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Nutrient Composition, Mineral and Anti-Nutrient Components of Processed Wild Cocoyam (*Caladium Bicolor, (Ait) Vent*)

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Abstract

In the subtopic and perhaps worldwide a novel plant *Caladium bicolor* (wild cocoyam, Ikpong Ekpo) has not actually been utilized as food for man, livestock or poultry, though in abundance. Also, the effective utilization of wild cocoyam (*Caladium bicolor*) tubers in livestock and poultry feed is limited by the presence of anti-nutrient components which requires some form of processing. The effect of boiling and soaking on gross energy, mineral composition, anti-nutritional factors (ANFs) and proximate composition of wild cocoyam (*Caladium bicolor (Ait), Vent)* were determined with the aim of investigating its suitability as a feed ingredient. The soaked, raw and boiled tubers were dried, milled and analyzed for chemical compositions. Crude protein contents of raw and processed Caladium bicolor tubers range were 7.58% - 8.28% and the crude fibre values ranged between 1.92 - 2.12%. The gross energy value of boiled Caladium bicolor tubers was higher (2.85kcal/g) and also statistically similar ($p>0.05$) to both raw and soaked *Caladium bicolor* tubers. The micro and macro mineral composition of boiled *Caladium bicolor* tubers was significantly ($p<0.05$) lower compared to soaking method. Values obtained for boiled Caladium bicolor tubers were significantly ($p<0.05$) lower in all the toxic substances determined, except for the HCN content being above the tolerable limit for ruminant animals. The results indicate that processing techniques adopted enhanced the proximate composition, caloric components, mineral contents and significantly ($p>0.05$) lowered in the level of anti-nutrients present in wild cocoyam (*Caladium bicolor (Ait)*. Vent) tubers with boiling being the best and hence the recommended processing method for use in detoxifying *C. bicolor.*

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Introduction

Imbalanced feed for animal is a major factor affecting livestock and poultry production in the developing countries.[1] Feed accounts for above 70% of livestock and poultry cost of production.[2,3] This has been attributed to over reliance on the conventional feedstuff such as soya bean, groundnut and maize. The major problem in livestock production is the accelerated cost of conventional feedstuffs (soya bean, maize, groundnut etc); therefore leading to high cost of animal production. To solve this problem the use of non-conventional or alternative feed sources such as *Caladium bicolor* tubers becomes imperative.[4,5] Due to an increased need to utilise alternative feedstuff for feed availability at low cost, research into the use of unconventional feedstuffs plays important role in livestock production at this point where population pressure and development reduced the available grazing land for livestock.

Caladium bicolor of family *Araceae* was reported as fancy-leafed plant, elephant's ear and heart of Jesus, has colourful foliage or outdoor plant that can be cultivated by tubers, tissue cultureorseed.[4] *Caladium bicolor* is indigenous to South and Central America.[5] It is a tropical perennial plant grown for their large or showing leaves.[6] This plant is also known as heart of Jesus, Angel's wing, elephant ear. *C. bicolor* has injurious properties due to the presence of water-soluble calcium oxalate raphides, some anti-nutritional factor and unverified proteinous toxin constituent causing painful burning sensation on lips and mouth. Excessive dosing may cause nausea, diarrhea, swelling of the mouth, tongue, eye as well as redness of eye and inflammatory reaction with blister, dysphagia, and hoarseness.[7] Production of seed takes long time and result in variations in seedlings and limits breeding program. *Caladiums* can be cultivated in large scale by tubers mainly planted in April and harvested from November. Tubers storage is better at 65-70°F with relative humidity of about 75%.[4,8] Raw *Caladium bicolor* contains 81.59% nitrogen free extract, 1.48% crude fibre, 7.31% crude protein, 4.60% ether extract, 5.21kcal/g gross energy and 5.13% ash.[9] *C. bicolor* also contains significant anti-oxidant activity against variety of free radicals.[10] Anti-oxidants like phenolics and flavanoids protect human body of free radicals and retard progress of cancer.[11]

However, not much work has been done on the nutritional quality of this alternative feedstuff (*Caladium bicolor*). Thus, the need arose to evaluate this feed resource for its optimum utilization in feeding animals. The study reported here was conducted to determine the chemical components, mineral composition and anti-nutritional factors of *Caladium bicolor* tubers.

Experimental Location

Fresh Caladium tubers (*Caladium bicolor*) were harvested from fallow land in Obio Akpa, Oruk Anam L.G.A of Akwa Ibom State. Obio Akpa is located between latitudes 5°17N and 5°27N and between longitudes 7°27' N and 7°58'E with an annual rainfall ranging between3500-5000mm and average monthly temperature of 25°C, and relative humidity between 60-90%. Obio Akpa is in the rainforest zone of Nigeria.

Processing Methods

Boiling of *Caladium bicolor*

One kilogram of raw *Caladium bicolor* tubers was introduced into cooking pot with boiling water of 100°C temperature. The boiling continued for another 30 minutes before the tubers were drained out. The boiled tubers were peeled, cut into pieces, sundried and milled to obtain boiled *Caladium bicolor* meal. Three samples of boiled *C. bicolor* were taken for analysis.

Soaking

One kilogram of raw *Caladium bicolor* tubers was soaked in 20 liters of water and kept for 24 hours at a room temperature of 22-23°C. The soaked water was decanted and samples were withdrawn, peeled, cut into pieces, sundried and milled to obtain soaked *Caladium bicolor* meal. Three samples of soaked *Caladium bicolor* meal were taken for analysis.

Raw

One kilogram of raw *Caladium bicolor* was peeled, cut into pieces, sundried and milled to obtain soaked *Caladium bicolor* meal. Three samples of raw *C. bicolor* were taken and analyzed for proximate composition, mineral constituents and anti-nutritional composition in it.

Analytical Procedure

The proximate compositions of soaked, boiled and raw *Caladium bicolor* were investigated.[12] The samples were also analysed for gross energy composition.[13] Iron (Fe), Calcium (Ca), Zinc (Zn), Magnesium (Mg), Manganese (Mn), Copper (Cu)of soaked, boiled and raw *Caladium bicolor* meals were analysed using Atomic Absorption Spectrophotometer (Model AA280FS; Agilent Technologies). Potassium (K) and Sodium (Na) content of soaked, boiled and raw *Caladium bicolor* meals were determined using Jenway flame photometer (Model PFP7;Cole-Parmer, Vernon Hill) in line with the AOAC methods.[12] Total Phosphorus range of 0.111-0.128 was determined using Ascorbic acid method by measuring the absorbance at 880 mm with KH_2SO_4 as standard.[14] Quantitative analysis of tannin, hydrogen cyanide (HCN), trypsin inhibitor, phenol, saponin, phytate, oxalate, and flavonoids of raw, boiled, and soaked *Caladium bicolor* meal were also assayed,[15,16,17,18,19,14,20] respectively.

Statistical Analysis

Data obtained in this study were analysed by analytical procedure developed by Steel and Torrie (1980). Durican's Multiple Range Test was used to separate the significant means among the treatment groups.[22]

Table1: Proximate composition of raw, boiled and soaked *Caladium bicolor* meals

Parameters	A(Raw)	B(Boiled)	C(Soaked)	SEM
Dry Matter (DM)%	89.25^c	89.82^a	89.50^b	0.025
Crude Protein (Cp)%	8.28^a	7.58^c	8.08^b	0.030
Ether extract (EE)%	0.67^a	0.55^c	0.61^b	0.012
Crude Fibre (CF)%	2.12^a	1.92^c	2.05^b	0.013
Ash%	1.67^a	1.40^b	1.61^a	0.032
Nitrogen Free extract (NFE)%	76.52^c	78.37^a	77.16^b	0.027
Gross Energy (GE) (Kcal/g)	2.83	2.85	2.84	0.000

mean on the same row with different superscripts a,b,c differ significantly ($p<0.05$)

Results and discussion

Proximate Composition of Wild Cocoyam (*Caladium Bicolor*)

The proximate composition of soaked, raw and boiled *Caladium bicolor* meal is shown in Table 1. The values recorded for parameters in this study had significant ($p<0.05$) differences between soaked, raw and boiled *Caladium bicolor* tubers except for gross energy values. The values of parameters for raw tuber meal were significantly ($p<0.05$) higher compared to the values of soaked and boiled with the exception of dry matter (DM) and nitrogen free extract. Raw meal of *Caladium bicolor* caused digestive ailments in man and probably same to non-ruminant animals due to common gastro-intestinal tract shared by man and livestock.[23] This explains emphasis for tubers to be processed before incorporation into animal diet.

The values of processed *C. bicolor* on crude protein decreased significantly ($p<0.05$) as compared to raw *Caladium bicolor* meal. The trend might be as a result of solubilisation or leaching of nutrient compositions due to water treatment.[1,9] The crude protein range of 7.58%-8.28% fell within the range reported range of 7.15-7.21% for the same plant.[9] Crude protein values reported in this study may not be sustainable for non-ruminant animals but can enhance ruminant animal performance.[13,24]

Ether extract (EE) constituent of the raw *Caladium bicolor* (0.67%) was significantly different from boiled meal 0.55%). The range of 0.55%-0.67% recorded for EE in this study was lower than 4.22%-4.6% reported for the same plant.9The low EE values reported in this study shows a poor energy source. However, the values obtained in the present investigation was comparable to the values earlier reported for *Colocasia esculenta* meal (00.48%.0.73%) jack fruit seeds (0.75%) and was still within the range of 0.13%-0.77% reported for jack fruit seed.[1,25,26] The low EE value suggests that medicinally, *Caladium bicolor* meal will be less susceptible to lipid-related type of spoilage.[25,27] The crude fibre of raw and processed *Caladium bicolor* meal was 1.92%-2.12%, and was higher than 1.48%-1.49% earlier reported.[9] The values of CF in this study was lower than CF of conventional feedstuffs like soybean meal and groundnut cake with 6.5 and 5% crude fibre, respectively, but comparable with conventional feedstuffs such as maize and guinea corn with 2.0% crude fibre, respectively.[28,29] Fibre has some nutritional and health benefits in human/livestock nutrition especially in gastro-intestinal tract by reducing gastric emptying time in the small intestine, enhancing bile salt and cholesterol excretion, increasing faecal bulk and faecal transit time through the bowl.[30,31] The values of fibre obtained for raw and processed tubers tend to be advantageous to monogastric animals especially poultry, knowing fully that they have low ability to handle fibrous materials.[34,30] Ash components are the inorganic materials left after the extraction of organic matter through processing.[32,25] The reported ash content in this study ranged from 1.40%-1.67%. These values did not agree with values (5.12-5.133%) previously reported.[9] Geographical location, stage of maturity and soil type might be the cause of the ash content variations.[33] The nitrogen free extract (NFE) of boiled *C. bicolor* (78.37) was significantly different (p>0.05) from soaked (77.16) which was also significantly lower than raw (76.52). The ranged values were higher than NFE values recorded for energy feedstuff as maize (57.90%).[28] Tuber plant seems to deposit carbohydrate food reserve in their tubers which likely is the cause of *Caladium bicolor* having high NFE.[34,30]

Tables 2: Mineral content of soaked, raw and boiled *Caladium bicolor* meals]

Parameters	Raw	Boiled	Soaked	SEM
Sodium%	0.052	0.025	0.033	0.014
Potassium%	0.177^{a}	0.148^{c}	0.155^{b}	0.001
Calcium%	0.103^{a}	0.081^{c}	0.089^{b}	0.001
Phosphorus%	0.128^{a}	0.111^{c}	0.117^{b}	0.001
Magnesium%	0.123^{a}	0.091^{c}	0.104^{b}	0.001
Iron (mg/kg)	13.27^{a}	9.60^{c}	11.47^{b}	0.112
Copper (mg/kg)	0.474^{a}	0.245^{c}	0.310^{b}	0.011
Manganese (mg/kg)	11.400^{a}	7.650^{c}	8.450^{b}	0.111
Zinc (mg/kg)	29.15^{a}	21.55^{c}	23.25^{b}	0.103

a,b,c mean on the same row with different superscript indicated significant differences (P<0.05) among the groups.SEM = Standard error of mean.

Mineral Composition of Soaked, Raw and Boiled Wild Cocoyam (*Caladium Bicolor*)

The result of mineral content (both macro and micro) of processed and raw *Caladium bicolor* meal is presented in Table 2. All the minerals except sodium had significant differences (P<0.05) between the treatment groups in both raw and processed *C. bicolor* meal. However, processing reduced the mineral content of the samples with boiling having the highest reducing effect followed by soaking. Heat treatment and solubilisation does not destroy mineral, therefore low values of minerals for soaked and boiled *C. bicolor* meal might be due to leaching of minerals into the water.[35,36,37] For macro minerals (K, Ca, P and Mg), soaked *Caladium bicolor* meal has a value which differed significantly (P<0.05) from boiled C bicolor meal: implying that when used in feeding trials would enhance good neural conduction and muscular contraction, blood coagulation, bone and teeth formation, better membrane function and carbohydrate metabolism.[38,13,29] Micro minerals result followed trend of macro minerals in that the tuberous roots processed by soaking had the superior value for Mn, Cu, Zn and Fe. This implies that using soaked tuberous root as ingredient in animal diet would enhance blood formation (because of high value of iron), normal utilization of carbohydrate by livestock/ poultry animals (because manganese serves as a co-factor to enzymes responsible for carbohydrate metabolism such as kinase, decarboxylase, peptidase); enhanced zinc promotion for healing of wounds and also favour good taste, appetite and growth, provide copper as a component of cytochrome oxidase, which is important in oxidative phosphorylation.[39,40,13]

Anti-nutrient Constituents in Wild Cocoyam (*Caladium Bicolor*)

The anti-nutrient components present in boiled, raw, and soaked *Caladium bicolor* meals are shown in Table 3. The factors (anti-nutrients) retard the productivity of animal and are deleterious to animal when plant materials rich in them are consumed in large quantities. Generally, processing drastically reduced the anti-nutrient factors in *C. bicolor*. This agrees with similar trend for rubber seeds meals (*Havea brasiliensis*) subjected to different processing methods.[29]

Tables 3: Anti-nutrients in boiled, raw and soaked *caladium bicolor* meals

Parameters	Raw *C. bicolor*	Boiled *C. bicolor*	Soaked *C. bicolor*	SEM
Tannin %	0.00[a]	0.001[c]	0.002[b]	0.001
Phylate %	0.010	0.010	0.010	0.000
Oxalate %	0.010	0.010	0.010	0.000
Phenol %	0.012[a]	0.10[c]	0.011[b]	0.001
Saponia %	0.128[a]	0.113[c]	0.121[b]	0.001
Flavonoids %	0.004[a]	0.002[c]	0.003[c]	0.001
Hydrogen Cyanide (HCN) mg/kg	6.225[a]	4.870[c]	6.060[b]	0.015
Trypsin Inhibitor (mg/g)	1.370[a]	1.247[c]	1.310[b]	0.010

a,b,c mean in a row with different superscript are significantly different ($P<0.05$).

Tannin content of *C. bicolor* ranges from 0.003 in raw to 0.002 in soaked and 0.01 in boiled cocoyam meal. Tannins are known to have resistance to heat treatment and decrease the digestibility of protein inhuman and animal; either by partially making the protein unavailable or by inhibiting the digestive enzymes and thereby increasing faecal nitrogen content41,42 It is obvious that boiled tubers had significantly ($P<0.005$) lower tannin and the materials were better detoxified by boiling method compared to soaking method. Tannin value range of 0.001-0.003 for *Caladium bicolor* meal recorded here is lower than the values of (0.18-0.35%) observed in *Colocasia esculenta*.[1]

Phenols are active molecules that have a lot of beneficial properties to man and animal; yet a high quantity of it may create problem in animal. High doses of phenol lead to the reduction in bone mineralization and a case of Cholesterol or estrogen imbalance.[43,44,45] Flavonoids with its metal chelating properties binds with iron to make it less available and disturb the acid/base balance.[46] Phenol values in *Caladium bicolor* showed variation in total phenol (0.010-0.012%) and flavonoid (0.002-0.004%) contents (Table 3). Among the processed, the highest value of phenols (Phenol and flavonoid) was found in soaked *Caladium bicolor* tubers whereas lowest value was found in boiled tubers. Values obtained for phenols in this study were below deleterious level.[44] Phenols and flavonoids have a wide range of hormonal0 and non-hormonal health benefits that includes anti-inflammatory, anti-oxidative, ant-microbial, gastro-intestinal and ant-diabetic properties.[47,44]

Saponin is characterised by its hemolytic and foaming properties, ability to produce pores in membranes, astringency and bitter taste.[48] In the present study, the saponin values in soaked, raw and boiled *Caladium bicolor* were significantly ($P<0.05$) different with a value range from 0.113%

(boiled), 0.121% (soaked) to 0.128% (raw). The lower saponin level in the boiled and soaked as compared to the value in the raw *C. bicolor* meal qualifies them (boiling and soaking) as good detoxifying methods. Current report (Shi *et al.,* (2004) proved that low doses of saponin helps to reduce blood cholesterol thus improving defense mechanisms and fight diseases (cancer). They stressed that ration with 1.0-1.2% saponin inclusion level lower plasma and liver cholesterol in rabbits.[49]

Hydrogen cyanide values range from 6.225mg/kg in raw to 6.060 (mg/kg) in soaked and 4.870 mg/kg in boiled. The boiled *Caladium bicolor* tubers recorded a lower value for HCN in this study than soaked processing method. Values obtained in this study for HCN were less than the 50mg/kg required as the maximum level tolerated by poultry.[50,51] However, the HCN values in *C. bicolor* were above the tolerable level(2.0-4.0 mg/kg/ body weight) for ruminant animals.[42,52] Cyanide ion above tolerable level inhibits the cytochrome oxidase; that stops ATP formation and no supply of oxygen to the tissues therefore causing sudden death in animal.[42,52] The range of HCN from 4.870-6.225mg./kg for *Caladium bicolor* meal obtained in this study was above the range 3.24-4.18% reported for *Colocasia esculenta*.[1]

This study recorded (1.370 mg/g) value of trypsin inhibitor in raw *C. bicolor* tubers and 1.247 mg/g and 1.310mg/g for processed (boiled and soaked) tubers of *Caladium bicolor*. Soaking and boiling reduced trypsin inhibitor significantly ($P<0.05$) with the highest reduction being in the boiling method; implying that boiling method enhances the digestibility of protein in *Caladium bicolor* meal. Also, problem of pancreatic hypertrophy due to trypsin inhibitors may not exist.[41,53]

Conclusion

The results indicate that processing techniques adopted have enhanced the proximate, caloric components, mineral contents, and significantly reduced the anti-nutritional factors in *Caladium bicolor* tubers meal with boiling being the best. Wild cocoyam has a moderate crude protein value of 8.28%, 7.58% and 8.08% for raw, boiled and soaked meals respectively. Nitrogen free extract is high with 76.52%, 78.37% and 77.16% for raw, boiled and soaked with a complementary energy range of 2.83-2.85 MJ/kg. However, anti-nutritional factors in *C. bicolor* appeared to be heat labile, it could therefore means that boiling it for 30 minutes could make it considered as an ingredient in poultry feed because the HCN value in wild cocoa yam was found to be within the permissible value tolerated by poultry, except ruminant animal that cannot tolerate the level of hydrogen cyanide (HCN) obtained in this work. Therefore, further study is recommended on the elimination or reduction of HCN to a tolerable level by ruminant animals. However further clinical studies on poultry with wild cocoa yam feed is required to validate its use as an alternative poultry feed.

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Conflict of Interest

The authors do not have any conflict of interest.

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