Review Article
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Phytochemical, vitamins and toxic level of processed cocoyam (*colocasia esculenta* (L.) schott) inflorescence

Abstract

Phytochemical, Vitamins and Toxic level of processed Cocoyam inflorescence were determined. Samples of cocoyam inflorescence were processed by blanching, soaking, Boiling, sun drying, and oven drying. Fresh sample of Cocoyam inflorescence was analyzed and stands as the control. All the chemical analysis was determined, using standard analytical method. Processing methods caused significant ($p<0.05$) reduction on the Vitamins, phytochemical composition and toxic components of cocoyam inflorescence. Pro vitamin A content of fresh sample was 348.91µg/dl while Vit. E, B_2 and C were 16.82, 12.59 and 27.21 mg/100g respectively. The fresh sample showed 114.01, 586, 1.52, 36.07, 254.24, 32.27 and 32.87% respectively for flavonoid, carotenoid, phenol, oxalate, steroid, phytate and alkaloid contents. Water blanching and oven drying showed significantly ($p<0.05$) reduction in Vit. E, B_2, C and pro vit A by 83.5, 79.1, 98.6 and 95% respectively. Boiling and sun drying caused significant ($p<0.05$) reduction in alkaloid, flavonoid, carotenoid, saponin, phenol, oxalate, steroids, phytate and tannin content by 95.8, 83.2, 94.4, 74.6, 45.4, 43.1, 87.2 and 97.8% respectively. These results showed that fresh Cocoyam inflorescence contains appreciable amount of vitamins with moderate level of phytochemicals. The highest dosage of 5000 mg/kg body weight of cocoyam inflorescence extract had no significant ($p<0.05$) toxic effect on the tested animals. Petroleum ether extract showed the presence of rich variety of the secondary metabolites. Boiling with sun drying showed higher losses of vitamins and phytochemical composition of Cocoyam inflorescence while boiling with oven drying showed better retention of these bioactive components in Cocoyam inflorescence.

Volume 11 Issue 2 - 2023

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Received: June 26, 2023 | **Published:** October 05, 2023

Introduction

Phytochemicals, found in fruits, vegetables and nuts, may help slow the aging process and reduce the risk of many diseases, including cancer, heart disease, stroke, high blood pressure, osteoporosis and urinary, tract infections.[1] Kalu[2] showed that the protective effects of Cocoyam inflorescence foods are considered to be related to various phytochemicals contained in the vegetable. Green leafy vegetables are widely consumed in Nigeria, Africa and some other parts of the world. Vegetarians who consume a lot of vegetables are likely to have a higher intake of phytochemicals which may reduce nutrient availability in their body systems if not properly checked and regulated. Several vegetable species are available in Nigeria and most of them serve as foods, herbal supplement or medicinal purposes and also as condiment or spices in human diets or even as animal feeds. Green leafy vegetables occupy an important place among the food crops as they provide adequate amount of many minerals and vitamins for humans. They are rich sources of carotene, ascorbic acid, riboflavin, folic acid and minerals like calcium, potassium, magnesium, sodium, iron and phosphorus.[2] They are also high in dietary fibre which helps in digestion and prevention of colon cancer. In addition, they contain anti-nutrients such as oxalate and phytic acid which reduce the bioavailability of some essential minerals.[3,4] Cocoyam inflorescence is one of these vegetables widely consumed in Nigeria. Cocoyam inflorescence is the flower of cocoyam leaves. The colours of the inflorescence varies according to species. Some have pale yellow, while others are pink, light green, dark red, violate etc. Cocoyam as a vegetable begins to flower at about between late June and August of every year. It emergence or production during the season in the farm, marks the maturity of the cocoyam and therefore, ready for harvesting.[5] However, (4) species of *Colocasia esculenta* produce inflorescence while some of the species of *xanthosoma* produce inflorescence in Nigeria.[6] Examples of species of *xanthosoma* that produce inflorescence include *xanthosoma roseum and Xanthosoma sagittifolium* but they are not common in Nigeria. *Colocasia esculenta* and *Xanthosoma roseum* are among the largest inflorescence in the world. The inflorescence of *Colocasia esculenta* has green spathe tube with coloured blade on both sides. The major parts of an aroids inflorescence are known as the spathe and spadix. In South America like Brazil and some part of Asia, it is used in dressing salad.[7] Furthermore, Kalu et al.[5] stated that Cocoyam inflorescence should be properly processed to reduce the oxalate level to tolerable level to avoid irritation and scratching sensation in the mouth and throat when consumed. In some localities like Uturu, the plant especially the stem is used in the treatment of some ailments (wounds caused by infection) when roasted in the fire and used to treat scratches on the legs and foots caused by worms contacted by swimming in streams and pond waters.

There are four (4) species of *colocasia esculenta* that produce inflorescence, namely Nigerian *colocasia esculenta* (NCe) which include; NCe_{002} (Ede ofe green), NCe_{003} (Ede ofe Purple), NCe_{004} (Ede ofe giant/green) and NCe_{005} [Ede ofe light yellow]. This NCe_{005} is locally called Ukpon (Anambe or inambe). Among all these only NC_{e005} 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. Some of the phytochemicals in vegetables are oxalate, tannin, saponin, phytate among others.[7,8] Phytochemicals or ant nutritional factors are those compounds or substances either natural or synthetic origin that interfere with the absorption of nutrients. They act to reduce nutrient intake, utilization, digestion and may produce other adverse effects in the body system. The level of anti-nutrients in plant vegetable becomes an indication of the toxicity and safety nature of the vegetable. The application of qualitative analytical techniques is generally used to classify and

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trace the levels of these non-nutrient substances. The purpose of this research therefore is to ascertain the phytochemical, vitamins and toxic levels of these antinutrients in processed cocoyam inflorescence

Materials and methods

Sources of materials

Fresh samples of Cocoyam (*Colocasia esculenta* (L.) schoot inflorescence NCe_{005} used for this study were procured from Cocoyam section of Natural Root crop Research Institute (NRCR) Umudike, Abia State where it was also identified. All the chemicals were purchased from Hi-mEDIA pvt. Ltd., Bombay. The chemicals used were of analytical grade.

Sample preparation

Fresh Cocoyam inflorescence was harvested, washed with portable water, drained and allowed the water on the surface to dry under the fan for 30- 40minutes at room temperature. The washed air dried Cocoyam inflorescence were sliced and divided into five portions of 2kg each. Each portion was subjected to different processing treatment described as follows;

Fresh portion of the sample served as control and was not given any treatment. This portion was blended using kenwood blender-BL300/ISL350 series to obtain the wet milled fresh sample. It was packaged in a plastic container and stored in the freezer until used for analysis.

The second sample was made up of 2kg of fresh cocoyam inflorescence blanched in hot water for about 98°C for 4mins. The time for adequate blanching of the inflorescence was determined as described. The blanched sample was air dried for 40 minutes. This blanched sample was divided into two equal parts each. One portion was oven dried at 70°C for 7 hours to a constant weight while the second portion was sun dried for a period of 7 days. The dried samples were milled using kenwood blender-BL300/BL350series. They were packaged in a plastic container and stored in a refrigerator (10°C) until used for analysis.

The third sample was made up of 2kg of fresh cocoyam inflorescence which was divided into two portions. One portion (1kg) was oven dried at 70°C for 7 hours to a constant weight while the other portion (1kg) was sun dried for a period of 7 days. The samples were milled as previously described and packaged in a plastic container and stored in a refrigerator until used for analysis.

The fourth sample was made up of 2kg of fresh cocoyam inflorescence soaked in hot water (100°C) for 20 minutes. The sample was allowed to dry under the fan for 40 minutes, it was divided into two equal parts each and one portion was oven dried at 70^0C for 7 hours while the other was sun dried for a period of 7 days. The samples were milled and stored as described above until used for analysis.

The fifth sample was made up of 2kg of fresh cocoyam inflorescence boiled at 100°C for 10 minutes and allowed to cool and air dried for 40 minutes under the fan. The boiled samples were divided into two equal parts. One portion was oven dried at 65°C for 10 hours. The other portion was sun dried for a period of 8 days. All the dried samples were milled and stored as previously described above until used for analysis.

Acute toxicity studies

Animal procurement and care

The animals were housed in well-ventilated cages containing wood shavings for bedding. All the animals were fed standard pelletized grower's mash (UAC Vital Feed, Jos, Nigeria) and portable water ad libitum. They were maintained under normal environmental temperature (26±2°C) with normal 12:12 hour dark/light cycle. The animals were acclimatized for 7 days. The weight of each animal was taken prior to the commencement of administration of the test samples. The environment was cleaned and disinfected regularly. Soiled wood shavings were replaced within 5 days interval. The feed and water containers were washed regularly. Each animal was marked for identification. The experiment was conducted in accordance with the internationally accepted principles for laboratory animal use and care as found in the US and guidelines.

This was carried out using the method of Lorke[9]

Mice of either sex were randomly shared into 5 groups of 10 mice each. Each group of Animals was used for each treatment. The animals were starved for 24h before the samples were administered. Each sample dispersion (made from the powdered sample) was administered by intubation method to the mice at standard dose levels of 10, 100, 400, 1000, 1600, 2900, and 5000 mg/kg of body weight so as to ascertain a lethal dose. Each of the group animals was administered with all the doses as indicated above. The animals were closely observed (monitored) for the first 6 and 12 hour for any toxic symptoms such as psychomotor co-ordination, mood position and general behavior and for up to 24 hours for mortality. The dose of the sample that would kill 50% of the animal population tested was used to determine the $LD_{50.}$ (Mice have small weight so because of that the dose range could reach up to 5000 mg/kg to enable the least sensitive result to be obtained from the tested sample).

Samples (50g/250ml) for phytochemical qualitative preliminary test were extracted successively with petroleum ether using soxhlet apparatus at 55-85 °C for 8-10h.[10] All the dried samples were re dissolved in dimethyl sulfoxide to get the solution of 10mg/10 ml used for the analysis.

Analysis

Vitamin A, C, E and B_2 were determined using HPLC as described. 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

Quantitative determination of phytochemical constituent of cocoyam inflorescence

Determination of total phenolics

Briefly, 2.5 g of the powdered leaves was boiled with 25 ml of ether for 15 min. Then 5 ml of the extract was pipette into a 50 ml volumetric flask and 10 ml of distilled water, 2 ml ammonium hydroxide and 5 ml amyl alcohol were added sequentially. The solution was made up to the mark with distilled water and allowed to stand for 30 min for color development. The absorbance of the solution was read at 505 nm using a UV spectrophotometer and tannic acid was used as the standard.[11]

Citation: Okechukwu KE, Sampson Ogah U. Phytochemical, vitamins and toxic level of processed cocoyam (colocasia esculenta (L.) schott) inflorescence. *MOJ Food Process Technol.* 2023;11(2):116–128. DOI: 10.15406/mojfpt.2023.11.00289

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Determination of tannins

The determination of tannin was done using the method of Edeoga[12] with some modifications. One gram of the ground leaves was added to 40 ml of 50% methanol. The mixture was shaken vigorously and placed in a hot water bath at 80°C for 1h. The extract was filtered into a 100 ml volumetric flask, then 20 ml distilled water, 2.5 ml Folin-Denis reagent and 10 ml of 17% sodium carbonate was added and shaken vigorously. The mixture was then made up to the mark with distilled water and allowed to stand for 20 min for full color development. The absorbance was read at 760 nm on a UV spectrophotometer and tannic acid of concentrations ranging from 0-10 ppm was prepared and used as standard. A standard graph was plotted and the calibration curve Y = 0.0593x –0.0485, R = 0.9826 was obtained, where x was the absorbance and Y was tannic acid equivalent.

Determination of alkaloids

A volume of 200 ml of 10% acetic acid in ethanol was added to 5 g of the powered leaves. This was covered with a watch glass and allowed to stand for 4 h. It was then filtered and the filtrate was concentrated to ¼ of the original volume on a water bath. Concentrated ammonium hydroxide was added drop wise for complete precipitation and the solution was allowed to settle. The collected precipitates were washed with dilute ammonium hydroxide and then filtered. Finally, the residue was dried and weighed.[12]

Determination of flavonoids

Flavonoid determination was by the method reported by Ejikeme et al.[13,14] Exactly 50 cm3 of 80% aqueous methanol added was added to 2.50 g of sample in a 250 cm3 beaker, covered, and allowed to stand for 24 hours at room temperature. After discarding the supernatant, the residue was re extracted (three times) with the same volume of ethanol. Whatman filter paper number 42 (125 mm) was used to filter whole solution of each wood sample. Each wood sample filtrate was later transferred into a crucible and evaporated to dryness over a water bath. The content in the crucible was cooled in a desiccator and weighed until constant weight was obtained. The percentage of flavonoid was calculated.

Determination of *s*aponin content

The determination of saponin was done using the method of Obadoni and Ochuko.[11] About 5g of the sample was dispersed in 50 ml of ethanol prepared in distilled water (20% v/v). The mixture was heated over a hot water bath for 4 h at 55°C with continuous stirring. The residue collected after filtration was re- extracted with 50 ml ethanol (20%) and reduced to 20 ml over a boiling water bath. This was shaken with 10 ml diethyl ether in a separating funnel. The aqueous layer was collected and the process was repeated. Then, 20 ml of butanol was added to the filtrate and washed with 10 ml 5% w/v aqueous sodium chloride. The whole mixture was evaporated to dryness on a hot water bath and later oven-dried to constant weight at 40°C.

Determination of cyanogenic glycoside

Cyanogenic glycoside quantitative determination methodology used in this research is that by Amadi et al.[15] It was weighed into a 250 cm3 round bottom flask and about 200 cm3 of distilled water was added to one gram of each dry wood powder sample and allowed to stand for 2 hours for autolysis to occur. Full distillation was carried out in a 250 cm3 conical flask containing 20 cm3 of 2.5% NaOH (sodium hydroxide) in the sample after adding an antifoaming agent (tannic acid). Cyanogenic glycoside (100 cm3), 8 cm3 of 6 M NH4OH (ammonium hydroxide), and 2 cm3 of 5% KI (potassium iodide) were added to the distillate(s), mixed, and titrated with 0.02 M AgNO3 (silver nitrate) using a micro burette against a black background. Turbidity which was continuous indicates the end point. Content of cyanogenic glycoside in the sample was calculated

Determination of oxalate

Oxalate quantitative deter- mination was carried out using the method reported by Munro and Bassir.[16] Exactly 20 cm3 of 0.3 M HCl in each wood powder sample (2.50 g) was extracted three (3) times by warming at a temperature of 50°Cfor 1 hour with constant stirring using a magnetic stirrer. For oxalate estimation, 1.0 cm3 of 5 M ammonium hydroxide was added to 5.0 cm3 of extract to ensure alkalinity. Addition of 2 drops of phenolphthalein indicator, 3 drops of glacial acetic acid, and 1.0 cm3 of 5% calcium chloride to make the mixture acidic before standing for 3 hours was followed by centrifugation at 3000 rpm for 15 minutes. After discarding the supernatant, the precipitate was washed three times using hot water by mixing thoroughly each time centrifugation. Then, to each tube, 2.0cm3 of 3M tetraoxosulphate (vi) acid was added and the precipitate dissolved by warming in a water bath at 70□C. Freshly prepared 0.01 M potassium permanganate (KMnO4) was titrated against the content of each tube at room temperature until the first pink colour appears throughout the solution. The solution was allowed to stand until it returned colourless, after which it was warmed on an electric hot plate at 70°Cfor 3 minutes, and retitrated again until a pink colour appears and persists for at least 30 seconds. Titration reaction of oxalate in sample was calculated.

Determination of steroids

1ml of test extract of steroid solution was transferred into 10ml volumetric flasks. Sulphuric acid (4N, 2ml) and iron (III) chloride (0.5% w/v, 2 ml), were added, followed by potassium hexacyanoferrate (III) solution (0.5% w/v, 0.5 ml). The mixture was heated in a water-bath maintained at 70±2°C for 30 minutes with occasional shaking and diluted to the mark with distilled water. The absorbance was measured at 780nm against the reagent blank.

Determination of carotenoids

Extraction of carotenoids

The extraction was carried out as described by Kimura and Rodriguez-Amaya[17] with slight modifications. Four (4g) of cocoyam inflorescence sample was transferred to a mortar and 0.3 g of MgCO3 was added. The mixture was ground with 25 ml of cold acetone (refrigerated for about 2 hours). The extract was filtered using a Whatman filter paper.

Total carotenoid estimation

Fifteen (15ml) of Petroleum ether were pipetted into a separating funnel with Teflon stopcock. Ten (10 ml) of the acetone extract were added and allowed to stand for 15 minutes. One hundred and thirty (130) ml of distilled water were added by flowing along the walls of the funnel. The mixture was allowed to separate into two phases, and the aqueous phase was discarded. The petroleum ether phase was washed 4 times with 100 ml of distilled water to remove residual acetone. The petroleum ether phase was collected in a 25 ml volumetric flask by passing the solution through a small funnel containing 7.0 g of anhydrous sodium sulfate to remove residual water. The separating funnel was then washed with petroleum ether and the washing was collected into the volumetric flask by passing it

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through the funnel with sodium sulfate. The volumetric flask was then made up to volume with petroleum ether and the total carotenoids content were determined from the molar absorptivity β-carotene E1% = 2590 at λmax 450nm and lycopene E1% = 3450 at λmax 472nm derived from the standard plots.[18,19]

Determination of phytate

The method described by Nkama and Gbenyi[20] was used for the determination of phytate. Two grams (2g) of the sample was weighed into a 100 ml flask and extracted with 50 ml of 0.2N HCl. Five millilitres (5 ml) of the extract was measured into a test tube fitted with a glass stopper. One millilitre (1ml) of ferric solution was added to the extract. The tube was heated in a boiling water bath for 30 min and cooled in ice water for 15 min before allowing it to adjust to 25 ^{0}C (room temperature). The content of the tube was mixed and centrifuged for 30 min at 3000 rpm. One millilitre (1ml) of the supernatant was transferred to another test tube and 1.5ml of 2,2-bipyridin solution made by dissolving 10g of 2,2-bipyridine and 100 ml thioglycollic acid in distilled water. Calibration curve was prepared by plotting the concentration of the reference solution (phytate reference solution) against the corresponding absorbance. The absorbance of the test sample was then used to obtain the concentration from the calibration curve.

Qualitative determination of phytochemical constituent of cocoyam inflorescence

Test for terpenoids: Method used is as reported. Each cocoyam inflorescence sample (0.30 g) was weighed into a beaker and extracted with 30 cm3 and component extracted for 2 hours. A mixture of chloroform (2 cm3) and concentrated tetraoxosulphate (VI) acid (3 cm3) was added to 5 cm3 of each extract to form a layer. The presence of a reddish brown colouration at the interface shows positive results for the presence of terpenoids.

Test for flavonoids: The test for flavonoid adopted is as reported by Sofowara and Harborne.[21,22] Each sample (0.30 g) weighed into a beaker was extracted with 30 cm3 of distilled water for 2 hours and filtered with Whatman filter paper number 42 (125 mm). To 10 cm3 of the aqueous filtrate of each wood extract was added 5 cm3 of 1.0 M dilute ammonia solution followed by the addition of 5 cm3 of concentrated tetraoxosulphate (VI) acid. Appearance of yellow colouration which disappeared on standing shows the presence of flavonoids.

Test for steroid: Analytical method used is according to each sample (0.30 g) weighed into a beaker was mixed with 20 cm3 of ethanol; the component was extracted for 2 hours. To the ethanolic extract of each sample (5 cm3) was added 2 cm3 acetic anhydride followed with 2 cm3 of concentrated tetraoxosulphate (VI) acid. A violet to blue or green colour change in sample(s) indicates the presence of steroids.

Test for saponin: The determination of saponin was done using the method of Obadoni and Ochuko[11]

Distilled water (30 cm3) was added to cocoyam inflorcence samples (0.30 g) and boiled for 10 minutes in water bath and filtered using Whatman filter paper number 42 (125 mm). A mixture of distilled water (5 cm3) and filtrate

(10 cm3) was agitated vigorously for a stable persistent froth. The formation of emulsion on addition of three drops of olive oil showed positive result.

Test for alkaloid was carried out as reported by Hikino et al.[23] Extract of components from 2g of each sample was carried out using 5% tetraoxosulphate (vi) acid (H2SO4) (20Cm^3) in 50% ethanol by boiling for 2minutes and filtered through whatman filter paper number 42 (125mm) The filtrate was made using 5Cm^3 of 28% of ammonia solution (NH_3) in a separate funnel. Equal volume of chloroform (5cm^3) was used in further solution extraction in which chloroform solution was extracted with two 5cm3 portions of 1.0M dilute tetrxosulphate (vi) acidThis final acid extract was then to carry out the following test: 0.5cm3 of Dragenorff"s reagent (Bismuth potassium iodide solution) was mixe with 2cm3 of acid extract and precipitated orang colour infers the presence of alkaloid.

Text for glycoside: Glycoside test was conducted according to the method reported by Hikino et al. (1984). To 2.00 g of each sample was added 20 cm3 of water, heated for 5 minutes on a water bath and filtered through Gem filter paper (12.5 cm). The following tests were carried out with the filtrate: (a) 0.2 cm3 of Fehling's solutions A and B was mixed with 5 cm^3 of the filtrate until it became alkaline (tested with litmus paper). A brick-red colouration on heating showed a positive result. (b) Instead of water, 15 cm3 of 1.0 M sulphuric acid was used to repeat the above test and the quantity of precipitate obtained compared with that of (a) above. High precipitate content indicates the presence of glycoside while low content shows the absence of glycoside.

Test for tannin: Analysis used was the method reported by Ejikeme et al.[13] Each sample (0.30g) was weighed into a test tube and boiled for 30 minutes in a water bath containing 30 cm3 of water. Filtration was carried out after boiling using number 42 (125mm) whatman filter paper. To 5cm3 of the filtrate was added 3 drops of 0.1% ferric chloride. A brownish green or a blue black coloration showed the presence of tannin.

Test for oil: Translucent spot test: Two 2g) of the sample was folded filter paper and pressed a little. The appearance of a greasy spot indicates the presence of oil. Heating and drying the filter paper with an increase in the oil spot was used to determine different oil level in the different sample of the cocoyam inflorescence.[24]

Test for carbohydrates: 1ml molisch reagent (a solution of α - naphthalol) is added to 2 ml aqueous extract and few drops of concentrated sulfuric acid are slowly dripped and the resulted solution is shaken carefully. The appearance of a violet ring at the interface of the two liquids indicates the presence of carbohydrates in the acqueous extracts. But in the case of cocoyam inflorescence aqueous extract, the solution turns purple red.

Test for reducing sugar: Benedict test was used; to 1 ml of aqueous (a complex solution of sodium carbonate, sodium citrate, and copper sulfate pentahydrate) was added and the resultant mixture is boiled for 5 min. Initially, the solution turns green and upon boiling a red, yellow or green precipitate is formed.

Test for resins: Acetic anhydride test; to 1 ml cocoyam inflorescence extract, added to acetic anhydride solution with concentrated hydrochloric acide (H2SO4), appearance of orange colour was an indication that resin was present.

Protein was determined by the Micro KJELDAHL'S method.[25] Test for acidic compounds: Acidi compound test was done using schiffs test as described by Obadoni and Ochuko.[11]

Data analysis

Experimental design: The experiment was laid out in Completely Randomized Design (CRD). One way analysis of variance (ANOVA) was used to analyze the data. Means separation was by Duncan

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multiple range test as described. Results were expressed as Mean ± SD (standard deviation) of triplicate determination. The data analysis was aided by SPSS version 20.

Results and discussions

The results of the vitamin composition of Cocoyam inflorescence is presented in Table 1 while Table 2 shows the phytochemical components of processed cocoyam inflorescence and Table 3 shows preliminary qualitative photochemical analysis of extract of Fresh and Processed Cocoyam inflorescence. The vitamin C content of cocoyam inflorescence was 27.21mg. Baojun et al.[26,27] reported 23.74mg and 11.27mg/100g for vitamin in chickpea and Tomatoes respectively. The value shows that Cocoyam inflorescence is a good source of vitamin C. The vit. C content of processed samples increased significantly ($p<0.05$) from trace-0.38mg. Un blanched and soaked samples recorded the least values of Vit. C since they showed trace in all the sun dried samples while boiled sample recorded 0.09-0.15mg, The decrease of vitamin C in the processed samples was attributed to leaching, thermal destruction and oxidation.[28–30] Similar reductions were reported by Nkafamiya et al.[31,32] Unblanched dried samples showed lower values than the blanched samples probably due to oxidation. Oboh[33] reported vitamin C losses at 45-82.4% during blanching process while Duke et al.[34,35] reported that heating (especially boiling in open pots) can cause huge losses of vitamin C. Sun dried samples generally showed lower vit. C content than the oven dried samples probably due to oxidation of the vitamin. Wilting is one of the factors that contribute to the vitamin losses during sun drying.[36] Sun drying therefore, is not a good method of preserving vegetables with the aim to retain vitamin C as this research suggest. Losses of ascorbic acid are used as an indicator of food quality, and the severity of blanching.[37] In this work the losses of Vit. C ranges from 99.2-99.89%. Vitamin C is essential in the body. Some evidence indicates that vitamin C may have antiviral activities. Ascorbic acid reduces viral activity by degrading phage and vital nucleic acids inhibiting viral replication.[38] The vit. C content of fresh sample (27.21mg) is adequate when compared with 30mg (RDA).[39] This level of vit. C in Cocoyam inflorescence suggests that cocoyam inflorescence is a good source of antioxidant.

Table 1 Effect of processing methods on vitamin composition of cocoyam inflorescence

Samples/processing methods	Vitamin E (mg/100g)	Vitamin B_2 (mg/100g)	Vitamin C (mg/100g)	Vitamin A (µg/dl retinol)
Water blanched oven dry	2.77±0.22^{g}	2.63±0.00^{d}	0.38±0.01^{e}	17.44±0.01^{h}
Water blanched sun dry	0.39±0.21^{a}	1.45±0.15^{b}	0.23±0.00^{d}	15.56±0.01^{f}
Unblanched oven dry	1.59±0.15^{f}	8.67±0.07^{f}	0.15±0.02^{b}	16.09±0.01^{g}
Unblanched sun dry	1.12±0.01^{e}	4.85±0.00^{e}	TRACE	14.75±0.01^{e}
Soaked (20mins) oven dry	0.98±0.02^{d}	2.03±0.05^{c}	0.29±0.01^{c}	11.17±0.01^{b}
Soaked (20mins) sun dry	0.68±0.01^{c}	0.87±0.05^{e}	TRACE	10.19±0.01^{a}
Boiled(10mins) oven dry	1.59±0.00^{f}	2.59±0.00^{c}	0.15±0.01^{b}	13.69±0.01^{d}
Boiled (10mins) sun dry	0.43±0.06^{b}	0.59±0.02^{a}	0.09±0.01^{a}	11.28±0.01^{c}
Fresh sample(control)	16.82±0.01^{h}	12.59±0.02^{g}	27.21±0.01^{f}	348.91±0.01^{i}

Means along the column with different alphabetical superscript indicates a significance difference ($P<0.05$) at 5% level of significance. Each value represent the mean of the triplicate determination.

Table 2 Effect of processing methods on phytochemical/antinutrients composition of cocoyam inflorescence

Samples/ processing methods	Alkaloid (%)	Flavonoid (mg/100g)	Saponin (%)	Carotenoid (mg/100g)	Phenol (mg/100g)	Oxalate (mg/100g)	Steroid (mg/100g)	Phytate (mg/100g)	Tannin (mg/100g)	CN (mg/100g)
Water blanched oven dry	0.45±0.05^{b}	25.87±0.05^{d}	34.72±0.34^{f}	35.22±0.45^{g}	0.79±0.03^{b}	18.72±0.16^{e}	2.37±0.17^{b}	3.81±0.03^{c}	0.39±0.00^{a}	0.019±0.00^{b}
Water blanched sun dry	1.38±0.02^{e}	19.16±0.05^{b}	21.80±0.06^{d}	32.75±0.06^{f}	0.83±0.06^{c}	20.51±0.01^{g}	4.44±0.01^{d}	4.12±0.02^{d}	0.38±0.01^{a}	0.055±0.50^{c}
Unblanched oven dry	1.17±0.15^{d}	24.43±0.37^{e}	43.13±0.30^{p}	29.57±0.20^{e}	0.36±0.00^{a}	19.67±0.01^{f}	2.97±0.02^{c}	19.55±0.00^{g}	0.29±0.00^{a}	0.088±0.50^{d}
Unblanched sun dry	0.29±0.50^{a}	15.41±13.1^{a}	34.20±0.32^{f}	27.83±0.05^{m}	0.74±0.01^{b}	21.16±0.06^{h}	4.75±0.01^{e}	23.57±0.07^{h}	4.04±0.06^{c}	0.128±0.50^{e}
Soaked (20mins) oven dry	0.73±0.01^{c}	16.03±0.25^{a}	15.83±0.12^{b}	20.03±0.75^{c}	0.24±0.75^{a}	8.17±0.05^{a}	2.05±0.02^{a}	5.81±0.12^{e}	1.73±0.05^{b}	0.001±0.50^{a}
Soaked (20mins) sun dry	0.33±0.15^{a}	14.13±0.05^{a}	11.87±0.53^{a}	13.63±0.12^{a}	0.29±0.00^{a}	15.49±0.53^{d}	3.24±0.05^{c}	8.47±0.53^{f}	4.03±0.53^{c}	0.012±0.50^{b}
Boiled (10mins) oven dry	0.13±0.05^{a}	33.03±0.13^{e}	27.01±0.15^{e}	22.83±0.30^{d}	0.24±0.13^{a}	8.89±0.05^{b}	2.98±0.09^{c}	2.35±0.00^{a}	0.32±0.07^{a}	TRACE
Boiled (10mins) sun dry	0.51±0.07^{b}	24.01±0.07^{c}	18.63±0.07^{c}	15.41±0.07^{b}	0.42±0.07^{a}	12.57±0.10^{c}	4.72±0.07^{e}	3.36±0.07^{b}	0.30±0.07^{a}	TRACE
Fresh sample (control)	32.87±.11^{f}	114.01±0.11^{f}	85.72±0.11^{g}	586.00±0.10^{h}	1.52±0.12^{d}	36.07±0.11^{i}	254.24±0.1^{f}	32.27±0.15^{i}	17.15±0.1^{d}	TRACE

Means along the column with different alphabetical superscript indicates a significance difference ($P<0.05$) at 5% level of significance.

Each value represent the mean of the triplicate determination. NB; CN means cyanide

Citation: Okechukwu KE, Sampson Ogah U. Phytochemical, vitamins and toxic level of processed cocoyam (colocasia esculenta (L.) schott) inflorescence. *MOJ Food Process Technol.* 2023;11(2):116–128. DOI: 10.15406/mojfpt.2023.11.00289

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Table 3 Preliminary qualitative photochemical analysis of extract of fresh and processed cocoyam inflorescence

Sample Mark	Acidic compd.	Saponin	Tannins	Reducing sug.	Alkaloid	Resins	Steroids	Terpe noids	Oil	Carbo hydrate	protein	Gly cosides	Flavo noids
Water blanched over dry	+	++	+++	+++	+	+	+	+	+++	++	+	Tr	-
Water blanched sun dry	+	+	+++	+	+	+	+	+	-	++	+++	++	+
unblanched oven dry	+	+	+++	+++	++	-	+	+	+	-	+++	+	+
unblanched sun dry	-	+	+++	++	-	-	++	++	+	+	+++	++	+
Soaked (20mins) oven dry	++	+	+++	++	-	-	+	+	++	++	++	+++	+
Soaked (20mins) sun dry	++	+	+++	+	+	+	++	++	+	+	+++	+++	-
Boiled (10mins) Oven dry	+	++	+++	+++	-	+	-	-	++	+	+++	+++	-
Boiled (10mins) sun dry	-	Tr	+++	++	-	+	-	-	+	+	+++	+++	+
Fresh sample (control)	++	+++	+++	++	++	++	+++	++	-	+++	+++	+++	++

Keys: Absent, +, Low, ++, Moderate, +++, Abundant.

Vitamin A content of the fresh was significantly ($p<0.05$) higher (348.9µg) than the processed samples that ranged between 10.19-17.44µg. the significant ($p<0.05$) decrease of the processed sample could be due to leaching and effect of sun light. Losses of vitamins are mostly due to leaching, thermal destruction and to a lesser extent Oxidation.[40] The vitamin A content of the blanched samples ranged 15.56-17.44µg more than the unblanched (14.75-16.09). Badifu et al.[41] recorded that blanched dried leaves retained considerable amount (48-62%) of beta-carotene than the unblanched (28-31%). The loss of vitamin A in unblanched inflorescence when compared to the blanched was probably due to the activities of enzymes. In all the processed samples, oven dried samples recorded significant increase over the sun dried and therefore, become a better drying technique than sun drying. According to Yadav and Sehgal[42] loss of beta-carotene was higher (48%) in spinach and amaranth leaves on oven drying than that of sun drying (14%). The RDA (900µg) of vit. A is higher than the vit. A of the Cocoyam inflorescence both fresh (348.89µg) and the processed. Vit. A content of the fresh sample is preferable to that of the processed and may go a long way to solve the vit. A deficiency if properly consumed. Vitamin A helps to develop good eyesight and as well prevent anaemia. Deficiency may lead to poor eyesight and night blindness. Cocyam inflorescence contained relatively high levels of total carotenoid. Therefore, they may serve as good sources of provitamin A,Vitamin E content of fresh cocoyam inflorescence was 16.82mg. There was a significant decrease in the vitamin E content of the processed samples which ranged from 2.77- 0.26mg probably due to thermal destruction. Blanched samples recorded higher vitamin E content (2.77mg) than boiled, soaked and unblanched samples. Similar increase in vitamin E content of blanched vegetables had been reported by Osum et al.[43,44] Boiled sample had the least Vit E values while the soaked samples showed 0.98mg (oven dried) and 0.68mg (sun dried). Unblanched sample recorded 1.12mg (sun dried) and 1.59mg (oven dried). Sun dried samples showed lower values of vit. E than the oven dried. Ottaway (1993) reported that vitamin E is unstable to heat in the presence of air. It is readily oxidized by air and decomposed by light. The 16.82mg vit. E content of the fresh sample is above the RDA of 15mg/day and this makes cocoyam inflorescence a good antioxidant vegetable since Vit. E has been shown to exhibit antioxidant properties.[45]

The vitamin B_2 content of the fresh cocoyam inflorescence was 12.59mg. The vitamin B_2 content of the processed samples decreased significantly ($p<0.05$) from 8.67-0.59mg.[46] Nkafamiya et al.[31] reported similar reduction in riboflavin content of non-conventional leafy vegetables. This significant ($p<0.05$) decrease of vit. B_2 could be due to low pH, thermal destruction and possibly leaching. Unblanched dried sample showed the highest value (8.67mg) of vit.B_2 content than blanched, soaked and boiled samples. Boiled sample recorded the least value (0.59mg). Sun dried samples recorded significant ($p<0.05$) decrease in vit. B_2 than oven dried samples probably due to the high sensitivity of vitamin B_2 to light and heat. Vitamin B_2 is unstable to light, heat, alkaline condition and sensitive to pH (Ottaway, 1993). The RDA of vitamin B_2 for adult human beings ranged from1.1-1.3mg.[47] Vitamin B_2 serves as a good source of antioxidant and a precursor of the coenzyme flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD).[48] This also implies that both fresh and processed cocoyam inflorescence are good sources of antioxidant vitamins. The deficiency of vit. B_2 include weakness, fatigue, mouth pain and tenderness, eye burning and itching. But advanced deficiency leads to cheilosis, angular stomatitis, dermatitis, cornea vascularization, anaemia, and brain disfunction.[49] Deficiency of vit B_2 cannot only come from poor diet but also from disease, endocrine abnormalities and psychotrapic drugs like chlorpromazine, imipramine, amitriptyline and some cancer drugs like doxorubicin and also antimalaria drugs like quinacrine as well as alcohol which interferes with both its digestion and intestinal absorption.[50] Therefore Cocoyam inflorescence may be

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suitable or recommended to sick people especially, the psychiatrics, cancer and malaria patience to augment and replace vitamin B_2 that may have been inactivated or unavailable by the treatment given to them through drugs administration.

Results of the effect of processing on the phytochemical/ antinutrient composition of Cocoyam inflorescence is presented in Table 2. The phytochemicals in medicinal plants have been reported to be the active principles responsible for the pharma- cological potentials of medicinal plants.[12] The presence of these chemicals in Cocoyam inflorescence may have been its justification for the local use of the plant for the treatment of various ailments. The flavonoid content of the fresh sample was 114mg. This value was however lower than 6186mg flavonoid content reported by Olayede et al.[51] for raw struchium sparganophora leaves but higher than 78.13mg reported by Inyang and Ani[52] for unblanched leaf blended with water. There were significant ($p<0.05$) reduction in all the processed samples. Water blanching reduced flavonoid by 77.3%, unblanched dried by 78.5%, soaking by 87.6% and boiling by 78.9%. These significant ($p<0.05$) reductions of flavonoid could be due to leaching, activities of enzymes and the application of heat during processing. Mohdzainol et al.[53] reported similar reductions in flavonoid by wet thermal processing. Onyeka and Nwajo[54] reported similar reduction in flavonoid during blanching, soaking and boiling treatments while Schieber[55] and Zang and Hamauzu[56] reported 65-97% flavonoid, phenolics, ascorbic acid and antioxidant activity losses due to thermal processing. Boiled sample (oven dried) recorded 33.03mg as the highest value of flavonoid while soaked sample (sun dried) recorded 14.13mg as the least value of flavonoid content in all the processed sample. Oven drying recorded significant ($p<0.05$) increase in the flavonoid content than sun drying process due probably to increase in moisture loss.

Boiling (10min) and oven drying techniques showed the best treatment in terms of flavonoid retention in the processing of cocoyam inflorescence. Flavonoids are polyphenolic compounds that are biologically active against liver toxins, microorganisms, inflammation, tumor and free radicals.[57] Flavonoid can be added to food products and represents valuable resources and may act or terminate free radical chain reaction in biological system and therefore, may play important roles in alleviating risk in development of chronic disease. Flavonoids are very important for their ability to act as natural antioxidant in food.[58] They not only inhibit the autoxidation of lipids but also retard lipid oxidation by inhibiting lipoxygenase activity (Vinson et al., 1999). They act in vitro as scavenging of reactive oxygen species and electrophiles and as chelators of metal ions and therefore, be beneficial in vivo to reduce the risk of cardiovascular diseases and related disorders.[59,60] Vegetables and fruits are some of the major sources of flavonoids.[61] Cocoyam inflorescence by this result is a good source of flavonoid especially the fresh sample and hence has high anti oxidant potentials. Flavonoids have also been reported to inhibit the growth of cataracts in diabetic patients.[62] The high level of flavonoids in this inflorescence suggest that the plant may be used in the treatment of diabetes.

The total carotenoid content of fresh Cocoyam inflorescence was 586mg. This is much lower than 8772mg reported by Musa and Ogbadoyi[63] for fresh hibiscus sabdariffa but higher than 36 to 238mg reported by Lakshmininaravan et al.[64] for Indian vegetable. This level of carotenoid in the fresh sample could be attributed to it yellow and dark green coloration. The colour of Cocoyam inflorescence varied according to specie. The carotene content of the processed samples decreased significantly ($P<0.05$) to 32.75-35.22mg, 27.83-29.57mg, 13.63-20.03mg and 15.41-22.83mg for blanched, unblanched, soaked and boiled samples respectively. This significant decrease in the processed samples was attributed to leaching, enzyme activities and thermal destruction. Similar reduction was reported by Oboh[65] in blanched and dehydrated green leaves. Blanched sample showed the highest carotene (32.75-35.22mg) content while soaked samples had the least (13.63-20.03mg) carotene content. This is in agreement with the work of Negi and Roy[66] who reported that the carotene content of carots in blanched samples (29.16mg) was higher than the unblanched (23.38mg). Sun dried samples recorded lower value than the oven dried samples. Researchers established that carotenoids are destroyed by sun light.[67–71] It is estimated that only 20-40% of total carotenoids may be retained if Moringa leaves are dried under direct sun light. Carotenoids are among the food components most affected by environmental conditions. Sun light and higher ambient temperature promotes the biosynthesis of carotenoid thereby increasing the carotenoid levels during maturation but accelerates oxidative degradation once the cellular integrity is destroyed (Albinhn and Savage, 2001). Blanching (4min) and Oven drying seemed to be a better processing methods for the retention of carotenoid based on the results of this research. Cocoyam inflorescence should therefore be recommended as one of the vegetables with high carotene values and antioxidant potentials.

The phenol content of fresh Cocoyam inflorescence was 1.52mg.[72] The value was lower than 8.6% and 16.83% reported for raw struchium sparganophora and cashew nutshell. Guzmanz-maldonado[73] reported 0.3%, 0.1% and 0.2% for Corchorus olitorus, struchium sparganophora and varnonia amydalina. There were significant decrease ($p<0.05$) in the level of phenol content of the processed samples to less than 1mg. Blanched samples recorded the highest value (0.79-0.83mg) while unblanched sample and boiled sample recorded 0.36-0.74mg and 0.24-0.42mg. Soaked sample recorded 0.24-0.29mg as the least value of phenol content in cocoyam inflorescence. This significant ($p<0.05$) reduction was due to leaching and drying effect. Drying techniques had significant effect on the phenol level of the processed samples. Oven dried samples recorded lower values while sun dried had higher values and therefore seemed to be the best drying techniques in terms of phenolic compounds. The lower loss of phenol in sun dried could be attributed to the fact that the sun drying minimizes the degradation of heat sensitive compounds such as antioxidant phenol. Dehydration of plant material is performed at a low temperature thereby retaining heat sensitive compounds. In particular, the phenol content decreased by 79.6% and 87.5% for sun dried and oven dried respectively. Recent works also demonstrated that the temperature affects the stability of phenolic compounds in herbal infusion.[74] The significant decrease of the oven dried samples could be due to severity or higher temperature which degraded the heat sensitive phenolic compounds. Lim ad Murtijaya[75] revealed that the application of heat inactivates enzymes rapidly but they may simultaneously degrade heat sensitive phenolic compounds. Supplementation with food high in phenol or much consumption of Cocoyam inflorescence is advisable since phenol possesses antioxidant activity. Phenols have antioxidant capacities that are much stronger than those of vitamin C and E.

The alkaloid content of the fresh Cocoyam inflorescence was 32.87%. There were significant ($p<0.05$) decrease in the level of alkaloid content of all the processed samples. Blanched sun dried sample and unblanched oven dried sample recorded 1.38% and 1.17%. Soaked sample recorded 0.33-0.73% while boiled sample showed 0.13-0.51%. Omezi[76] repoted 2.6 and 2.8% for unblanched dried African spinach leaves and garden egg leaves. The significant ($p<0.05$) decrease in the alkaloid content of the processed samples was attributed to leaching and effect of heat application. It had

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been reported that alkaloids were developed in plants as defense mechanisms against predators to ensure the plants survival. Alkaloids have wound healing effect on the body of animals.[77] Consumption of more than 20mg of alkaloid causes fatal illnesses. The fresh and processed samples are safe for human consumption irrespective of the processing methods as used in this work. The level of alkaloid in the fresh Cocoyam inflorescence suggests that fresh Cocoyam inflorescence could impact wound healing effect and as well be a good source of treatment of ulcerations. This work therefore, support the traditionalist who claim to use both, the cocoyam stem and the inflorescence when they are roasted over the fire and place it on the injured part of the body or foot sour infected by earth worm or Jigger for a short time.

The steroid content of fresh Cocoyam inflorescence was 254.24mg. The steroid content of the processed samples reduced significantly ($p<0.05$). This could be due to leaching and effect of heat application. Blanched samples were at 2.37-4.44mg while the unblanched sample recorded 2.97-4.75mg. Soaked sample recorded 2.05-3.24mg while boiled samples had 2.98-4.72mg. It has been established that there was an increased losses of phytosterol during long time processing especially boiling/cooking, soaking and drying. According to National Cholesterol Education Programme's Adult treatment Panel III (ATP III), daily intakes of 2-3g per day of plant steroid/stanol esters will reduce low density lipoproteins (LDL) cholesterol by 6-15%.[78] It has been established that people with blood cholesterol should take cholesterol lowering medicine (statins) or addition of plant steroid to their diets. The fresh cocoyam inflorescence may be a good source of steroids tha the processed samples. Therefore, reasonable consumption of Cocoyam inflorescence would go a long way to reduce the LDL cholesterol. Cocoyam inflorescence may be good source of plant steroids. Plant steroids are essential components in plant membrane that resemble the chemical structures of cholesterol and carry out similar cellular structures in plants.[79] Steroids are present naturally in small quantites in many fruits, vegetables, nuts, seeds, cereals, legumes, vegetable oils and other plants.[80] Plants steroids have cholesterol lowering effects.[81] Food and beverages supplemented with plant steroids reduced cholesterol and intervenes at lowering heart diseases such as coronary heart disease (CHD). The cholesterol lowering effects of plant steroids is not limited to those with hyper cholesterolemia or CHD but also healthy persons with II diabetes, and postmenopausal women and cancer have also benefited from consuming plant steroid.[82]

The saponin content of fresh Cocoyam inflorescence was 85.72%. There were significant decreases in the saponin content of the processed samples. Soaked sample showed 11.87-15.83% as the least significant ($p<0.05$) reduction of saponin while the unblanched sample recorded 34-20-43.13% as the highest values of saponin among the processed samples. Blanched sample recorded 21.80-34.72% while boiled sample recorded 18.13-27.01%. This agreed with the work of Badifu and OKeke[83] who reported 2.19% and 10.18% for water blanched oven dried and unblanched oven dried vernonia amygdalina. This significant ($p<0.05$) reduction was due to leaching of saponin into the processing water. Sun dried samples reduced saponin significantly in all the treated samples than the oven dried samples. Nworgu et al.[84] reported that 1-5mins heat treatment (100°C) had no effect on the oxalate and saponin concentrations. The authors noticed that little time of heat application have no effect on saponin hence the bitterness of saponin can be reduced by soaking the leaves in cold water for longer time. Soaking in cold water with squeezing is commonly used to reduce drastically the concentration of saponin in vernonia amygdalina. Mbah et al.[85] recorded 0.33mg and 0.49mg for sun and oven dried Moringa oleifera at Nsukka. These authors revealed that sun dried had an age over other processing methods in reducing saponin content of Moringa leaves. Soaking and sun drying treatment reduced saponin effectively than blanching and boiling. Other processing methods seemed to still have a higher retention of saponin. Boiling, steaming, and otherwise cooking foods will not have much effect on saponin, however saponin is nontoxic.[86] Saponin has the ability to increase the body's levels of immune response. Saponin is used as a component of spermicides and vaccines.[87] Saponins are reported to inhibit the growth of benign and malignant tumours and are also reported to have anti-microbial and anti-viral properties. Saponin is an essential element in ensuring hormonal balance and synthesis of sex hormones.[88] The saponin content of Cocoyam inflorescence is considerably high. This could substantiates its use as a local spice and condiment especially for the nursing mothers in some tribes in Nigeria.

The Oxalate content of fresh cocoyam inflorescence was 36.07mg. This value is however, lower than 132mg reported by Imaobong et al.[89] for fresh *Gongronema latifolium*. Processing methods significantly ($p<0.05$) reduced the oxalate content of the processed samples by 48.1%, 45.4%, 77.3% and 75.3% for water blanched, unblanched dried, soaked and boiled samples. Blanched samples recorded 18.72- 20.51mg while the unblanched recorded 19.67-21.16mg.The boiled sample valued at 8.89-12.57mg while the soaked sample ranged between 8.17-15.49mg. The different drying techniques seemed to have no effect on the levels of oxalate. These values above were significantly ($p<0.05$) lower when compared with 105.60 and 52.80mg reported for blanched Ocimium canum and Gongronema latifoluim. Similarly, Ogbadoyi et al.[90–93] reported that various food processing methods reduce oxalate content in vegetables. This significant decrease could be attributed to leaching and the effect of heat. According to environmental health and safety, U.S.A, the lethal dose of oxalate is 15-30g. Both the fresh and the processed samples recorded lower values of oxalate bellow this lethal dose. Boiling and soaking retained the lowest value of oxalate in all the processed samples and therefore should be used as the best processing method to reduce oxalate to a barest minimum. The traditional method of soaking Cocoyam inflorescence in the hot water to reduce the oxalate content which is responsible for itching and scratching before cooking/boiling is recommendable. Moist heat is known to reduce the oxalate level of vegetables. Boiling for a long period of time reduces the Antinutrients compositions of vegetables. Kaayla[86] revealed that oxalate was not significantly neutralized by cooking. In this work it was observed that oxalate level was still high in the processed samples despite it significant reduction. It has been established that plant foods that contains above 2% level of soluble oxalate could cause toxicity in ruminants.[94] Furthermore, It has also been established that most spices contain oxalate in a high level. Therefore, Cocoyam inflorescence should be consumed in a smaller quantity at a time or used as spices which are usually added to the food in a small quantity. Apart from irritation, oxalates are indigestible compounds in foods that prevent the proper absorption of calcium. Duckworth[95] had reported that inorganic crystals, most commonly the oxalate are usually found in the tissues of fruits and vegetables which normally results to the formation of oxalate stones and vulvodynia. Consumption of vegetables or plants high in oxalate may lead to accumulation of oxalate in the body system and might be chronic after a long period of administration.

Phytate recorded 32.27mg in the fresh samples higher than all the processed sample. Unblanched samples recorded the highest values (19.55-23.57mg) among all the processed sample. This high level of

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phytate in the unblanched samples could be attributed to the absence of wet thermal processing from where some phytate could have leached out. Blanched samples recorded 3.81-4.12mg, soaked sample recorded 5.81-8.47mg while the boiled sample had 2.35-3.36mg. All the oven dried samples were significantly lower than the sun dried. Boiled sample recorded the least value of phytate content in the Cocoyam inflorescence. The significant reduction of phytate content in blanched, soaked and boiled sample could be due to leaching. These values of phytate were significantly lower when compared with the work of 11.37mg and 14.64mg for boiled and unblanched dried Moringa oleifera. Macrae et al.[77] reported that 5-10mg of phytate is needed to reduce the iron absorption by half. Boiling and oven drying treatmen could be effective in the reduction of phytate. Fresh Cocoyam inflorescence might be chronic in the body system, if not properly processed owing to it high level of antinutrients. Osagie[96] reported that toxicants such as oxalate, phytic acid and HCN can be reduced by processing methods such as cooking. Dunu et al.[97] reported that most of these toxicants are eliminated during processing and cooking.

The tannin content of the fresh Cocoyam inflorescence was 17.15mg. There was a significant ($p<0.05$) reduction in the processed samples which ranged from 0.29-4.04mg. Unblanched sun dried and oven dried samples recorded 4.04mg and 0.29mg tannin content. Blanched sample recorded 0.38-0.39mg, soaked sample 1.75-4.03mg and boiled sample recorded 0.30-0.32mg tannin content which is the least among all the processed samples. This significant reduction could be as a result of leaching of small fraction of hydrolysable phenolic compounds located in the cell walls of the Cocoyam inflorescence. Akanji et al.[98] reported that phytate and tannin contents of jack beans were partially affected by heat treatment. Similar reductions in tannins due to hot water blanching, soaking and boiling of vegetables were reported by Akanji et al.[98–100] reported a linear significant ($p<0.05$) decrease in the concentration of tannic acid with increase in the duration of cooking. Though all the processed samples seemed not to retain a higher level of tannin content but boiling would be the best processing method in reducing the tannin level of Cocoyam inflorescence. Singleton and Kratzer et al.[101,102] reported that higher intake of tannic acid has been associated with carcinogenic effects in man, poor protein utilization, liver and kidney toxicity. Tannins are bitter polyphenolic compounds that hasten the healing of wounds. They also possess anti-diuretic and antidiarrheal properties. Tannin has been reported to selectively inhibit HIV replication.[103] Cocyam inflorescemce may have potential in the treatment of viral disease. The significant amount of tannins in this leaves of Cocoyam inflorescence might be responsible for its use by the local herbalists to treat gastrointestinal disorders. More so, condensed tannins can inhibit herbivore digestion by binding to consumed proteins, thereby making it indigestible for animals. Its concentration in the leaves might be the reason why animals do not graze on the plant.

Fresh cocoyam inflorescence contains trace amount of hydrocyanic acid (HCN). Similarly 0.009% HCN for raw cashew nutshell while reported 0.006% and 0.02% for African spinach leaves and local garden eggs leaves. Blanched, unblanched and soaked dried samples significantly ($p<0.05$) recorded 0.019-0.055mg, 0.088-0.128mg and 0.001-0.012mg HCN respectively. The boiled samples recorded trace amount of HCN probably due to leaching. Oke[104] reported 0 and1.22mg of HCN for unblanched leaves of *C. olitorus* and boiled dried flour of Moringa leaves while 0.002% HCN content for soaked cashew nut shell. Unblanched dried samples recorded the highest value (0.088-0.128mg) of hydrogen cyanide among all the processed samples. The significant increase in the soaked, blanched and unblanched dried samples could be due to the concentration of soluble solids as a result of dehydration. Oven drying method reduced HCN content of the samples significantly ($p<0.05$) compared to sun drying method. The quantity of HCN in leaves varied with vegetable species and processing methods. Okaka et al.[105] reported that the safety of plants high in HCN can be assumed only if enough time is allowed during processing for the breakdown of the glycosides to bleachable or volatile cyanide compounds which thereafter must be leached by soaking, washing or volatilized by heating. Boiling and oven drying methods therefore seem to be the best methods of reducing HCN in cocoyam inflorescence. According to Taiwo et al.[106] the lethal dose of HCN range from 50-60mg per 65kg body weight for normal adult human. Okaka et al.[105] reported that consumption of large quantities of vegetable (10kg of cauliflower/day) would lead to thyroid enlargement. Other toxic effects of cyanogenic glucosides range from diarrhea to sever gastroenteritis often leading to death or chronic neurological disorders such as tropical ataxic neuroperthy (TAN).[107,108] The possibility of chronic toxicity arising from prolonged consumption of low levels of cyanogens has been inferred from epidemiological studies.[109] Generally, the level of HCN in the processed samples and the trace amount in the fresh sample depict that Cocoyam inflorescence is not a vegetable with high content of HCN and may therefore, be considered safe from cyanogenic glucoside toxicity.

Toxicological assays

Acute toxicity (LD_{50}) Within the first 10min after administering the cocoyam inflorescence extract, the animals that received all doses of soaked, boiled, blanched and unblanched samples were hyperactive. The animals that received blanched sample extract continued in hyperactivity throughout the 24 hours of the experiment. The animals that received fresh sample extract were hyperactive only within the first 10-15 min and thereafter slept for more than 7 hours. Following the 7 hour sleep the animals woke up to active behavior, expressing hunger till the termination of the experiment. Animals fed soaked, boiled and unblanched samples returned to normal active behavior after initial 10min. There was no record of death or sign of toxicity observed among all the treatment groups even those that received the highest single dose of 5000 mg/kg body weight within the 24 hours of the experiment. The observed behavior of the animals after administration of the samples to them shows that the samples are not toxic even at the highest level of 5000 mg/kg body weights. Consequently, the LD_{50} could not be estimated. Kennedy et al.[110] noted that substances whose LD_{50} is higher than 5000 mg/kg by oral route can be considered practically nontoxic. Lorke had also earlier stated that LD_{50} values greater than 5000 mg/kg are practically nontoxic. The sample is therefore considered safe. However, cocoyam inflorescence may have some chronic effect when administered over a long period especially the blanched samples if the duration and doses of administrations are not regulated. After the administration of the cocoyam inflorescence extract, all the rats exhibited decreased activity for the first 10 to 12 hours. Clinical symptoms like vomiting, diarrhea and anorexia were not observed in the rats during the period of the experiment. Each treatment group exhibited significant ($p<0.05$) body weight changes on the 10^{th} day relative to the initial weight.

Table 3 showed the preliminary qualitative phytochemical analysis of extract of fresh and processed cocoyam inflorescence. It was carried out to identify the secondary metabolites present in extracts of Cocoyam inflorescence. The present study showed that petroleum ether extract of Cocoyam inflorescence contained alkaloids, glycosides, flavonoids, phenols, resins, saponins, steroids, tannins, terpenoids,

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acidic compound, reducing sugar, oil, carbohydrates and proteins. All the sample treatment showed higher number of secondary metabolites with higher degree of precipitation (+++) mainly tannin, protein, glycosides and reducing sugar. This was followed by carbohydrate and oil that showed some moderate degree of precipitation in most treated samples. Acidic compound, saponin, alkaloids, terpenoids, steroids, resine and flavonoids were determined to be present in all the treated samples with low degree of precipitation (+). This reduction in these secondary metabolites could be as a result of leaching, activities of enzymes and probably heat application during processing. Onyeka and Nwajo[99] reported same while reported that various food processing methods reduce phytochemical content of vegetables. This significant (<0.05) increase in the protein content of the processed samples compared to the unprocessed samples could be due to moisture loss.[111] Theses secondary metabolites (Saponin, alkaloids, terpenoids, steroids, resine and flavonoids, glycosides and phenols) are reported to have many biological and therapeutic properties.[112–115] Therefore, Cocoyam inflorescence may have some health promoting properties as this research suggest.

Conclusion

The research showed that various food processing techniques, namely boiling, blanching, soaking, sun and oven drying led to varying losses of vitamins and nonnutrient phytochemicals as evident in their lower levels in the processed Cocoyam inflorescence. The losses notwithstanding, still left appreciable levels of vitamins and beneficial phytochemicals and the levels of these phytochemicals / anti-nutrients were low and would not pose threat to health. The appreciable levels of vitamis and health protecting phytochemicals in the processed Cocoyam inflorescence especially boiled (10min), soaked (20min) and oven dried samples suggest that Cocoyam inflorescence could be useful in the preparation of food spices and management of some chronic diseases. Cocoyam inflorescence is not toxic and therefore is safe for consumption and can as well be used as vegetable. However, cocoyam inflorescence may have some chronic effect when administered over a long period especially the blanched samples if the duration and doses of administrations are not regulated.

Acknowledgments

I wish to acknowledge the research and development center of Masters Energy industrial City Onuaku Uturu where part of this research work was carried out especially the president of Masters Energy Group; Dr. Uchechukwu Samson Ogah who formed the bed rock of this research.

Conflicts of interest

The authors declare that there are no conflicts of interests.

References

1. Yulia VB. Pharmacy in vegetables. 2009.
2. Kalu EO. Effects of boiling on anti-oxidan potential of Cocoyam [*Colocasia esculenta* (L.) Schott] Inflorescence. *Global Journal of Agricultural Research and Review*. 2018;6(1):1–6. A paper presented on 12th world Haematology and oncology congress. August 21-22, 2017 Barcelona, Spain.
3. Fasuyi AO. Nutritional potential of some tropical vegetable meal: chemical characterization and functional properties. *African Journal Biotechnology*. 2006;5(1):49–53
4. Grosvernor MB, Smolin LA. *Nutrition: from science to life*: New York: Harcourt College Publishers. 2002:288–371.
5. Akindahunsi AA, Salawu SO. Phytochemical screening, nutrient and anti-nutrient composition of selected tropical green leafy vegetables. *African J Biotechnol*. 2005;4(6):497−501.
6. Kalu EO, Ijeoma LPO, Eberechukwu AZ, et al. Nutritive and anti-nutritive evaluation of cocoyam (*Colocasia Esculenta* L. Schott) inflorescence. *Am J Food Sci Technol.* 2020;8(2):42−48.
7. Mulokozi G, Svanberg V. Effect of tradition open sun drying and solar cabinet drying on carotene content and vitamin A activity of green leafy vegetables. *Plant Foods Hum Nutr*. 2003;58(3):1−15.
8. Kalu EO, Jane A, Joel NC. Effects of differently processed cocoyam (*Colocasia esculenta* (L.) Schott) inflorescence on hematological and histopathological parameters of albino rats. *Indian Journal*. 2019;15(3):191−192.
9. Kalu EO Okocha Kalu, Ezegbe Clement. Effects of different processing methods on nutrient compositions of cocoyam [*Colocasia esculenta* (L.) Schott] inflorescence. *Int J App Sci Res.* 2021;4(4): 2581–7876.
10. Mello D. *Leguminous leaf meals in non-ruminant nutrition*. In: D Mello JPF, Devendra C. *In tropical legumes in animal nutrition*. 1st ed. Wallingford, UK: CAB international. 1995;247−280.
11. Lorke D. A new approach to acute toxicity testing. *Arch Toxical*. 1983;54:275−287.
12. Elgorashi EE, Van Staden J. Pharmacological screening of six Amaryllidaceae species. *J Ethnopharmacol*. 2004;90(1):27−32.
13. Obadoni BO, Ochuko PO. Phytochemical studies and comparative efficacy of the crude extracts of some homeostatic plants in Edo and Delta states of Nigeria. *Glob J Pure Appl Sci*. 2001;8:203–208.
14. Edeoga HO, Okwu DE, Mbabie BO. Phytochemical constituents of some Nigerian medicinal plants. *African J Biotechnol*. 2005;4(7):685−688.
15. Ejikeme CM, Ezeonu CS, Eboatu AN. Determination of physical and phytochemical constituents of some tropical timbers indigenous to Niger Delta Area of Nigeria. *European Scientific Journal*. 2014;10(18):247–270.
16. Boham BA, Kocipai AR. Flavonoids and condensed tannins from leaves of Hawaiian Vaccinium vaticulatum and V. calycinium. *Pacific Science*. 1994;48:458–463.
17. Amadi JBA, Agomuo EN, Ibegbulem CO. *Research Methods in Biochemistry*. Nigeria: Supreme Publishers. 2004.
18. Munro A, Bassir O. Oxalate in Nigerian vegetables. *West African Journal of Biological and Applied Chemistry*.1969;12(1):14–18.
19. Kimura M, Rodriguez Amaya DB. *Harvest plus handbook for carotenoids analysis*. Washington DC: International food policy research Institute. 2004:12–54.
20. Ball GFM. *Fat soluble vitamin assays in food analysis*. London. Elsevier. 1988.
21. Rahway NJ. Encyclopaedia of chemicals, drugs and biological. Merck Index. 11th ed. 1989.
22. Nkama I, Gbenyi DI. The effect of malting of millet and sorghum on the residual phytate and polyphenols in “Dakura” a Nigerian Cerial/Legumes snack food Nig. *J Tropl Agric*. 2011;3:270–271.
23. Sofowara A. Medicinal Plants and Traditional Medicine in Africa. Ibadan. Nigeria: Spectrum Books. 1993.
24. Harborne JB. Phytochemical Method; a guide to modern techniques of plan analysis. New York: Chapman and Hall. 1973.

25. Hikino H, Kiso Y, Wagner H, et al. Antihepatotoxic actions of flavonolignans from Silybum marianum fruits. *Planta Med*. 1984;50(3):248–250.

26. Bradbury MG, Egan S, Bradbury JH. Picrate paperkits for determination of total cyanogens in cassava roots and all forms of cyanogens in cassava products. *Journal of Science Food and Agriculture*. 1999;79:598–601.

27. Horwitz W. Official Methods of Analytical Chemistry of AOAC International: 17th ed. Maryland USA. 2000.

28. Baojun Xu, Sam KC, Chang. Effect of Soaking Boiling and Steaming on Total Phenolic Content and antioxidant Activities of Cool season Food Legumes. *Food Chemistry*. 2008;110:1–13.

29. Laura D'Evoli, Ginevra LB, Massimol Lucarini. Influence of heat treatments on carotenoid content of cherry tomatoes. *Foods*. 2013;2(3):352–363.

30. Oshodi AA. Comparison of proteins, minerals and vitamin C content of some dried leafy vegetables. *Pak J Sci Indust Res*. 1992;35:267–269.

31. Yadav SK, Sehgal A. Effect of home processing on ascorbic acid and beta-carotene content of spinach (*spinachia olercia*) and amaranth (*Amaranthus tricolor*) leaves. *Plant Foods Hum Nutr.* 1995;47(2):125–131.

32. Odukoya AO, Inya Agha, SI Segun, et al. Antioxidant activity of selected Nigeria green leafy vegetable. *Am J Food Technol*. 2007;2(3):169–175.

33. Nkafamiya II, Oseameahon SA, Modibbo UU, et al. Vitamins and effect of blanching on nutritional and anti-nutritional values of non-conventional leafy vegetables. *African Journal Food Science*. 2010;4(6):335–341.

34. Ejoh AR, Nkonga DV, Innocent G, et al. Effect of the method of processing and preservation on some quality parameters of three non-conventional leafy vegetables. *Pakistan Journal Nutrition*. 2007;6(2):128–133.

35. Oboh G. Effect of some post-harvest treatments on the nutritional properties of *Cnidosccolus acontifolus* leaf. *Pakistan Journal Nutrtion*. 2005;4(4):226–230.

36. Duke JA. *The Quest for Tolerant germplasm*. In: ASA special symposium 32, crop tolerance to sub-optimal land conditions. *Am Soc Agron*. 1983:1–61.

37. Gernah DI, Ajir E. Effect of wet heat treatment and cultivar type on some chemical properties of young cassava (*Maniholt esculenta*) leaves. *Journal sustainable Agric Environ*. 2007;9(2):153–163.

38. Addo AA. Ascorbic acid contents of food commonly consumed in the Northern states of Nigerian. *Nigerian Food Journal*. 1983;1:129–133.

39. Passmore, Eastwood MA. *Human nutrition and dietetics.* 8th ed. Churchill Livingstone. London, Edinburgh. 1986:15–363.

40. Kazakov SA, Astashkina TC, Mamaev SV, et al. Site specific cleavage of single-que sites by a copper-depenstranded DNA at unique sites by a copper-dependent redox reaction. *Nature*. 1988;335(6186):186–188.

41. Olson JA, Hodges RE. Recommended dietary intake (RDI) of vitamin C in humans. *Am J Clin Nutr.* 1987;45(4):693–703.

42. Fellows PJ. *Food Processing Technology*. Principles and practice. 2nd ed. Cambridge. England: *Wood head publishing limited*. 2000;233–246.

43. Badifu GIO, Akpapuman MA, Mgbemere VM. The fate of beta-carotene in processed leaves of fluted pumpkin (*Telfairia occidentalis* Hook-F): a popular vegetable in Nigeria diet. *Plant Foods Hum Nutr*. 1995;48(2):141–147.

44. Iwuoha EI, Kalu FA. Calcium oxalate and physicochemical properties of cocoyam (*Colocasis esculenta* and *Xanthosoma saggitifolium*) tuber flours as affected by processing. *Food chemistry.* 1995;54(1):61–66.

45. Osum FI, Okonkwo TM, Okafor GI. Effect of processing method on the chemical composition of Vitex doniana leaf and leaf products. *Food Sci Nutr*. 2013;1(3):241–245.

46. Ottaway PB. *The technology of vitamins in food.* 1993.

47. Food and Nutrition Board. Dietary reference intakes for Vitamin C, Vitamin E, selenium and carotenoids. Washington DC. USA: National Academy Press. 2000.

48. AOAC. Official method of analysis of association of analytical chemist, 17th ed. Washington DC. USA. 2010.

49. FNB. Dietary reference intakes for Calcium, Phosphorus, Magnesium, Vitamin D and Fluoride. Washington DC. USA: National Academy Press. 1998.

50. Dutta P. Disturbances in glutathione metabolism and resistance to malaria: current understanding and new concepts. *Journal Soc Pharm Chem*. 1993;2:11–48.

51. Cimino JA, Jhangian S, Schwartz E. Riboflavin metabolism in the hypothyroid human adult. *Proc Soc Exp Biol Med.* 1987;184(2):151–153.

52. Pinto JT, Huang YP, Rivlin RS. Mechanisms underlying the differential effects of ethanol upon the bioavailability of riboflavin and flavin adenin dinucleotide. *J Clinical Invest*. 1987;79(5):1343–1348.

53. Olayede FM, Obuotor EM, Olayede FA. Effect of processing on chemical composition of *struchium sparganophora* (Linn.) Ktze. *Journal Agric Veterinary Science*. 2014;1(1):33–37.

54. Inyang UE, Ani JC. Effect of traditional processing methods on the nutrients and phytochemical contents in *Lasianthera africana* leaf residue. *Int J Curr Res Biosci Plant Biol.* 2015;2(5):101–107.

55. Mohdzainol MK, Abdul Hamid, Abu Bakar, et al. Effect of different drying method on the degradation of selected flavonoids in *centtella asiatica*. *Int Food Res J*. 2009;16:531–537.

56. Onyeka EU, Nwajo AC. Phytochemical, nutrient and anti-nutrient contents of *Cnidoscolus oconitifolius*, a lesser known green leafy vegetable. *Nigerian Food Journal*. 2010;26(2):14–24.

57. Scheber A, Keller P, Carle R. Determination of phenolic acids and flavonoids of apple and pear by high-performance liquid chromatography. *J Chromatogr A*. 2001;910(2):265–273.

58. Zhang DL, Hamauzu Y. Phenolics, ascorbic acid, carotenoids and antioxidant activity of broccoli and their changes during conventional and microwave cooking. *Food Chemistry*. 2004;88(4):503–509.

59. Okwu DE. Phytochemicals and vitamin content of indigenous spices of South eastern Nigeria. *J Sustain Agric Environ.* 2004;6(1):30–37.

60. Vinson JA, Jang J, Yang J, et al. Vitamins and especially flavonoids in common beverages are powerful In-vitro antioxidants which enrich lower density lipoproteins and increase their oxidative resistance after ex-vivo spiking in human plasma. *J Agric Food Chem*. 1999;47(7):2502–2504.

61. Hollman PCH. Evidence for health benefits of plant phenols: local or systemic effects? *Journal of Science of Food and Agriculture* 2001;81(9):842–852.

62. Pietta PG. Flavonoids as antioxidants. *J Nat Prod*. 2000;63(7):1035–1042.

63. Amic D, Davidovic Amic, D Beslo, et al. Structure-radical scavenging activity relationship of flavonoids. *Croatia Chemical Acta*. 2003;76(1):66–61.

64. Okwu DE, Omodamiro DO. Effect of hexane extract and phytochemical content of *Xylopia aethiopica* and *Ocimum gratissimum* on uterus of guinea pig. *Biol Res.* 2005;3(2):40–44.

Copyright: ©2023 Okechukwu et al.

65. Musa A, Ogbadoyi EO. Effect of processing methods on some micronutrients, antinutrients and toxic substances in *Hibiscus Sabdoriffa*. *Asian Journal of Biochemistry*. 2012;7(2):63–79.

66. Lakshmininaravan TP, Raju M, Krishnakantha TP, et al. Determination of major carotenoids in few media leafy vegetables by high performance liquid chromatography. *J Agric Food Chem*. 2005;53(8):2838–2842.

67. Oboh G, Ekperigin MM, Kazeem MI. Nutritional and haemolytic property of eggplants (*solanum macrocarpon*) leaves. *J Food Composition Anal*. 2005;18(2):153–160.

68. Negi PS, Roy SK. Retention of quality characteristics of dehydrated green leaves during storage. *Plant Foods Hum Nutr*. 2011;56(3):285–295.

69. Devadas RR, Premakumari S, Subramania G. Biological availability of beta-carotene from fresh and dried green leafy vegetables on preschool children. *Indian Journal Nutrition*. 1978;15:335–340.

70. Eskin NAM. *Plant pigment, flavours and textimes*. The chemistry and biochemistry of selected compounds. *Academic Press*. 1979;52–65.

71. Goodwin TW. *The biochemistry of caroteneoids*. 2nd ed. London: Chapman and Hall. 1980;40–60.

72. Onayemi O, Badifu GIO. Effect of blanching and drying methods on the nutritional and sensory quality of leafy vegetables. *Plant Foods Hum Nutr*. 1987;37(4):291–298.

73. Albinhn PBE, Savage GP. The effect of cooking on the location concentration of Oxalate in three cultivars of New Zealand grown ocra (*Oxalis tuberose Mol*). *J Science Food and Agriculture*. 2001;61(10):1027–1033.

74. Muller HG. *An introduction to tropical food science*. Cambridge University Press. 1988;59–64.

75. Guzman MS, Paredes LO. Functional products of plant indigenous to Latin America.s *Technomic Publishing*. 1988;351–360.

76. Riehle P, Vollmer M, Rohns S. Phenolic compounds in *citus incanus* herbal infusions during brewing process. *Food Res Int*. 2013;53(3):891–899.

77. Lim YY, Multijaya J. Antioxidant properties of *phyllantus amarus* extracts as affected by different drying methods. *Food Sci Technol*. 2007;40(9):1664–1669.

78. Omezi IM. Evaluation of Africa spinach (*Amarantus hybridus*) and local Garden egg (*Solanum macrocarpon*) leaves as sources of Nutraceuticals. MSc thesis Department of Food Science and Technology University of Nigeria Nsukka. 2009.

79. Macrae R, Robinson RK, Sadler MJ. *Encylopedia of food science, food technology and nutrition.* Academic Press.1993;6:3584–3623.

80. NCEP. National cholesterol education programm (NCEP). Export panel on Detection, Evaluation, and treatment of high blood cholesterol in adult (Adult treatment panel III). Final report. *Circulation*. 2002;106(25):3143–421

81. Awad AB, Flink CS. Phytosterol as anticancer dietary components: evidence and mechanism of action. *J Nutr*. 2000;130(9):2127–2130.

82. Piironen V, Toivo J, Puupponen PR, et al. Plant sterols in vegetables, fruits and berries. *J Sci Food Agric*. 2003;83(4):330–337.

83. Cater NB, Grundy SM. Lowering serum cholesterol with plant sterols and stanol: historical perspectives. *J Postgrad Med.* 1998;83(12):6–14.

84. Lau VWY, Journoud M, Jones PJH. Plant sterols are efficacious in lowering plasma LDL and non-HDL cholesterol in hyporcholesterolamic type 2 diabetic and nondiabetic persons. *Am J Clin Nutr.* 2005;81(6):1351–1358.

85. Badifu GIO, Okeke EM. Effect of blanching on oxalate, hydrocyanic acid and saponin content of four Nigeria leafy vegetables. *J Agric Sci Technol.* 1992;2(1):71–75.

86. Nworgu FC, Ekemezie AAO, Ladele AO, et al. Performance of broiler chickens served heat-treated fluted pumpkin (*Telfaria occidentalis*) leaves extract supplement. *Afric J Biotechnol.* 2007;6(6):818–825.

87. Mbah BO, Eme PE, Paul AE. Effect of drying techniques on the proximate and other nutrient composition of *Moringa Oleifera* leaves from two areas in Eastern Nigeria. *Pakistan Journal Nutrition*. 2012;11(11):1044–1048.

88. Kaayla TDE. Plants bite back: the surprising, all- natural anti-nutrients and toxins in plant foods. 2010.

89. Sidhu GS, Oakenfull DG. A mechanism for the hypocholesterolemic activity of saponins. *Br J Nutr.* 1986;55(3):643–649.

90. Okwu DE. The potentials of *Ocimum gratissimum*, *Penrgularia extensa* and *Tetrapleura tetraptera* as spice and flavoring agents. *Nig Agric J*. 2003;34:143–148.

91. Imaobong IV, Roland UE, Efiok JU. Effect of thermal processing on anti-nutrients in common edible green leafy vegetables in Ikot Abasi, Nigeria. *Pakistan Journal Nutrition.* 2013;12(2):162–167.

92. Ogbadoyi EO, Makun HA, Bamigbade RO, et al. The effect of processing and preservation methods on the oxalate levels of some Nigerian leafy vegetables. *Biokimistri*. 2006;18(2):121–125.

93. Adeboye AS, Babajide JM. Effect of processing methods on anti-nutrients in selected leaf. *Nigerian Food Journal*. 2007;25(2): 77–87.

94. Virginia P, Swati V, Sushma, et al. Effect of looking and processing methods on oxalate content of green leafy vegetables and pulses. *Asian J Food Agric Ind*. 2012;5(04):311–314.

95. Musa A, Ogbadoyi EO. Effect of processing methods on some Micronutrients, Antinutrients and toxic substances in *Hibiscus Sabdoriffa*. *Asian J Biochem*. 2012;7(2):63–79.

96. Mckeuzie RA, Bell MA, Stone GJ, et al. Acute oxalate poisoning of sheep by Buffel grass (*cenchrus ciharis*). *Aust Vet J*. 2005;65(1):26-26.

97. Duckworth RB. *Fruits and vegetables*: California. Pergamom Press. 1996;5–7.

98. Osagie AU. Nutritional quality of plant foods. Post-harvest research unit, Department of Biochemistry, University of Benin, Benin City. 1998.

99. Dunu DJ, Eka OU, Ifon ET, et al. Chemical evalution of the nutritive value of fruit of calabash plants (*Lagenaria scierania*). *Niger J Sci*. 1986;20(2):47–50.

100. Akanji MA, Ologbobo AD, Emole IA, et al. The effect of processing on hemagglutinin and other anti-nutritional factors in jackbean (*Canavalia ensiformis*). *Plant Foods Hum Nutr*.1990;40(3):207–14.

101. Onyeka EU, Nwambaekwe IO. Phytochemical profile of some green leafy vegetables in Southeast Nigeria. *Niger Food J*. 2007;25(1):67–76.

102. Bawa GS, Tegbe TSB, Ogundipe SO, et al. The effect of duration of cooking lablab seeds on the level of some anti-nutritional factors. *Journal of Biological Sciences*. 2007;7(3):562–565.

103. Singleton VL, Kratzar FH. Toxicity and related physiological activity of phenolic substances of plant origin. *J Agric Food Chem.* 1969;17(3):497–501.

104. Singleton VL, Rossi JA. Colorimetry of total phenolics with phosphomolydic phosphotunstic acid reagents. *Am J Enol Vitic*. 1965;16(3):144–158.

105. Kashiwada Y, Huang L, Kilkuskie RE, et al. New hexahydroxydiphenyl derivatives as potent inhibitors of HIV replication in H9 lymphocytes. *Bioorganic Medicinal Chemistry Letters*. 1992;2(3):235–238.

106. Oke OL. Chemical studies on the more commonly used leafy vegetables in Nigeria. *J West Afric Sci Assoc*. 1965;11:42–48.

107. Okaka JC, Akobundu ENT, Okaka ANO. *Human nutrition, an integrated approach*. Ocjanco academic publishers. 2002;357–375.

Citation: Okechukwu KE, Sampson Ogah U. Phytochemical, vitamins and toxic level of processed cocoyam (colocasia esculenta (L.) schott) inflorescence. *MOJ Food Process Technol.* 2023;11(2):116–128. DOI: 10.15406/mojfpt.2023.11.00289

108. Taiwo KA, Irefin IA, Ilorin MO. Integration of modern technologies in traditional food processing in Nigeria. *Food Rev Int*. 1997;36(4):611–621.

109. Osuntokun BO. Aladetoyinbo A, Adeiya AOG. Free cyanide levels in tropical ataxic neuropathy. *Lancet*. 1970;2(7668):372–373.

110. Oke OL. Toxicity: cyanogenic glycosides. *Food Chemistry*. 1980;6(2):97–109.

111. Osuntokun BO. Cassava diet and chronic cyanide intoxication and neuropathy in Nigeria Africans. *World Rev Nutr Diet*. 1981;36:141–173.

112. Kennedy GL, Ferenz RK, Burgess BA. Estimation of acute oral toxicity in rats by determination of the approximate lethal dose rather than the LD50. *J Appl Toxicol.* 1986;6(3):145–148.

113. Ihekoronye AI, Ngoddy PO. *Integrated food science and technology for the tropics.* Macmillan publishers. 1985;44(4):82–83.

114. Vishnu R, Nisha R, Jamuna S, et al. Quantification of total phenolics and flavonoides and evaluation of in vitro antioxidant properties of methanolic leaf extract of *Tarenna asiatica* – an endemic medicinal plant species of Maruthamali hills, Western Ghats, Tami Nadu. *J Res Plant Sci.* 2013;2(2):196–204.

115. Benedec D, Vlase L, Oniga I, et al. Polyphenolic composition, antioxidant and antibacterial activities for two Romanian subspecies of Achillea distans Waldst. Et Kit. Ex Wid. *Molecules*. 2013;18(8):8725–8739.

116. Charalampos P, Konstantina L, Olga KM, et al. Antioxidant capacity of selected plant extracts and their essential oils. *Antioxidants*. 2013;2(1):11–22.

117. Narender PD, Ganga R, Sambasiva E, et al. Quantification of phytochemical constituent and in vitro antioxidant activity of Mesua ferrea leaves. *Asian Pac J Trop Biomed*. 2012;2(2):S539–S542.

Citation: Okechukwu KE, Sampson Ogah U. Phytochemical, vitamins and toxic level of processed cocoyam (colocasia esculenta (L.) schott) inflorescence. *MOJ Food Process Technol.* 2023;11(2):116–128. DOI: 10.15406/mojfpt.2023.11.00289