [27]*, 0.21mg in raw potato leaves [20]. This value is however, lower than 40.6mg recorded in raw *Tefairia occidentalis* leaf meal [42]. Tannins have been reported to have anti-helminthic properties and anti-carcinogenic effects [37]. However, reports reveal that higher intake of tannic acid has been associated with poor protein utilization, liver and kidney toxicity [50]. The levels of tannins in cocoyam inflorescence in this work appeared moderate when compared to its high levels in some common vegetables being consumed as delicacies as reviewed in this work and other literatures. Boiling, cooking washing reduce the tannin content of vegetables since tannin is soluble in water.

The saponin content of fresh cocoyam inflorescence was 85.72%. This value is quite high compared to 10.18% recorded in (*Vernonia amygdalina*) [43], 0.060% in Cashew nut [37], 0.25% recorded in (*Tefaira occidentalis*) [29]. Saponin has the ability to increase the body's levels of immune response. Saponin is used as a component of spermicides and vaccines [51]. Saponin are reported to inhibit the growth of benign and malignant tumors, to have anti-microbial and anti-viral properties [37]. Saponin though non-toxic exhibit cytotoxic effects and growth inhibition against variety of cells making it to have anti-inflammatory and anticancer properties [9]. According to Nityanand (1997), ruminants can break down saponin but mono-gastric cannot. Saponin have a bitter taste and have reduced palatability as well as cause depression in feed intake [52]. Adequate processing reduces the saponin to tolerable level. High levels of anti-nutrients such as oxalate, phytate and hydrogen cyanide are known to be very poisonous to humans. It is however noted that most of these toxicants are eliminated during processing or boiling [53]

Table 3. Minerals and Vitamin Composition of Fresh Cocoyam Inflorescence

Mineral Elements	Composition (mg/100g)
Calcium	1.14±0.01
Magnesium	4.80±0.00
Manganese	5.49±0.00
Zinc	60.70±0.0
Iron	0.003±0.0
Copper	0.04±0.00
Sodium	22.92±0.10
Potassium	152.43±0.10
Phosphorus *	1.60±0.10
Iodine *	18.13±0.05
Vitamin A	348.91±0.01
Vitamin C	27.21±0.01

Values are means ± standard deviation of triplicate determination. * Percentage (%).

The mineral compositions of Cocoyam inflorescence are presented in Table 3. The result revealed high concentration of potassium (152.43mg) and zinc (60.70mg). Levels for calcium, magnesium, manganese, iron, copper and iodine, where 1.14, 4.80, 5.49, 0.003, 0.04, and 22.92mg while phosphorus and iodine were 1.60 and 18.13% respectively.

The mineral content of cocoyam inflorescence as revealed in this study appeared high when compared with other green leafy vegetables with good sources of minerals as reported by Akindaliunsi and Oboh, 1999 [19]. Photosynthesis in plant does not occur in the inflorescence (flowers) but on the leaves some of the minerals needed for photosynthesis are usually low or even not found in flowers.

For instance magnesium occurs abundantly in chloroplast as a constituent of chlorophyll molecule. Its low concentration in cocoyam inflorescence (4.80mg) is not surprising as against 400mg and 310mg for adult men and women. This value (4.8mg) is slightly higher than the values 3.6mg and 0.7mg [21] for *Talfairia occidentalis* (Ugu) and cocoyam leaf respectively but however below 24.40mg recorded for fresh *Moringa oleifera* [22].

The fresh cocoyam inflorescence contains 1.14mg calcium higher that the cocoyam leaf (0.7mg), *Amaranthus hybridus* (0.2mg) [21] but lower than 2.6g/w *Telfairia occidentalis* leaf meal [42]. According to research, a good food calcium content is greater than 0.5mg [54]. Therefore, cocoyam inflorescence is a good calcium food and should be consumed as a plant source for calcium. Calcium helps to build the bone in the body system. It is very essential during childhood growing years. Deficiency can cause rickets, bone pain and muscle weakness. Increasing the consumption of fresh cocoyam inflorescence would meet up calcium need based on the recommended daily allowance (RDA) of 20-25% [55].

The zinc level in cocoyam inflorescence was 60.70mg which is less than 103.6ppm recorded for *Telfairia occidentalis* leaf meal [42] but higher than 27.98mg for fresh *Telfairia occidentalis* leaf [56]. The average requirement for zinc for men and women are given as 9.4mg/day and 6.8mg/day [57]. This study showed that Cocoyam inflorescence is a good source of zinc. Increase in it consumption especially by children would prevent the incidence of zinc deficiency. Zinc deficiency in developing countries is becoming a growing concern because it has been shown that zinc deficiency is related to decreased growth (dwarfism), alopecia, diarrhea, mental disturbances but also increase morbidity [58].

The sodium in Cocoyam inflorescence was 22.92mg. This value is lower than 140.72mg recorded for fresh *Moringa oleifera* leaf [22] but however higher than 4.23mg for raw potato leaves [20]. The low level of sodium in this fresh inflorescence is preferable since increased High intake results to increased calcium loss in urine and cause of hypertension in some people [55].

The potassium content of Cocoyam inflorescence was 152.43mg higher than the potassium content recorded in banana (88mg) [59] but lower than the value recorded for fresh *Moringa oleifera* (280.32mg) [22]. Potassium helps the body to maintain normal water balance in cells, transmit nerve impulses, keep acids and alkalis in balance and stimulate normal movement of the intestinal trait [33]. Deficiency can cause vomiting, acute muscle weakness and loss of appetite. The adult requirement (RDA) for potassium is 2000mg/day [55]. Reasonable consumption of Cocoyam inflorescence can meet up with this recommendation Cocoyam inflorescence is therefore a good source of potassium.

The iron content was very low (0.003mg). This value is also lower than the values recorded for Cocoyam leaf (0.4mg) [21] and *Baseila alba* (0.6mg), for sweet potato leaves (16mg) [20]. Vegetables are generally poor sources of iron [21]. Cocoyam inflorescence is considered inadequate in iron content when viewed against an RDA of 8mg for men and 18mg for women [57]. Iron is a vital component of red blood cells, which carry oxygen. It assists the muscles to keep reservoirs of oxygen and makes the body more resistant to infections. Iron deficiency cause anemia, Tiredness, headache, insomnia and heart palpitations [22]. Alternative vegetables can be used to augment cocoyam inflorescence where iron is greatly needed.

The copper content of Cocoyam inflorescence was 0.04mg. This value is higher than 0.03mg raw cashew nut shell [37] but lower than 0.068mg *Telferia occidentalis* [18]. Trace elements are usually needed by the body in a minute quantity. This value of cooper in this inflorescence is within the WHO limit for CU in the spices. The recommended dietary allowance (RDA) of copper for adult male and females is 0.9mg/day and 1mg for pregnant women, 1.3mg for lactating women [57]. Therefore, the copper (cu) levels Cocoyam inflorescence are very tolerable. Importantly copper plays a role in the oxidative defense system, but however, chronic copper toxicity can result in severe poisoning [60].

Phosphorus content of the fresh Cocoyam inflorescence was as low as 1.60%. This value is higher than the value recorded for fresh *Telfairia occidentalis* (0.4%), [29] for raw cashew nut (0.016%) [37] and for raw Cocoyam leaf (0.07%) [21]. The recommended dietary allowance (RDA) for adult human being (19-70 years) according to research is 700mg [61]. Cocoyam inflorescence is not a better source of Phosphorus. Phosphorus is a constituent of cytoplasm and nuclear protein, phospholipids and nucleic acids as well as taking important part in carbohydrate metabolism. It provides energy and helps build the structure of bones and teeth. Efficient absorption and the wide availability in foods make phosphorus a much less important mineral than calcium [57]. Deficiency can lead to loss of appetite, weakness, bone pain and mental confusion. However, phosphorus deficiency is rare since it is present in many foods [59].

The iodine content of the fresh Cocoyam inflorescence was 18.13%. The recommended dietary allowance is set at 150µg (1.5mg)/day for adults [61]. The deficiency of iodine leads to preventable mental retardation and most common cause of goiter world-wide especially in mountain regions. Iodine is an essential mineral needed for the formation of thyroid hormone in the thyroid gland. Iodine is also needed to block various toxins from binding to and accumulating in the thyroid gland. Free iodine is in high concentration in the ovaries and breast tissue, acting as a protective buffer to estrogen. Iodine is essential for brain function and intelligence. Iodine is responsible for cognitive neurological development of the child [61]. Adequate consumption of Cocoyam inflorescence would meet this recommendation.

Vitamin A content of the fresh Cocoyam inflorescence was 348.91µg. This value was lower than the value recorded for fresh Uchakoro leaf (1583.26IU) [23]. It was also quite higher than 0.67mg recorded by Antia et al. (2006) [20]. The recommended dietary allowance (RDA) of vitamin A set it at 900µg (9mg). Adequate consumption of fresh Cocoyam inflorescence with vitamin A content of 348.9µg (3.5mg) will go a long way to supply vitamin A required by the body. Therefore fresh Cocoyam inflorescence from this study is said to be a good source of vitamin A. Vitamin A is important for developing a good eyesight, health skin, strong immunity and resistance to infection, strong bones, good growth and prevention of anemia [62]. Deficiency of vitamin A can cause intestinal and respiratory infections, poor hair quality, eyeball pain, poor eyesight, night blindness and exophthalmia (a dry thickened lusterless eye condition) which can damage the cornea and lead to blindness.

The vitamin C content of Cocoyam inflorescence was 27.21mg. This is in agreement with 27.44mg of fresh *Hibiscus sabdariffa* [63], and higher than the value reported for orange (20mg) [64], fresh sweet potato leaves (15.20mg) [20] but lower than the value recorded for fresh Uchakoro (32.98mg) [23], 58.1mg of raw Amaranthus [21]. Cocoyam inflorescence is an adequate source of vitamin C owing to the recommended allowance of 30mg [65]. Therefore, consumption of fresh Cocoyam inflorescence would alleviate the problem of lack of vitamin C and antioxidant where the need arises since it met up with this recommendation. This level of vitamin C present in this plant inflorescence makes it a good source of antioxidant vitamin. Vitamin C is necessary for health development of bones, teeth, blood organs and sex organs. Deficiency can cause bleeding and inflammation of gums, loosening of the teeth, weakness, lassitude and scurvy.

4. Conclusion

From this research, it can be inferred that fresh Cocoyam inflorescence, which are consumed in the southern part of Nigeria and some other part of the world, is rich in nutrients needed for good growth, maintenance and health of the human body. The Cocoyam inflorescence from the data, reveals that it contains appreciable amount of proteins, minerals, fat, fibre, carbohydrate, vitamins A and C and low levels of toxicant. Hence the Cocoyam inflorescence might not be as harmful to humans as this study suggested. However, it could be toxic in the body system when large quantities are eaten. Cocoyam, inflorescence can contribute significantly to the nutrient requirements of man and should be recommended.

References

[1] Okechukwu K.E, Jane A, Joel N.C. Effects of Differently Processed Cocoyam (Colocasia esculenta (L.) Schott) Inflorescence on Hematological and Histopathological Parameters of Albino Rats. Biotechnol Ind J. 15(3): 191-204, 2019.

[2] Onwueme, I.C., Charles, W.B. Cultivation of cocoyam In: Tropical root and tuber crops. Production, perspectives and future prospects. *FAO plant production and protection paper 126, Rome pp. 139-161*, 1994.

[3] Ndabikunze, B. K., Talwana, H.A.L., Mongi, R.J., Issa-Zacaria, A., Serem, A.K., Palapala, V. and Nandi, J. O. M.. Proximate and Mineral composition of cocoyam (*Colocasia esculenta L. and Xanthosoma sagittifolium L.*) grown along the lake Victoria Basin. Tanzania and Uganda. *African Journal of Food Science 5(4) : 248-254, 2011.*

[4] Mosha, T.C. and Gaga, H. E. Nutritive value and effect of blanching on trypsin and chemotrypsin inhibitor activities of selected leafy vegetables. *Plant Foods for Human Nutrition 54: 271-283, 1999.*

[5] Ani, J. C., Inyang, U. E. and Udoiedem, I. Effect ofconcentration of de-bittering agent on the mineral, vitamin and phytochemical contents of *Lasianthera africana* leafy vegetable. *African journal Food Science.*

[6] Fasuyi, A. O. Nutritional potentials of some tropical vegetable meals: Chemical characterization and functional properties. *African Journal Biotechnol. 5 (1), 49-53. 2006.*

[7] Saldanha, L.G. Fibre in the diet of U.S children: results of national surveys. *Pediatrics 96: 994-996, 1995.*

[8] Grosvernor, M. B. and Smolin, L. A. Nutrition: From Science to life.*Harcourt College Publishers,* New York. *Pp 288-371, 2002.*

[9] Akindahunsi, A.A., Salawu, S.O. Phytochemical screening, nutrient and anti-nutrient composition of selected tropical green leafy vegetables. *African Journal Biotechnol. 4(6): 497-501, 2005.*

[10] Levander, O. A.. Fruits and vegetable contribution to dietary intake in human health and disease. *Hortiscience. 25, 1456-1488, 1990.*

[11] Okwu, D. E. Phytochemicals and vitamins content of indigenous spices of South Eastern Nigeria. *Journal sustainable Agric. Environ. 6, 30-34, 2005.*

[12] AOAC.,. Official method of Analysis of Association of Analytical chemist (17th Ed.) Washington D.C. USA, 2010.

[13] Muir, Y. A. and Lamberts, J. Practical Chemistry,3rd ed. Heinem and educational Books Ltd, Butler and Tanner Ltd, Frons and London. Pp.320-325, 1973.

[14] Junaid, A., Mohammed, S. A., Saeed, A. K. and Abdul, O. K. HPLC analysis of water- soluble vitamins (B_1, B_2, B_3, B_6) in in-vitro andex-vitro germinated chick pea *(Licer arietinum L.). African Journal Biotechnol, 7(14):* 2310-2314, 2008.

[15] Iwuoha, E. I. and Kalu, F. A. Calcium oxalate and physicochemical properties of cocoyam (*Colocasis esculenta and Xanthosoma saggitifolium*) tuber flours as affected by processing. *Food chemistry, 54*: 61-66, 1995.

[16] Nkama, I and Gbenyi, D.I. The effect of malting of millet and sorghum on the residual phytate and polyphenols in “Dakura”a Nigerian Cereal/Legumes snack food. *Nig. J.Tropl. Agric. 3*: 270-271, 2011.

[17] Bradbury, M. G., Egan, S. and Bradbury, J. H. Picrate paperkits for determination of total cyanogens in cassava roots and all forms of cyanogens in cassava products. *Journal of Science Food and Agriculture, 79*: 598-601, 1999.

[18] Akwaowo, E.U., Ndon, B.A., Etuk, E.U.. Mineral and anti-nutritional in *fluted pumpkin.Food chem. 70*:235-740, 2000.

[19] Akindahunsi, A.A. and Oboh, G. Effect of some post-harvest treatments on the bioavailability of zinc from some selected tropical vegetables. La Rivista Italian a Della Grasse 76, 285-287, 1999.

[20] Antia, A.B., Akpan, E.J, Okon, P.A and Umoren, I.U. Nutritive and Anti-nutritive Evaluation of Sweet Potatoes (*Impomea batatas*) Leaves. *Parkistan Journal of Nutrition 5 (2)*: 166-168, 2006.

[21] Mepba, H.D, Eboh, L and Banigo, D.E.B. Effect of Processing Treatments on the Nutrition Composition and Consumer Acceptance of some Nigeria Edible Leafy Vegetables. *African Journal Food Agric. 7(1):* 2-18, 2007.

[22] Gernah, D.I. and Sengev, A.I. Effect of processing on some chemical, properties of the leaves of the Drumstick tree (*Moringa oleifera*). *NIFOJ 29(1):* 70-77, 2011.

[23] Osum, F.I., Okonkwo, T.M. and Okafor, G.I. Effect of processing method on the chemical composition of *Vitex doniana* leaf and leaf products.

[24] Inyang, U. E. and Ani, J. C. Effect of Traditional Processing Methods on the Nutrients and Phytochemical Contents in *Lasianthera africana* Leaf Residue. *International Journal Current Research in Bio Sciences and Plant Biology 2 (5)*: 101-107, 2015.

[25] Ifon, E.T. and Basir, O. The nutritive value of some Nigerian leafy green vegetable part 2. Distribution of protein, carbohydrate, fat. *Journal food chemistry. 5*: 231-235, 1979.

[26] Leung, W.W., Busson, F. and Jardin, C. Food composition table for use in Africa. Available at http://www. Fao org/docrep/003/x6877E00.htm (assessed April 13, 2012), 1968.

[27] Mbah, B.O., Eme, P.E. and Paul, A.E. (2012). Effect of drying techniques on the proximate and other nutrient composition of *Moringa oleifera* leaves from two Areas in Eastern Nigeria. *Pakistan Journal of Nutrition 11(11)*: 1044-1048.

[28] Etuk, E.U., Bassey, M.N., Umoh, U.O. and Inyang, E.H. Comparative nutritional studies on three local varieties of *Heinsia crinita*, Plant Varieties and Seeds. *11*: 151-158, 1998.

[29] Nworgu, F.C. Ekemezie, A.A.O., Ladele, A.O. and Akinrolabu, B.M. (2007). Performance of broiler chickens served heat-treated fluted pumpkin (*Telfaria occidentalis*) leaves extract supplement. *African Journal of Biotechnology 6(6):* 818-825.

[30] Davidson, S.P., Brock, J.F. and Truswell, A.S. Human Nutrition and Dietetics. 6th ed. Churchill Livingston/Longman Group Ltd. Pp.107-119, 221-224, 1975.

[31] Ihekoronye, A. I., and Ngoddy, P.O., 1985. Integrated Food Science and Technology for the Tropics. Macmillan publisher LTD London pp. 44-49, 82-83, 90-93, 119-125, 293-298.

[32] Agostoni, C., Riva, R. and Giovannin, M. *Dietary fiber in winning Food of Young Children*. Pediat. 96: 1000-1005, 1995.

[33] Gordon, T. W., 1999. *Perspectives in nutrition,* 4th ed. McGraw Hill. Pp. 75-372.

[34] Gamman, P.M. and Sherrington, K.B., 1990. The Science of Food. AN Introduction to Food Science, Nutrition and Microbiology, 3rd Ed. Pergamon Press, Oxford and New York. Pp. 104-115

[35] Frazier, W.C., and Westhoff. D.C., 1978. Food Microbiology. 3rd ed. McGraw-Hill Book Company New York Pp. 293-303.

[36] Scott, W. S. Water relations of food spoilage micro-process during baking of African bread fruit seeds. *IJFP 7*: 585-602, 1980.

[37] Ocheja, J.O., Aduku, A.O., Ayoade, J.A. and Lalab, B.C. Effect of steaming and soaking on chemical composition of Cashew Nutshell: Implications for Ruminant Animal Nutrition. *Pakistan Journal of Nutrition 12(7)*: 683-687, 2013.

[38] IITA.. Cassava in Tropical Africa. A Reference Manual. Ibadan Nigeria: International Institute of Tropical Agriculture, pp 87-92, 1990.

[39] Oke, O.L. Role of hydrocyanic acid in nutrition. World Review of Nutrition and Dietetics, 11, 170-198, 1969.

[40] Osuntokun, B.O., Aladetoyinbo, A. and Adeiya, A.O.G. Free cyanide levels in Tropical Ataxic Neuropathy (TAN). Lancet 2:372, 1970.

[41] Imaobong, I.V., Roland, U.E. and Efiok, J.U. Effect of thermal processing on Anti-nutrients in common Edible Green leafy vegetables in Ikot Abasi, Nigeria. *Pakistan Journal Nutrition. 12(2)*: 162-167, 2013.

[42] Fasuyi, A.O. and Nonyerem, A.D. Biochemical Nutritional and haemotological implication of *Telfairia occidentalis* Leaf as protein supplementation in broiler starter Diets. *African Journal of Biotechnology 6(8),* pp 1055-1065, 2007.

[43] Badifu, G.I.O and Okeke, E.M. Effect of blanching on oxalate, hydrocyanic acid and saponin content of four Nigeria leafy vegetables.*Journal Agric. Science Technology, 2(1):* 71-75, 1992.

[44] Whitney, E.N., Corin, B., Linda, K. and Rolfes, R. Nutrition for health 11.57 and health care. West Pub. Co., Toronto, pp.39-45. 643, 1996.

[45] Udensi, E.A. Effect of soaking time on some anti-nutritional factors of vegetable cowpea (sesquipedialis) “Akidi”. In: proceedings of the 29th conference of the Nigeria Institute of Food Science and Technology (NIFST), 25th- 28th Oct. 2005. Ebonyi State University, Abakaliki, pp. 184-185, 2005.

[46] Ebuehi, O.A. T., Babalola, O. and Ahmed, Z. Phytochemical, nutritive and anti-nutritive composition of cassava (*Manihot esculenta*) tubers and leaves. *Nigerian Food Journal 23*: 40-48. 2005

[47] Kaayla, T.D.E.Plants Bite Back: The surprising, All- Natural anti-nutrients and Toxins in Plant Foods. Article of health at wellness 09: CDT, 2010.

[48] Thompson, L.U. Potential health and problems associated with Anti-nutrients in foods. *Food Research international, 26*: 131-149, 1993.

[49] Apata, D.F. Biochemical, nutrition and toxicological assessment of some tropical legume seeds. Ph.D Thesis. Animal science department, university of Ibadan, Nigeria Pp. 125-126, 1990.

[50] Singleton, V.L. and Kratzar, F.H. Toxicity and related physiological activity of phenolic substances of plant origin. *Journal Agric Food Chemistry. 17*: 497-501, 1969.

[51] Sidhu, G.S. and Oakenfull, D.G. A mechanism for the hypocholesterolemic activity of saponin. Br. *Journal Nutrition. 7 55*, 643, 1986.

[52] Nityanand, P. Textbook of Food processing Technology Vikas Publishing House PWT Ltd, New Delhi India, 1997.

[53] Dunu, D.J., Eka, O.U., Ifon, E.T. and Essien, E.U. Chemical evaluation of the nutritive value of fruit of calabash plants (*Lagenaria scierania). Nigerian Journal of Science, 20*: 47-50, 1986.

[54] Shills, MEG and Young, V.R. Modern Nutrition in health and diseases In: Nutrition Nieman D.C. Buthepodorth D.E. and Nieman C. N. (eds) WMC Brown publishers, Dubuque, U.S.A. pp. 276-282, 1988.

[55] Wardlaw, G.M and Kessel, M. W. Minerals: Dietary needs, absorption, transport and excretion: In: perspective in Nutrition (5th edition). MC Graw Hil companies Inc. pp. 418-464, 2002.

[56] Kalu, E.O. The Effect of Processing on Nutrient and Anti-nutrient components of Fluted Pumpkin leaves. M.sc project dept. of Food and Applied Science. MOUA Umudike, Abia State, 2009.

[57] Food and Nutrition Board. Dietary reference intakes for vitamin A, vitamin K, Arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium and zinc. Washington, DC: National Academy press, 2001.

[58] Huffman, G. Zinc can reduce pediatric respiratory infections. American Family physician 58: 2127, 1998.

[59] Olushola, A.T.E. “The Miracle Tree” *Moringa Oleifera* (Drumstick). In: Achieve vibrant health with Nature, keep Hope Alive Series 1, Unijos consultancy limited press, Jos, Nigeria, pp. 120-136, 2006.

[60] Uriu-odams, J.Y. and Keen, C. L. Copper oxidative stress, and human health. Mol. aspects. Med. 26, 268, 2005.

[61] Barbara, A.B. and Robert, M.R. Present Knowledge in Nutrition 8th edition. International Life Sciences institute. ILSl Press Washington, DC pp 315-331, 2001.

[62] Villamor, E. and Fawzi, W.W. Vitamin A supplementation: implications for morbidity and mortality in children. Journal Infect. Dis. 182(1): 122-133, 2002.

[63] Musa, A. and Ogbadoyi, E.O. Effect of processing methods on some Micronutrients, Anti-nutrients and toxic substances in *Hibiscus Sabdoriffa*. *Asian Journal of Biochemistry, 7:* 63-79, 2012.

[64] Muller, H.G. An Introduction to Tropical Food Science. Cambridge University Press, Cambridge pp.59-64, 1988.

[65] Olson, J.A. and Hodges, R.E. Recommended dietary intake (RDI) of vitamin C in humans.*American Journal clinical Nutrition. 45*: 693, 1987.