Effects of different processing methods on nutrient compositions of Cocoyam (Colocasia esculenta (L.) Schott) Inflorescence

[1] Kalu Emmanuel Okechukwu*, [2] Okocha Kalu Sunday and [2] Ezegbe Clement Chinedum

[1] Department of Agriculture, Gregory University, Uturu, Nigeria.
[2] Department of Food Science and Technology Nnamdi Azikiwe University Awka Anambra state Nigeria.

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Abstract: Cocoyam inflorescence was processed by blanching (water), soaking at 100°c (for 20mins), Boiling (for10mins) and drying (oven and sun drying). Unprocessed (fresh) samples served as the control. Samples were analysed for proximate and mineral composition. All the analysis was determined, using standard *analytical* method. Processing methods had significant ($p<0.05$) effect on the proximate and mineral composition of cocoyam inflorescence. Oven and Sun drying increased the proximate composition significantly ($p <0.05$). Fresh Cocoyam inflorescence contain 2.83% ash, 1.17% fibre, 1.78% fat , 3.10% protein and 19.84% carbohydrate. Boiled samples showed the highest ash content (9.40-9.80%). Blanched samples showed the highest fat content (3.59%) while unblanched dried samples had the highest fibre (8.62-9.19%) and protein (6.56-7.50%) contents. The mineral contents (mg/100g) of the fresh sample were (1.14), (4.80), (60.70), (0.003), (22.92) and (18.13%) for Ca, Mg, Zn, Fe, Na and I. Boiling reduced Ca content ($p <0.05$) by 7.89%. Soaking reduced Mg content ($p <0.05$) by 73.8% while boiling reduced Mg content by 73.9%. Water blanched sample showed Fe content of 1.91mg/100g ($p <0.05$). Blanching reduced iodine content from 18.13 to 0.64%. These results revealed that fresh Cocoyam inflorescence contains appreciable amount of minerals and nutrients. Different processing methods caused significant ($p<0.05$) reduction in minerals, and increased the proximate composition of Cocoyam inflorescence. Boiling with oven drying showed higher nutrient values.

Keywords: Cocoyam Inflorescence, minerals, processing, proximate, nutrient.

INTRODUCTION

Vegetables serve as indispensable constituent of the human diet, supplying the body with minerals, vitamins and certain hormone precursors, in addition to protein and energy (Aletor and Adeogun, 1995). Green leafy vegetables (wiled or cultivated) are important items of diet in many Nigerian home as valuable sources of nutrients especially in rural areas where they contributes substancially to micronutrients which are usually in short supply in most diet. Leaves in general are important sources of Iron, potassium, calcium, magnesium, zinc, provitamine A, Thiamine, Riboflavin, ascorbic acid and folic acid (Uwaegbute, 1989; Fasuyi, 2006). High consumption of green leafy vegetable plays vital role in human nutrition. Plant foods have traditionally been viewed as a source of nutrients provision for normal growth and development (Inyang and Ani, 2015). The poor state of economy in the developing countries has made consumption of high protein foods out of reach of more than 65-70% of the people (Nworgu et al., 2006). One of the ways of solving this problem is to use unconventional sources of protein such as leaf protein to supplement the diet of man and farm animals. Leafy vegetables are high in moisture content and this makes them susceptible to deterioration, spoilage and as well low in energy (calories). Leaves, seeds and flowers of vegetables can be eaten either as fresh vegetable or herb and spices. There nutrient volume is based mainly on their richness in minerals and vitamins (Chima and Igyor, 2007).

Cocoyam inflorescence is one of the edible flowers being consumed in the southern parts of Nigeria to cook a special meal or delicacy (Okechukwu et al., 2019 and Kalu et al., 2020). In some other parts of the world, it can be used in dressing salad, making drinks, Jellies, syrups and main dishes. Cocoyam inflorescence is usually surrounded by stem leaves of the corm (Okechukwu et al., 2019). The colour 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 (Okechukwu et al., 2019 and Kalu et al., 2020). Cocoyam inflorescence is an edible flower (Okechukwu et al., 2019 and Kalu et al., 2020). Cocoyam inflorescence can be cooked as vegetable, dried and milled and used as spices (Okechukwu et al., 2019 and Kalu et al., 2020). Cocoyam inflorescence is locally called different names by the igbo tribes in south/easthern parts of Nigeria as "Akpuru ede" (Ebonyi state), "Opere" (Nsukka in Enugu State), "Efuru ede" (Mbano in Imo state), "Ogbala ede" (Anambra state), 'Opi ede' (Abia/Anambra state), 'Orim ede' (Ezeagu in Enugu state) and'Umi ede' (Uturu in Abia stete) (Kalu et al., 2020).Onwueme et al. (1994) reported that the leafy parts of Cocoyam have high protein content that is highly degradable and suggested that the leafy parts of Cocoyam should be soaked, washed, cooked or even dried before consumption or feeding them to livestock. Among all the species, only NC_{E005} (Nigerian *Colocasia esculenta*) is commonly consumed in the southern parts of Nigeria and has the highest yield during their season (Okechukwu et al., 2019 and Kalu et al., 2020). This research is only restricted to NC_{E005} species of cocoyam inflorescence.

It is believed that the presence of some antinutritional compounds plant vegetables limit the utilization of some of these vegetables that could be beneficial to the body system. Many food processing techniques have been highlighted as possible means of reducing or totally eliminate the Antinutrients levels in plant food sources to low levels that can be tolorable by humans and animal especially in monogastric nutrition (Fasuyi and Aletor, 2005). Furthermore, processing improves the utilization of protein and energy in vegetables. Further investigation of these and other past studies showed that there is no information on the effects of processing (particularly blanching, boiling, soaking and the use of drying techniques) on the nutrient compositions of Cocoyam inflorescence. Therefore, the purpose of this research is to determine the effects of different processing methods on the nutrient composition of Cocoyam inflorescence of the specie NCe_{005}.

MATERIALS AND METHODS

Sources of Materials

Fresh samples of Cocoyam (Colocasia esculenta (L.) schott inflorescence NCe_{005} used for this study were identified and procured from Cocoyam section of National Root crop Research Institute (NRCR) Umudike, Abia State Nigeria.

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;

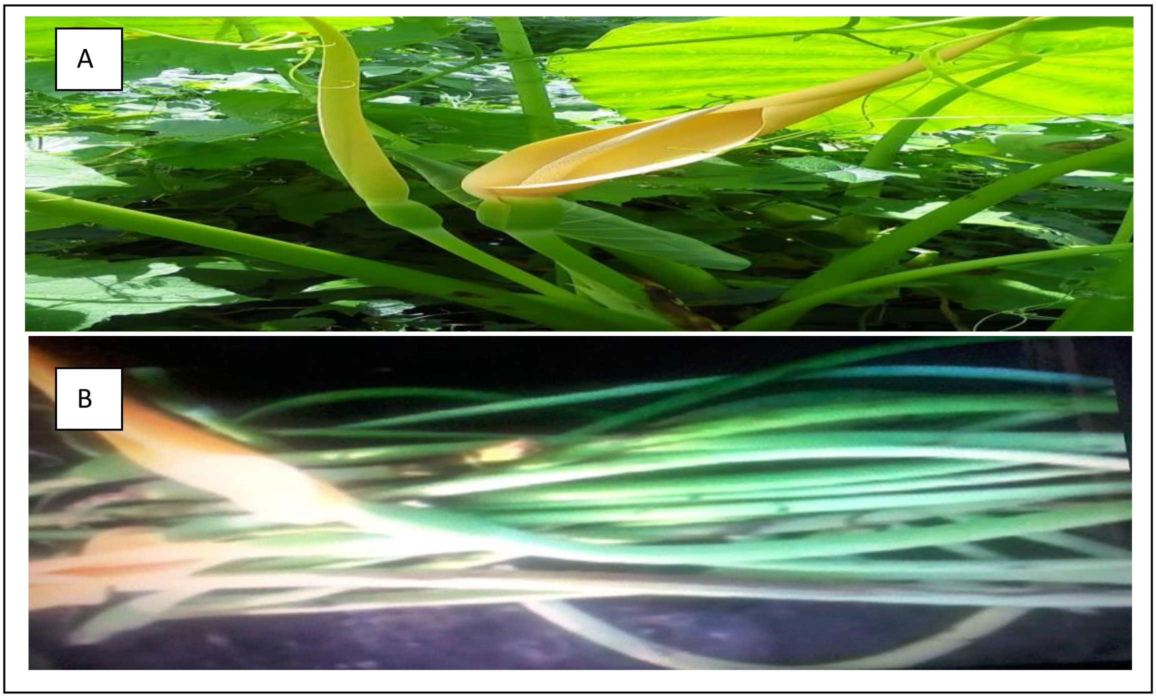

Fig.1: (A) Cocoyam inflorescence in the farm, (B) Harvested cocoyam inflorescence from the farm

1. The first portion (fresh 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, and was then used for analysis.
2. The second portion was blanched in hot water (98% for 4mins). The time for adequate blanching of the inflorescence was determined as described by Luh and O�Neal (1992). This blanched sample was divided into two equal parts each. One portion was oven dried at 70cC for 7 hours to a constant weight while the second portion was sun dried for a period of four days. The dried samples were milled using kenwood blender-BL300/BL350series. They were packaged in a plastic container and stored in a refrigerator (100C) until used for analysis.
3. The third portion was dried (unblanched dried) in two forms. One portion (1kg) was oven dried at 700C for 7 hours to a constant weight while the other portion (1kg) was sun dried for a period of four days. All the samples were milled as previously described and packaged in a plastic container and stored in a refrigerator until used for analysis.
4. The fourth portion was soaked in hot water (1000C) for 20 minutes. The sample was soaked in a water bath to maintain the constant temperature of the water. The sample was allowed to air dry after which, it was divided into two equal part each and one portion was oven dried at 700C for 7 hours while the other was sun dried for a period of four days. All the samples were milled and stored as described above until used for analysis.
5. The fifth portion was boiled at 1000C for 10 minutes and allowed to cool and air dried. The boiled samples were divided into two equal parts. One portion was oven dried at 650C for 10 hours. The other portion was sun dried for a period of five days. All the dried samples were milled and stored as previously described above until used for analysis.

Analysis

Proximate composition of all the samples was determined using standard methods (AOAC, 2010).

Calcium, magnesium, sodium, potassium, phosphorus, copper, manganese, iron and zinc were obtained when 1g of the sample was ashed in a furnace at 5500C for 3hrs. The ash was dissolved in 10MHCl (hydrochloric acid) in a conical flask and filtered into a 10ml flat bottomed standard flask and made up to the mark with distilled water. These individual minerals were measured from the solution using Atomic Absorption spectrophotometer (AAS) (UNICAM model 939 United Kingdom). Iodine was determined by the method of Muir and Lambert (1973).

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 multiple range test as described by Klaus and Oscar (2005). Results were expressed as Mean ± SD (standard deviation) of triplicate determination. The data analysis was aided by SPSS version 20.

RESULTS AND DISCUSSION

The proximate composition of fresh, boiled, soaked, blanched and unblanched Cocoyam inflorescence is presented in table1. There was significant ($p<0.05$) increase in almost all the nutrients in the dried leaf compared to the fresh sample. This could be due to reduction in the moisture content of the samples which in turn increased the concentrations of the nutrients thus showing apparent increase in protein, ash, fat, carbohydrate and fibre. This agreed with the report of Gernah and Sengev (2011) for Moringa oleifera leaf, Virginia et al. (2012) and Osum et al. (2013).

Fresh sample showed 70.33% moisture content. This moisture content reduced ($p<0.05$) to (5.71-6.82%), (6.65-7.62%), (4.40-7.80%) and (6.83-7.20%) in the blanched, unblanched, soaked and boiled samples. Oven dried soaked sample had the least moisture content (4.40%) than all the processed samples. These reductions were also similar to 6.55 and 5.13% for sun and oven dried Moringa oleifera leaf reported by Mbah et al. (2012). This reduction in moisture content was due to dehydration. This value is below 15% recorded by Antia et al. (2013) as the critical factor for the post harvest management of herbs. According to Holdsmorth (1983), this 15% moisture content or below on a dry weight bases is required to prevent bacterial growth.

The ash content of fresh Cocoyam inflorescence was 2.83%. This value compared well with 3.28%, 2.52% and 2.2% ash content reported by Osum et al. (2013), Gernah and sengev (2011) and Mepba et al. (2007) for raw Uchakoro leaf, Moringa oleifera and Amranthus hybridus.The boiled sample (oven dried) recorded the highest value of ash content (9.80%) while unblanched sample (sun dried) had the least 5.20%) ash content. Blanched and soaked samples showed 8.90 and 6.63% ash content. This increase could be due to the concentration of the minerals.

The fibre content of the fresh sample was very low (1.17%). The value was similar to 1.3% and 1.85% fibre content reported by Mepba et al. (2007) and Osum et al. (2013) for raw cocoyam leaf and Uchakoro leaf. The fibre content of blanched, soaked and boiled samples were 7.01-7.73, 6.63-7.91 and 8.1-8.74% respectively while unblanched sample showed 8.62-9.19% fibre content significantly as the highest value. These values are below the work of Gernah and Sengev who recorded 19.32% of dried Moringa oleifera. This general increase in the fibre content could be due to the concentration of soluble solids as a result of dehydration. Crude fibre does not contribute nutrients to the body, it adds bulk to food thus facilitate bowel movements (peristalsis) and preventing many gastrointestinal diseases in man (Gordon, 1999).

The fat content of the processed samples increased significantly ($P<0.05$) from 1.78% (fresh)-3.59 (blanched oven dried), 2.39 (unblanched sundried), 2.43 (soaked sundried) and 1.79% (boiled oven dried). These values are similar to 1.2% and 1.8% recorded by Okafor (1995) for dried milled leaves of Gnetun africanum and fluted pumpkin leaves. There was a significant ($p<0.05$) reduction in the fat content of the boiled sun dried (1.48%) and the blanched (1.20%) due to leaching of the fat into the processing water. Okafor (1995) and Gernah and Sengev(2011) similarly observed that blanching and other thermal processing had variable effects on dry matter composition with significant reduction in lipids, crude fibre, total ash and carbohydrate contents but had no effect on the protein content of the vegetables. The significant ($p<0.05$) increase in soaked and blanched oven dried sample could be due to concentration of dry matters (Garrow and James, 1998). Generally, the fat contents of the Cocoyam inflorescence both the fresh and the processed is low when compared to other vegetables. The low fat content showed that the product will not easily go rancid during the storage especially when processed into powdered form and therefore might be shelf stable. According to Ajayi and Oneyemi 1977, a diet providing 1-2% of fat is said to be suitable for human consumption as excess fat consumption is implicated in other cardioverscular disorders such as athoroschlerosis, cancer and again.

The protein content of the fresh sample was 3.10%. This value was similar to 4.3, 3.8 and 3.1% reported by Mepba et al. (2007) for Amranthus hybridus, Basella alba and Colocasia esculenta respectively. Ihekoronye and Ngoddy (1985) noted that proteins in raw leafy vegetables are usually low, but they have high biological value. The protein content of blanched, unblanched, soaked and boiled samples were 4.01-4.42, 6.56-7.50, 4.30-4.90 and 5.12-6.16% respectively. This general increase in the protein content might be due to moisture loss (Osum et al.,2013 and Ihekoronye and Ngoddy 1985). Blanched and soaked samples recorded low level of proteins than unblanched and boiled samples. Osum et al. (2013) also reported that blanching reduced the protein content due to leaching. Proteins are essential constituents of all body tissues, which help the body to produce new tissues. Adequate consumption of Cocoyam inflorescence might contribute to protein needs.

The carbohydrate content of the fresh sample was 19.84%. The value indicates that Cocoyam inflorescence is not a good source of carbohydrate. Plant vegetables are known to have low levels of carbohydrate. The carbohydrate content increased significantly ($p<0.05$) to 71.06, 69.61, 78.89 and 68.70% in blanched, unblanched, soaked and boiled samples. These values are similar to 58.08% and 64.22% recorded by Osum et al. (2013) and Mbah et al. (2012) for dried Uchakoro leaf and Moringa oleifera leaf. Boiling recorded the least of carbohydrate (66.50%). This significant decrease of carbohydrate in the boiled sample could be as a result of gelatinization of starch which migrate into the boiling water. Duckworth (1966) noted that heating starch grains lost their crystalinity and become gelatinized, going into solution in the cell sap. Carbohydrate provides heat and energy for all forms of body activity. Deficiency can cause the body to divert proteins and body fact to produce needed energy, thus leading to depletion of body tissues. The recommended dietary allowance (RDA) of carbohydrate values for people within 4 years or older, eaten about 2000 calories per day is 300g (Nestle, 2002). Cocoyam inflorescence is not a good source of carbohydrates.

Oven dried samples seemed to have an age over sun dried samples. Albinhn and savage (2001) noted that traditional sun drying which is the cheapest and most accessible means of food preservation in poor countries causes considerable destruction of nutrients and bioactive compounds. The results revealed the superiority of instrumental drying method (oven) against the traditional method.

Table 1: Effect of Processing methods on Proximate Composition of Cocoyam Inflorescence

Samples/Processing methods	Moisture (%)	ASH (%)	Fibre (%)	FAT (%)	Protein (%)	CHO (%)
water blanched oven dry	$5.71^{b} \pm 0.00$	$9.40^{f} \pm 0.00$	$7.73^{c} \pm 0.01$	$3.59^{e} \pm 0.02$	$4.42^{b} \pm 0.01$	$69.54^{c} \pm 0.00$
water blanched sun dry	$6.82^{c} \pm 0.00$	$8.90^{e} \pm 0.00$	$7.01^{c} \pm 0.01$	$1.20^{a} \pm 0.00$	$4.01^{b} \pm 0.23$	$71.06^{d} \pm 0.01$
Unblanched oven dry	$6.65^{c} \pm 0.01$	$5.70^{c} \pm 0.00$	$9.19^{e} \pm 0.01$	$1.79^{c} \pm 0.01$	$7.50^{f} \pm 0.08$	$69.17^{c} \pm 0.01$
Unblanched sun dry	$7.62^{d} \pm 0.00$	$5.20^{b} \pm 0.00$	$8.62^{d} \pm 0.04$	$2.39^{d} \pm 0.00$	$6.56^{e} \pm 0.01$	$69.61^{c} \pm 0.00$
Soaked (20mins) oven dry	$4.40^{a} \pm 0.43$	$6.71^{d} \pm 0.43$	$7.91^{c} \pm 0.43$	$2.31^{d} \pm 0.40$	$4.90^{c} \pm 0.00$	$78.89^{e} \pm 0.43$
Soaked (20mins) sun dry	$7.80^{d} \pm 0.45$	$6.63^{d} \pm 0.45$	$6.83^{b} \pm 0.45$	$2.43^{e} \pm 0.45$	$4.30^{b} \pm 0.07$	$75.20^{e} \pm 0.45$
Boiled(10mins) oven dry	$6.83^{c} \pm 0.38$	$9.80^{g} \pm 0.38$	$8.74^{d} \pm 0.38$	$1.79^{c} \pm 0.38$	$6.16^{e} \pm 0.03$	$66.50^{b} \pm 0.38$
Boiled (10mins) sun dry	$7.20^{d} \pm 0.41$	$9.40^{f} \pm 0.41$	$8.10^{d} \pm 0.41$	$1.48^{b} \pm 0.41$	$5.12^{d} \pm 0.65$	$68.70^{b} \pm 0.41$
Fresh sample(control)	$70.33^{e} \pm 0.45$	$2.83^{a} \pm 0.39$	$1.2^{a} \pm 0.39$	$1.78^{c} \pm 0.39$	$3.1^{a} \pm 0.12$	$19.84^{a} \pm 0.11$

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

Table 2 Present the results of the effects of boiling, soaking, blanching and drying techniques on the mineral composition of Cocoyam inflorescence. The results showed that the mineral content of all the processed samples were significantly ($p<0.05$) lower than that of fresh sample except Iron and copper that appreciated significantly ($p<0.05$) in all the treated samples. The significant ($p<0.05$) reduction in the minerals might be due to leaching during blanching, soaking and boiling. Ani et al. (2015) reported similar trend.

Calcium content of the fresh cocoyam inflorescence was 1.14mg. This value is similar to 1.6mg reported by Mepba et al. (2007) for raw slippery vine leaves. Ca content in the processed samples reduced significantly ($p<0.05$) to 0.88, 0.56, 1.06 and 1.05mg for blanched (sun dried), unblanched (oven dried), soaked and boiled (sun dried) samples. Similar reductions were reported by Alvi et al. (2003), Ebuehi et al. (2005), Ejorh et al. (2007) and Sobowale et al. (2010) for boiled, blanched and oven dried leafy vegetables consumed in Nigeria. Unblanched dried sample had the least level of calcium content (0.56mg) while blanched sample recorded the highest value (1.19mg). This could be as a result of residual antinutrients especially oxalate present in the samples which may have formed calcium oxalate (Reddy and Love, 2014). According to shills and young (1988), a food with good source of calcium must contain calcium greater than 0.5mg. This result shows that cocoyam inflorescence might be a good source of calcium food since both the processed and the fresh samples were above the recommendation. Albinhn and savage (2001) noted that minerals are generally not sensitive to heat during processing but are susceptible to leaching into the processing or cooking water. Albinhn and savage (2001) further reported that more than 50% of cobalt, zinc and manganese may be lost if the liquid is not consumed and that losses in magnesium, iron, copper, phosphorus, zinc, calcium and manganese during the cooking of pasta maybe as great as 86.5-100%. Calcium intake is very essential during childhood growing years. Deficiency can cause ricklets, bone pain and muscle weakness. Its high content in inflorescence vegetables such as Cocoyam inflorescence is expected. Much of these vegetable should be consumed where calcium is needed especially to meet up with the 20-25% RDA (Wardlaw and Kessel, 2002).

The magnesium content of the fresh cocoyam inflorescence was 4.8mg. Mepba et al. (2007) reported Mg content of 3.6mg and 0.7mg for fresh Telfaria occidentalis (Ugu) and Cocoyam leaf respectively. This value reduced significally ($p<0.05$) in processed samples. Unblanched sun dried recorded the highest value (1.59mg) of magnesium content followed by the boiled oven dried sample (1.54mg) while blanched (sun fried) had the lowest value (0.77mg). This significant reduction could be due probably to excessive leaching and application of heat which induced the chlorophyll and caused drastic removal of the magnesium. All the values recorded for magnesium in both processed and fresh samples were lower when compared with the recommended dietary allowance (RDA) of 320mg/dy for adult women and 430mg/day for adult men (Barbara and Robert 2001). Magnesium occurs abundantly in chloroplasts as a constituent of chlorophyll molecule. Inflorescence or plant flowers contain low level of chlorophyll because photosynthesis only takes place in the leaves of plants rather than the flowers. Therefore, low level of Mg in cocoyam inflorescence should be expected. Unblanched sun dried and boiled oven dried are suggested as the best processing method for magnesium retention.

The Manganese content of fresh sample was 5.49mg (Table 2). Antia et al. (2009) reported manganese content of fresh Ipomoea batatas to be 4.46mg. This value reduced significantly ($p< 0.05$) in blanched, soaked, boiled and unblanched dried with boiled sample showing the highest value (1.32mg) while blanched, unblanched and soaked sample recorded 0.55-0.99, 0.77-0.89 and0.29-0.69mg. The significant reduction in Mn content was due to leaching. Food and Nutrition Board (2001) placed the recommendation between 0.003mg-2.6mg/day for all ages including the pregnant and lactating women. The manganese content of both fresh and processed Cocoyam inflorescence is therefore adequate for all ages and is hereby recommended as a good source of manganese. Boiling (10min) and water blanching seemed to retain manganese adequately. This low level of manganese requirement made it difficult to induce or identify manganese deficiencies in humans and this considered it not nutritional concern (Barbara and Robert, 2001). Manganese is essential nutrient to humans especially as enzyme activator and to be a constituent of metalloenzyme (Leach and Harris, 1997). Different drying techniques may not have serious effect on the manganese content of the sample.

Zinc content of the fresh sample was 60.70mg. This value is higher than 27.98mg reported by Kalu (2009) for fresh Telfaria occidentalis leaf. This value reduced significantly ($p<0.05$) in the processed samples. The significant ($p<0.05$) decrease of Zn was due to leaching (Mepba et al., 2007 and Kawashima and Valente Soares, 2005). Unblanched dried sample recorded 8.02-8.24mg Zn content followed by the boiled sample (6.54-7.45mg) as the highest value in all the processed samples. Zinc content of 4.58-5.77mg and 1.67-1.74mg was recorded in blanched and soaked samples. Rajeswari (2010) similarly reported that the zinc content of the unblanched amaranthus (11.06mg) was higher than that of blanched (7.48mg) and also that the unblanched Shepu (4.42mg) higher than blanched shepu (2.61mg). Reddy and Love (2014) further noted that the bioavailability of minerals such as iron, zinc and calcium is known to be significantly affected by fibre, phytic acid and tannin content of foods. Oven dried samples recording significant increase in all the processed sample than the sun dried probably due to excessive loss of moisture. The RDA of Zn is 1mg/day for men and 8mg/day for women based on the negative effect of zinc (Hambidge et al. 1986). This result showed that both fresh and processed forms of Cocoyam inflorescence are good sources of zinc. Unblanched drying (either sun or oven) and boiling (10min) methods should be the best method of Zinc retention when processing cocoyam inflorescence. Zinc deficiency in developing countries is becoming a growing concern because it has been shown that zinc deficiency is related to decrease growth (dwarfism), alopesia, diarrhea, mental disturbances and also increased morbidity (Huffman, 1998). Studies have shown zinc supplementation to be effective in reducing the morbidity associated with infections in infants and children, possibly improving immune function. Therefore adequate consumption of dry milled Cocoyam inflorescence or incorporation of Cocoyam inflorescence flour into the wining foods for children would go a long way to circumvent diarrhea and constipation that are common in children and infant especially in developing countries.

The iron content of the fresh sample was 0.003mg. The iron content increased significantly in blanched, unblanched dried, soaked and boiled samples respectively (Table 2). The iron content of processed Cocoyam inflorescence significantly ($p<0.05$) increased in Blanched sample (1.91mg), boiled sample (1.12mg), soaked sample (0.40-0.70mg) and the unblanched dried sample (0.35-0.71mng). This significant increase in the processed samples could be due to concentration of minerals as a result of loss of moisture. The values are in agreement with 1.15mg and 0.73mg for oven and sun dried Moringa oleifera from Nsukka and 0.37mg and 0.39mg for oven and sun dried Moringa oleifera from Anambra state of Nigeria reported by Mbah et al. (2012). These values are also below 5.36mg boiled moringa oleifera reported by Gernah and Sengev (2011). The different processing and drying techniques seemed to affect the iron levels of vegetable. These results showed that blanching, soaking, boiling and dehydration improved iron content of the leaves. Mepba et al. (2007) reported that vegetables are generally poor sources of iron. Boiling seemed to be a better processing method for the retention of iron in Cocoyam inflorescence. The iron content of this inflorescence of both fresh and processed is lower compared to the recommended dietary allowance (RDA) of 5.00-9.00mg (WHO, 2001). However, neither the total iron content nor the nutrient density of the individual food, constitute an accurate guide for choosing dietary source of iron. Rather the bioavailability of iron present in a meal, which depends on its form and the presence or absence of factors that influence absorption and the body's need for iron ultimately, determining how much iron that is actually delivered to the body (Mepba et al., 2007). Iron is a vital content of red cells, which carry oxygen. It assists the muscles to keep reservoirs of oxygen and makes the body more resistance to infections. Iron deficiency can cause anaemia, tiredness; head ache insomnia and heart palpitations. The values of iron in this Cocoyam inflorescence suggest that it is not a good source of iron and therefore, more samples especially the processed should be consumed at a large quality to meet up with this recommended dietary allowance.

Copper. The copper content of the fresh sample was 0.04mg. There were significant ($p<0.05$) increase in the values of copper in the processed samples. Water blanched samples showed the highest level of Cu which ranged from 0.57 to 2.26mg. Boiled samples ranged from 0.68 to 0.79mg. Unblanched sample (0.89-91mg) and soaked (0.84-0.90mg) Table 2. These values were higher than 0.098mg of copper reported by Marian and Cosmos (2010) for curry leaf powder. The blanched dried sample showed higher Cu content than the unblanched dried sample (Table 3). Rajeswari (2010) reported similar results for fenugreek leaf. This significant increase in the copper content of the processed sample could be due to loss of moisture which had increased the concentration of the minerals. Heat processing is known to release the nutrients that are lorked up in the vegetables during processing. Trace elements are usually needed by the body in a minute quantity. The recommended dietary allowance (RDA) for copper for adult males and females is 0.9mg/day, 1mg for pregnant women, and1.3mg for lactating women (FNB, 2001). Therefore, the copper (Cu) levels in the samples are within the allowable limit and may not be harmful to the body system.

Sodium content of fresh cocoyam inflorescence was 22.92mg. The sodium content of blanched sample recorded 5.12-7.69mg, unblanched sample 4.02-5.36mg, boiled samples 6.35-7.34mg and the least is the soaked sample 2.74-3.79mg. Musa and Ogbadoyi (2012) reported 3.68mg and 3.17m sodium content for hibiscus sabdariffa boiled for 5 and 10mins, Mepba et al. (2007) reported 3.6mg, 2.5mg and 3.6mg for sun dried amaranthus, lycopersicon esculenta and fluted pumpkin while Osum et al. (2013) reported 1.25 and0.94mg for unblanched and blanched oven dried Uchakoro leaf. This significant reduction in the processed samples generally could be due to leaching during processing. Soaked sample recorded the least significant reduction while blanching and boiling showed the highest values of sodium content in all the processed samples. The RDA for sodium placed it at 2mg to prevent calcium loss through urine since higher intake can contribute to hypertension in some people (Wardlaw and Kessel, 2002). The reduction in the sodium content of Cocoyam inflorescence is recommendable. Soaked sample reduced sodium to a safe level and therefore, should be the best method in retaining content in vegetables during processing as this work suggest. Soaked Cocoyam inflorescence is suitable for use in sodium restricted diets.

Potassium (K) content of the fresh sample was 152.43mg. This value is lower than 280.32mg of K content reported by Gernah and Sengev (2011) for fresh Moringa oleifera leaf. Processing decreased the K content of cocoyam inflorescence significantly ($p<0.05$) to 62.77mg for blanched sun dried, 75.32mg for unblanched oven dried, 67.29mg for soaked sun dried sample and 60.49mg for boiled sun dried sample. These values of K are similar to 70.43mg for blanched Lasianthera Africana leaf reported by Ani et al. (2015), 55.99mg for dried hibiscus sabdariffa reported by Musa and Ogbadoyi (2012) but lower than 132mg of K content for dried Moringa oleifera reported by Gernah and Sengev (2011). This decrease was attributed to leaching. Inyang and Ani (2015), Oboh (2005), Alvi et al. (2003), Bakr and Gawish (1997) noted similar decreases in K content of vegetables during processing. Various conventional food processing techniques (blanching, boiling cooking) cause a significant decrease in the mineral content of the vegetables (Oboh, 2005). Different drying techniques had no effect on the levels of the K content of the Cocoyam inflorescence. Minerals are not volatile neither would it evaporise. In his finding, Chweya and Mnzava (1997) showed that mineral elements in vegetables were not significantly affected by sun drying the vegetable. Sun drying is a mere gradual evaporation which does not involve leaching. The level of K in these samples (fresh and processed) appeared low when compared with the recommended dietary allowance (RDA) of 2000mg/day for adult (Corazzi et al., 1989) potassium is a primary electrolyte and major cation inside the cell and low blood K is a life threatening problem (Wardlaw and Kessel,2002). Deficiency can cause vomiting, acute muscle weakness and loss of appetite. Fresh and processed Cocoyam inflorescence is a good source of potassium and therefore increase in the consumption of Cocoyam inflorescence would meet the dietary need of potassium. Boiling showed better K content in cocoyam inflorescence.

Phosphorus content of the fresh samples was as low as 1.60% significantly higher than the processed samples which were less than 1%. Mepba et al. (2007) reported 0.5mg and 0.7mg phosphorus content for sun dried amaranthus and Cocoyam leaves. Ocheja et al. (2013) and Nworgu et al. (2006) reported 0.016% and 0.40% for soaked cashew nut and dried Telfairia occidentalis. The different processing methods adopted in this work, did not have significant effect on the Phosphorus content as well as the drying techniques. The recommended dietary allowance for phosphorus in adult placed it at 700mg (Barbara and Robert, 2001). The significant ($p<0.05$) decrease of K in the samples could be due to leaching. Efficient absorption and wide availability in foods makes phosphorus a much less important mineral than calcium (FNB, 2007). Deficiency can lead to loss of appetite, weakness, bone pain and mental confusion. Phosphorus deficiency is rare since it is present in many foods (Olusola, 2006).

This result showed that Cocoyam inflorescence is not an adequate source of phosphorus.

The iodine content of the fresh sample was 18.13%. Blanching, drying, soaking and boiling reduced the iodine content of cocoyam inflorescence significantly ($p<0.05$) to trace for soaked sample, 0.64% for blanched sun dried sample, 1.27% for unblanched sun dried sample and 1.28% for boiled oven dried sample. This drastic reduction was due to excessive leaching. Boiled sample (1.16-1.28%) recorded the highest value among the entire processed sample followed by unblanched sun dried sample. Unblanched oven dried samples and blanched oven dried samples showed trace values of iodine. Oven drying caused severe loss of iodine. Sun drying showed higher retention of iodine over oven drying. Therefore, to retain reasonable quantity iodine, short processing period should be adopted. Boiling (10mins) showed the highest iodine retention. The recommended dietary allowance of iodine is 150μg (1.5mg)/day for adults (Barbara and Robert, 2001). Cocoyam inflorescence might be a good source of iodine. The deficiency of iodine leads to preventable mental retardation and most common cause of goiter worldwide especially in mountain regions. Iodine is an essential mineral needed for the formation of thyroid hormone in the thyroid gland. Iodine is also needed to block various toxins from binding to and accumulating in the thyroid gland. Free iodine is in high concentration in the ovaries and breast tissue, acting as a protective buffer to estrogen (Barbara and Robert, 2001).

Table 2 a: Effect of Processing methods on Mineral Composition of Cocoyam Inflorescence

Samples /Processing Methods	Ca^{++} (mg/100g)	Mg^{++} (mg/100g)	Mn^{++} (mg/100g)	Zn^{++} (mg/100g)	Fe^{++} (mg/100g)
water blanched oven dry	1.19±0.00 ^{f}	1.20±0.02 ^{c}	0.99±0.02 ^{f}	5.77±0.02 ^{d}	1.91±0.02 ^{g}
water blanched sun dry	0.88±0.01 ^{c}	0.77±0.00 ^{a}	0.55±0.00 ^{b}	4.58±0.11 ^{c}	0.52±0.00 ^{d}
Unblanched oven dry	0.56±0.01 ^{a}	1.06±0.01 ^{b}	0.77±0.01 ^{d}	8.02±0.54 ^{g}	0.35±0.01 ^{b}
Unblanched sun dry	0.65±0.01 ^{b}	1.59±0.01 ^{f}	0.89±0.00 ^{e}	8.24±0.15 ^{h}	0.71±0.05 ^{e}
Soaked (20mins) oven dry	1.06±0.30 ^{d}	1.34±0.00 ^{d}	0.69±0.01 ^{c}	1.74±0.00 ^{b}	0.70±0.13 ^{e}
Soaked(20mins) sun dry	1.06±0.51 ^{d}	1.26±0.05 ^{d}	0.29±0.05 ^{a}	1.67±0.05 ^{a}	0.40±0.16 ^{c}
Boiled (10mins) oven dry	1.07±0.01 ^{d}	1.54±0.00 ^{e}	1.32±0.00 ^{g}	7.45±0.00 ^{f}	1.12±0.11 ^{f}
Boiled(10mins) sun dry	1.05±0.02 ^{d}	1.25±0.00 ^{d}	0.77±0.01 ^{d}	6.54±0.00 ^{e}	1.12±0.15 ^{f}
Fresh sample (control)	1.14±0.01 ^{e}	4.80±0.00 ^{g}	5.49±0.00 ^{h}	60.70±0.0 ^{i}	0.003±0.0 ^{a}

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

Table 2 b: Effect of Processing methods on Mineral Composition of Cocoyam Inflorescence

Samples /Processing Methods	Cu++ (mg/100g)	Na++ (mg/100g)	K+ (mg/100g)	P(%)	I++ (%)
water blanched oven dry	2.26±0.10[h]	7.69±0.12[h]	69.04±0.02[d]	0.23±0.02[b]	TRACE
water blanched sun dry	0.57±0.11[b]	5.12±0.00[d]	62.77±0.11[b]	0.21±0.00[a]	0.64±0.50[a]
Unblanched oven dry	0.89±0.15[f]	4.02±0.01[c]	75.32±0.01[e]	0.33±0.01[d]	TRACE
Unblanched sun dry	0.91±0.00[g]	5.36±0.11[e]	81.59±0.10[f]	0.38±0.04[f]	1.27±0.45[b]
Soaked (20mins) oven dry	0.90±0.15[g]	3.79±0.00[b]	75.32±0.00[e]	0.36±0.00[e]	TRACE
Soaked(20mins) sun dry	0.84±0.05[e]	2.74±0.05[a]	67.29±0.50[c]	0.40±0.05[h]	TRACE
Boiled (10mins) oven dry	0.79±0.00[d]	7.34±0.00[g]	81.59±0.00[f]	0.27±0.00[c]	1.28±0.21[b]
Boiled(10mins) sun dry	0.68±0.00[c]	6.35±0.10[f]	60.49±0.00[a]	0.21±0.01[a]	1.16±0.70[c]
Fresh sample (control)	0.04±0.00[a]	22.92±0.10[i]	152.43±0.1[g]	1.60±0.10[g]	18.13±0.05[d]

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

CONCLUSION

The research showed that various food processing techniques, namely boiling, blanching soaking, sun and oven drying would significantly reduced the nutrient and mineral contents of Cocoyam inflorescence. However, boiling and soaking treatment lowered the nutrient contents when compared with other methods. Therefore, all the food processing techniques used had negative effect on the nutrients and minerals of Cocoyam inflorescence vegetable but boiling (10mins) and soaking (20mins) treatments were the best methods to retain some nutrients and mineral content in Cocoyam inflorescence. The better of the two drying techniques that would give Cocoyam inflorescence with enhanced nutritional value and safety from natural toxicants is oven drying techniques. Both sun and oven dried samples of the inflorescence can be milled into flour and stored in translucent or plastic containers. Sun dried method can serve as alternative drying techniques where oven drying is unavailable but with longer period of cooking.

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