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Effect of Processing on Energy Values, Nutrient and Anti-nutrient Components of Wild Cocoyam [*Colocasia esculenta* (L.) Schott] Corm

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Abstract: Effective utilization of wild cocoyam corm in livestock feed is limited by the presence of anti-nutrient components which requires some forms of processing. The effect of soaking, cooking and fermentation on proximate composition, caloric values and contents of Anti-Nutritional Factors (ANFs) of wild cocoyam [*Colocasia esculenta* (L.)] Schott corm were determined with the aim of investigating its suitability as a feed ingredient. Raw, Cooked, Soaked and Fermented Wild Cocoyam Corm (i.e. RWCC, CWCC, SWCC and FWCC respectively) were sun dried and their proximate composition, Gross Energy (GE), Metabolizable Energy (ME) and contents of ANFs were determined. Crude protein was significantly ($p<0.05$) highest in FWCC and significantly ($p<0.05$) lowest in CWCC. Crude fibre significantly ($p<0.05$) decreased by the processing methods with the highest values obtained in RWCC and SWCC. Ether extract of RWCC was significantly ($p<0.05$) higher than for the other processed Wild Cocoyam Corm (WCC). The highest Nitrogen Free Extract (NFE), GE, ME and ME as percentage of GE was obtained in RWCC, FWCC, FWCC and RWCC respectively. Contents of ANFs [tannins, phytate, oxalate, saponin and Hydrocyanide (HCN)] were significantly ($p<0.05$) reduced by processing methods with RWCC recording the highest value. Fermentation had the highest ($p<0.05$) percentage reductive values of 42.86, 69.23, 95.05, 73.58 and 57.91% in condensed tannins, hydrolysable tannins, phytate, oxalate and HCN respectively, while the highest ($p<0.05$) percentage reduction of 48.39% in saponin was obtained in CWCC. There were no activities detected for trypsin inhibitors in all the processed forms of WCC assayed. The results show that the processing techniques adopted significantly ($p<0.05$) enhanced the nutrients and caloric components and reduced the array of ANFs in RWCC, suggestive of its potential as a feed resource.

Key words: Wild cocoyam corm, nutrient, energy values, anti-nutrient components processing techniques

INTRODUCTION

It is evident from social studies and with particular reference to Reverend Thomas Malthus Theory of population that the world population was increasing at a geometric rate and the corresponding food production to meet the needs of this ever increasing population at an arithmetic progression (Richard, 1978). This trend has made food which is an indispensable item for the survival of man to be deficient. The shortage of energy and protein feeds for monogastric animals which compete with humans for the same class of foodstuff has led to massive importation of cereals and other resources. This also calls for decisive research effort on alternative feed resources to meet the needs of both humans and animals.

Root and tuber crops have shown great promise as novel and cheaper alternative energy to maize in developing countries. Nail (1984) confirmed that the use of root crops as feedstuffs in developing countries was expanding. Khajarern and Khajarern (1979) described root and tuber crops as the most efficient converters of solar energy that gives the second highest yield unit after sugar producing plants. According to these authors, root crop yield per unit area is approximately twice the biomass of cereal grains without taking account of the tops. This superiority is more where annual rainfall and/or soil fertility is low. They are easy to grow and have high resistance to insects, diseases and pests, and can be easily stored underground. They have less lignified stems which can be high in protein and therefore their aerial parts have considerable potential as ruminant feed supplement. They are well adapted to rough environment in cyclone regions and are thus more reliable than cereals. These advantages, together with the flexibility in plants age at harvest, make root and tuber crops the most promising basis for feeds for many classes of livestock including poultry.

The acceptability and utilization of root and tuber crops including corm as food and feed despite its nutritional potentials as rich source of energy has been hampered by the presence of relatively high concentration of Anti-Nutritional Factors (ANFs). The aim of this study therefore was to provide information on energy values, nutrient composition and the array of anti-nutrients in this cultivar of wild cocoyam corm [*Colocasia esculenta* (L.) Schott] and effect of processing on its ANFs. This was with a view to finding out its nutritional potential for livestock feeding.

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MATERIALS AND METHODS

The determination of the proximate composition, gross energy values and anti-nutrient components of the samples were carried out in the Laboratory of Institute of Agricultural Research and Training (I.A.R & T), Moor Plantation, Ibadan.

Source and preparation of wild cocoyam corm used for the study: Enough quantity of the same batch of the cultivar of cocoyam corm used for this study was purchased from Odo-Ori market in Iwo, Osun State, Nigeria. The unpeeled corms were divided into four batches and the processing methods adopted were sun-drying in the raw state, soaking, cooking and fermentation. The first batch of thoroughly washed unpeeled corms were sliced to about one centimeter thick and sun-dried for 6 days to a constant moisture content. The second batch of the corms were soaked in water at room temperature for 72 h as recommended (Marfo and Oke, 1988). After 72 h, the water was drained and the pieces of the soaked corms sun-dried for 8 days. The third batch of washed, sliced unpeeled corms were collected in a cooking pot filled with water and heated at 100°C for 15 min. The corms were considered cooked when they were soft sufficiently to be consumed like yam or other tubers. Cooked corms were thereafter sun-dried for 12 days. The fourth set of thoroughly washed corms were grated mechanically and packed in a jute bag, then into an air-tight polythene bag to exclude air and pressed. It was allowed to stand for 72 h to allow some forms of fermentation to occur and afterwards sun-dried for 4 days.

Chemical analysis: Proximate composition of the differently processed WCC were determined according to the method of AOAC (1995). Nitrogen free extract was determined by difference. Gross energy was determined by the use of Ballistic bomb callorimeter, while the metabolisable energy was calculated according to the procedure of Pauzenga (1985) as:

ME (kcal/kg DM) = 37 x % Protein + 81.8 x % Fat + 35.5 x % NFE

Determination of the anti-nutritional factors

Tannins: The method of Swain (1979) was used for the determination of tannin contents of the differently processed corms. 0.2 g of finely ground sample was measured into a 50 ml beaker. 20 ml of 50% methanol was added and covered with parafin and placed in a water bath at 77-80°C for 1 h and stirred with a glass rod to prevent lumping. The extract was quantitatively filtered using a double layered Whatman No.1 filter paper into a 100 ml volumetric flask using 50% methanol to rinse. This was made up to mark with distilled water and thoroughly mixed. 1 ml of sample extract was pipetted into 50 ml volumetric flask, 20 ml distilled water, 2.5 ml Folin-Denis reagent and 10 ml of 17% Na_2C0_3 were added and mixed properly. The mixture was made up to mark with distilled water, mixed well and allowed to stand for 20 min when a bluish-green colouration developed. Standard Tannic Acid solutions of range 0-10 ppm were treated similarly as 1 ml of sample above. The absorbances of the Tannic Acid Standard solutions as well as samples were read after colour development on a Spectronic 21D Spectrophotometer at a wavelength of 760 nm.

Percentage tannin was calculated using the formula:

$$\text{Tannin (\%)} = \frac{\text{Absorbance of sample x Average gradient x Dilution factor}}{\text{Weight of sample x 10,000}}$$

Saponin: The Spectrophotometric method of Brunner (1984) was used for saponin analysis. 1 g of finely ground sample was weighed into a 250 ml beaker and 100 ml Isobetyl alcohol was added. The mixture was shaken on a UDY shaker for 5 h to ensure uniform mixing. Thereafter, the mixture was filtered through a Whatman No. 1 filter paper into a 100 ml beaker and 20 ml of 40% saturated solution of Magnesium carbonate added. The mixture obtained with saturated $MgC0_3$ was again filtered through a Whatman No 1 filter paper to obtain a clear colourless solution. 1 ml of the colourless solution was pipetted into 50 ml volumetric flask and 2 ml of 5% $FeCl_3$ solution was added and made up to mark with distilled water. It was allowed to stand for 30 min for blood red colour to develop. 0-10 ppm standard saponin solutions were prepared from saponin stock solution. The standard solutions were treated similarly with 2 ml of 5% $FeCl_3$ solution as done for 1 ml sample above. The absorbances of the sample as well as standard saponin solutions were read after colour development on a Spectronic 2ID Spectrophotometer at a wavelength of 380 nm. Percentage saponin was calculated using the formula:

$$\text{Saponin (\%)} = \frac{\text{Absorbance of sample x Average gradient x Dilution factor}}{\text{Weight of sample x 10,000}}$$

Phytate: Phytate contents were determined using the method of Young and Greaves (1940) as adopted by Lucas and Markakes (1975). 0.2 g of each of the differently processed corms was weighed into different 250 ml conical flasks. Each sample was soaked in 100 ml of 2% concentrated HCl for 3 h. The samples were then filtered. 50 ml of each filtrate was placed in 250 ml beaker and 100 ml of distilled water added to each sample. 10 ml of 0.3% ammonium thiocyanate solution was added as indicator and titrated with standard Iron (III) chloride solution which contained 0.00195 g iron per

ml. The percentage phytic acid was calculated using the formula:

$$\text{Phytic acid (\%)} = \frac{\text{Titre value x 0.00195 x 1.19}}{2} \text{ x 100}$$

Oxalate: Total oxalate contents of the differently processed wild cocoyam corms was determined according to the precipitatory method of Dye (1956). The extraction was done by boiling 2 g of each of the samples in 40 ml of water for 30 min in a reflux condenser. 10 ml of 20% Na_2C0_3 was added and boiled for another 30 min. The liquid extract was filtered and washed with hot water till wash water showed no alkaline reaction. The combine wash water and filtrate was concentrated to a small volume and cooled. HCl (1:1) was added dropwise with constant stirring until the final acid concentration after neutralization was about 1% at which stage a heavy precipitate appeared, which was allowed to flocculate. Extract was carefully filtered into 250 ml flask, made up to mark and kept overnight. Supernatant liquid was filtered through a dry filter paper in a dry beaker. An aliquot of the filtrate in a 400 ml beaker was diluted with water to 200 ml and reacidified with acetic acid. 10 ml of a 10% Calcium Chloride solution was added to the medium and stirred very well to induce calcium oxalate precipitate to appear and left to settle overnight. The clear supernatant liquid was carefully decanted off through Whatman No. 42 filter paper. The precipitate was dissolved in HCl (1:1). Oxalic acid was precipitated by adjusting the pH with ammonium hydroxide solution. The content was boiled and allowed to settle overnight. Oxalic acid was determined by titrating against 0.05 $NKMnO_4$ solution.

1 ml of 0.05 $NKMnO_4$ = 0.00225 anhydrous oxalic acid

$$\text{Oxalic acid (\%)} = \frac{\text{Titre value x 0.00225}}{2}$$

HCN (Cyanide): The cyanide contents of the sundried raw and processed wild cocoyam corms was determined by an on-farm adaptable, economical and non-laborious Spectrophotometric method of Bradbury *et al*. (1999). 0.1 g of each of the samples was weighed into a flat-bottom plastic bottle with a screw cap lid. 0.5 ml of 0.1 M phosphate buffer at pH_6 was added with a pipette. A yellow picrate paper attached to a plastic strip placed immediately in the flat bottom plastic bottle containing sample and buffer. The picrate papers were not allowed to touch the liquid in the bottle. The bottles were immediately closed with the screw capped lids. A blank for each of the samples was also prepared as above into another screw capped bottle. Linamarin standard stock solutions were also prepared using 10 mg linamarin in 10 ml 0.1 M Phosphate buffer at pH_6. This was diluted to give concentrations of 25 ppm to 100 ppm (i.e. 25, 50, 75, 100). This was used to standardize and calibrate the spectrophotometer. Linamarin paper of 50 ppm concentration each were treated as samples above and put in a separate screw capped plastic bottles containing phosphate buffer and linamarase enzyme and the bottles were closed immediately. All the bottles containing samples, blank and linamarin standard paper were allowed to stand for 16-24 h at room temperature. At the end of 16-24 h, the bottles were opened, plastic backing sheets of the picrate papers were removed and placed in a test tube. 5 ml of distilled water was pipetted into each of the test tubes containing the picrate paper and was allowed to stand for 30 min with occasional gentle stirring. The Absorbances of all the solutions in the test tubes including linamarin standard solution were measured against blank on Spectronic 20 Spectrophotometer at a wavelength of 510 nm. The Total Cyanide content was calculated using the formula:

$$\text{Total cyanide content} = 396 \text{ x Absorbance (ppm) or mg/kg}$$

$$\text{Total cyanide content (\%)} = \frac{\text{ppm Cyanide}}{10{,}000}$$

Trypsin inhibitor activity: Trypsin inhibitor extraction of the differently processed corms followed the procedure of Chan and De Lumen (1982); its activity was determined by the method of Kakade *et al*. (1974).

Statistical analysis: All data obtained were subjected to Analysis of Variance (ANOVA) using the General Linear Model of SAS software (SAS, 1999). Treatment means were compared by Duncan option of the software at 5% level of probability or significance.

RESULTS AND DISCUSSION

Results of the proximate composition, gross energy and metabolisable energy (kcal/kg) are presented in Table 1. Variations in the proximate composition of the differently treated corms were significant ($p<0.05$) except for the ash content. The metabolisable and gross energy values were significantly ($p<0.05$) affected by the processing methods adopted. Crude protein ranged from 6.13-7.44%, crude fibre (3.45-3.90%), ash (2.63-2.93%), ether extract (0.75-1.10%) and nitrogen free extract (73.43-75.46%). Gross energy values ranged between 3434.80 and 3493.10 kcal/kg and metabolisable energy varied from 2943.70-2966.82 kcal/kg. Metabolisable energy expressed as percentage of gross energy ranged from 84.93-86.08%. The mean values of the proximate composition of the three

Table 1: Proximate composition and caloric values of processed wild cocoyam corms

	Processing methods				
Parameters	RWCC	SWCC	CWCC	FWCC	SEM
Dry matter (%)	88.42^{b}	88.06^{c}	88.64^{a}	87.90^{d}	0.02
Moisture (%)	11.58^{c}	11.94^{b}	11.36^{d}	12.10^{a}	0.02
Crude protein (%)	7.07^{b}	6.56^{c}	6.13^{d}	7.44^{a}	0.01
Crude fibre (%)	3.90^{a}	3.75^{a}	3.55^{b}	3.45^{b}	0.07
Ash (%)	2.93	2.86	2.76	2.63	0.03
Ether extract (%)	1.10^{a}	0.95^{ab}	0.75^{b}	0.88^{b}	0.05
Nitrogen free extract (%)	73.43^{b}	73.90^{b}	75.46^{a}	73.50^{b}	3.21
Gross energy (Kcal/kg)	3474.60^{b}	3459.90^{c}	3493.10^{a}	3434.80^{d}	0.09
Metabolisable energy (Kcal/kg)	2958.34^{b}	2943.70^{c}	2966.82^{a}	2956.52^{b}	8.42
Metabolisable Energy as % of Gross Energy (ME/GE (%))	85.14	85.08	84.93	86.08	9.14

RWCC: Raw wild cocoyam corm; SWCC: Soaked wild cocoyam corm; CWCC: Cooked wild cocoyam corm; FWCC: Fermented wild cocoyam corm; abcd: *Mean values with different superscripts along the same row are significantly ($p<0.05$) different

Table 2: Residual anti-nutritional factors in raw and processed wild cocoyam corms

Antinutrients	RWCC	CWCC	LOSS (%)	SWCC	LOSS (%)	FWCC	%LOSS	SEM
Condensed tannins (g/100 gDM)	0.28^{a}	0.22^{b}	21.43	0.18^{c}	35.71	0.16^{d}	42.86	0.004
Hydrolysable tannins (g/100 gDM)	0.13^{a}	0.05^{b}	61.54	0.04^{b}	69.23	0.04^{b}	69.23	0.008
Phytate (g/100 gDM)	1.01^{a}	0.26^{b}	74.26	0.08^{c}	92.08	0.05^{c}	95.05	0.006
Oxalate (g/100 gDM)	0.53^{a}	0.26^{b}	50.94	0.21^{c}	60.38	0.14^{d}	73.58	0.05
Saponin (g/100 gDM)	0.31^{a}	0.16^{d}	48.39	0.22^{b}	29.03	0.18^{c}	41.94	0.04
Hydrocyanide, HCN (mg/kg)	17.13^{a}	7.30^{c}	57.38	7.50^{b}	56.22	7.20^{c}	57.97	0.05
Trypsin inhibitors	NAD	NAD		NAD		NAD		

NAD: No Activity Detected; RWCC: Raw wild cocoyam corm; SWCC: Soaked wild cocoyam corm; CWCC: Cooked wild cocoyam corm;FWCC: Fermented wild cocoyam corm; abcd: *Mean values with different superscripts along the same row are significantly ($p<0.05$) different

cocoyam species evaluated by Sefa-dedeh and Agyir-sackey (2006) revealed lower crude protein, total fat and crude fibre values which compared with the values obtained in this study. The least crude protein of cooked corm was due to effect of heat which could have denatured part of the protein. FAO (1998) confirmed that proteins were denatured by heat. Also, nutrients could have been lost during cooking either by degradation as a result of destruction or chemical changes like oxidation; or by leaching into the cooking medium. The crude protein values recorded in this study were higher than the mean protein contents of three cultivars (white, yellow and red) of cocoyam reported by Onokpise *et al.* (1999).

Fermentation has long been a traditional means of processing root and tuber crops for both human and animal consumption. Iyayi and Losel (1999) described fermentation as an aerobic or anaerobic process involving the soaking of cassava in water for periods extending from 1-8 days (sub-merged fermentation). The lower crude protein value of soaked corm compared with that of the fermented could be as a result of loss of soluble components of the corm by soaking. Moreso, the water in which the corm was soaked was discarded after the soaking period. This conforms with FAO (1998) report that soaking may last for 3-8 days to allow fermentation to occur and in some traditional processing an appreciable amount of protein could be lost. Akinmutimi *et al.* (2002) obtained similar lower crude protein values in soaked and cooked sword bean (*Canavalia gladiata*). The highest crude protein and lowest crude fibre values obtained in the fermented corms must be as a result of the activities of micro-organisms which are known for the bio-conversion of carbohydrates and lignocelluloses into protein. This agrees with the findings of Hwei-Ming *et al.* (1994) and Balagopalan (1996). Higher gross and metabolisable energy values obtained in cooked corm compared with other processed forms was in line with the findings of Akpan and Umoh (2004).

The residual anti-nutritional factors in raw and processed wild cocoyam corm is shown in Table 2. The highest contents of all the Anti-Nutritional Factors (ANFs) viz; tannins, saponin, phytate, oxalate and hydrocyanide detected were in raw and sun dried corms. These were significantly ($p<0.05$) affected by the processing methods adopted. There were no activities detected for trypsin inhibitors. Contents (g/100 g DM) of condensed tannins, hydrolysable tannins, phytate, oxalate and saponin were 0.28, 0.13, 1.01, 0.53 and 0.31 respectively and HCN was 17.13 mg/kg. Although these values were significantly ($p<0.05$) reduced by all the processing methods adopted, however, fermentation was the most effective processing method except for saponin. The respective values (g/100 g DM) of these ANFs in fermented corm were 0.16 (42.86% loss), 0.04 (69.23% loss), 0.05 (95.05% loss), 0.14 (73.58% loss) and 0.18 (41.94% loss). The least HCN content (mg/kg)

was 7.20 (57.97% loss). The higher percentage reductions in hydrolysable tannins compared to condensed tannins by the processing methods could be as a result of ester bonds in the former as opposed to carbon-carbon bond links in the latter with considerable greater stability. This conforms with the submission of Gupta and Haslam (1980) and Ologhobo (2004). Tannin is an example of heat-stable anti-nutrient (Oke *et al*., 1996). So, an appreciable quantity is not expected to be removed by heat application. This may explain why fermentation and soaking were more effective at reducing the levels of the two forms of tannins.

The phytate content of the raw corm in this study was higher compared to the values recorded for cocoyam corms by Marfo and Oke (1988). The high content of oxalate crystals in some species of cocoyam corms has been implicated in the acridity or irritation caused by cocoyam (FAO, 1998). The higher reduction of HCN by fermentation compared to other processing methods could have been due to hydrolysis of glucosides to HCN prominent by disruption of the root and tuber crops. Such HCN is lost by pressing.

Conclusion: The results indicate that processing techniques adopted enhanced the proximate and caloric components; and significantly reduced the array of anti-nutritional factors in cocoyam corms with fermentation being the best. This may suggest a panacea to high content of anti-nutrients of root and tubers which had always limited its incorporation into livestock rations.

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