COMPARATIVE NUTRITIONAL ASSESSMENT OF TWO VARIETIES OF COCOYAM (*COLOCASIA ESCULENTA* AND *XANTHOSOMA SAGITTIFOLIUM*) GROWN IN BAYELSA STATE, NIGERIA

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Abstract

The proximate, mineral composition, vitamins and antinutrient content of two varieties of Cocoyam (*Colocasia esculenta* and *Xanthosoma sagittifolium*) grown in Bayelsa State, Nigeria, was investigated using standard analytical methods with a view of ascertaining nutritional and health promoting values and possibly dispel the myth associated with its cultivation and consumption. Proximate analysis indicated that *C. esculenta* had significantly greater ($p<0.05$) contents of moisture, lipid and ash content while the *X. sagittifolium* had statistically higher ($p<0.05$) values of carbohydrate, protein and fibre. The macro-mineral contents of both varieties are in the order of $Ca > Mg > Na > K$, the micro-minerals are in the order $Fe > Cu > Zn > Mn$. The vitamins concentration trend is $ascorbic\ acid > retinol > niacin > riboflavin > thiamin$. The trend for the antinutrients is $oxalate > phytate > cyanide$. The *X. sagittifolium* had statistically higher ($p<0.05$) concentration of mineral content, vitamins, caloric value and antinutrients compared to the *C. esculenta*. The dietary aspersion and myth associated with Cocoyam consumption should be discouraged owing to the fact that the nutritional value of Cocoyam is far over that of other major root and tuber staples of tropical developing countries, particularly with respect to their protein digestibility, mineral composition and vitamins.

Keywords: Cocoyam, caloric value, mineral, proximate composition, nutrients

Introduction

Malnutrition is a major challenge to the growth and development of most developing countries in Africa, Nigeria not an exception, it is the primary cause of one-third of childhood death in the continent (Bain *et al.*, 2013). Malnutrition may not necessarily be caused by poverty but sometimes largely by dietary myths (Perceptions or beliefs about food and nutrition that are ill supported or disputed by scientific proof). One major staple food whose consumption has been relegated to the background as a result of dietary myths and taboos is Cocoyam.

Cocoyam is an herbaceous perennial plant which belong to the family Araceae, Africa is the major producer with Nigeria producing the largest quantity of about 5,068,000 metric tons annually and accounting for about 37% of World total production (Okoye *et al.*, 2009). The two most cultivated genera in Bayelsa State are *Colocasia esculenta* and *Xanthosoma sagittifolium*. Although all parts of the cocoyam (cormels, petioles, leaves, and inflorescence) are edible (Boakye *et al.*, 2018), they are not consumed in the raw state because of its acridity, but rather eaten after heat treatment in the forms of boiling, frying, baking, and roasting, it is sometimes pounded into a dough called *fufu* and eaten with soup, it is also used as soup thickener in most traditional cuisines (Ejoh *et al.*, 2013).

Cocoyam produce its cormel in an average of 3 months and can be harvested separately as each mature or they can be left until they all mature in about 7-9 months, thus making it a substitute to the expensive tubers, also in Nigeria most staples are rich in carbohydrate but deficient in most other micro and macro-nutrients, studies have shown that cocoyam is superior in nutritional values when compared to other major tuber staples with reference to protein digestibility and mineral composition (Lim, 2016), thus cocoyam should be seen as a key contributor to food security in Nigeria

Over the years, there have been a gradual decline in Cocoyam production (Onyeka, 2014), it is ranked third after yam and cassava, and this decline may be attributed to the food myth associated with it, it is also seen as food for the poor and low income earners, these beliefs are largely due to paucity of information on the nutritional potentials inherent in cocoyam, this study is therefore aimed at evaluating the nutritional and anti-nutritional properties of the two species of cocoyam (*C. esculenta* and *X. sagittifolium*) cultivated in Otuoke, Bayelsa State.

Materials and Methods

Plant collection

The fresh tubers of *C. esculenta* and *X. sagittifolium* were collected at it natural growing habitat (farm) in Otuoke, Bayelsa State. They were identified and authenticated at the Department of Plant Science and Biotechnology, University of Portharcourt, Rivers State. Voucher specimen number was prepared and deposited in the herbarium of the same Department with voucher no. UPH/P/1289 for *X. sagittifolium* and UPH/P/1290 for *C. esculenta*

Sample preparation

Separately the fresh tubers of *C. esculenta* and *X. sagittifolium* were hand peeled with a kitchen knife, washed in distilled water, diced with a knife into a dimension of about 2 mm × 2 mm. 500 g (wet weight of peeled tubers). A portion each of *C. esculenta* and *X. sagittifolium* was separately cooked by boiling in about 3L of distilled water for 25 min and then air-dried for about 20 min. while the other portion was left uncooked. The cooked and the uncooked samples of both *C. esculenta* and *X. sagittifolium* were further dried in an oven at 60°C to constant weights. The dried samples were separately milled using an electric blender (Kenwood-BL 440, Japan), kept in well-labeled air-tight containers and stored in the refrigerator prior to analyses.

Chemicals and Reagents

All chemicals and reagents used are of analytical grade

Experimental

Proximate Analysis

The moisture, carbohydrate, ash, crude lipid, crude protein (N×6.25) and crude fibre contents of both *C. esculenta* and *X. sagittifolium* were assayed for according to the standard method of the Association of Official Analytical Chemists

(AOAC 1986). The caloric value of both samples was calculated using Atwater factor method [(4×crude protein) + (9×crude lipid) + (4×carbohydrate)] as described by Lewu *et al.* (2010) and Kpomah *et al.* (2018).

Quantitative Mineral Analysis

The mineral content were assayed by adopting the method of Lewu *et al*, (2010). A mixture of concentrated H_2SO_4, selenium (as catalyst), salicylic acid and hydrogen peroxide were used for sample digestion, and thereafter, the calcium, magnesium, sodium, Potassium, zinc, copper, iron and manganese in the digests were determined using an atomic absorption spectrophotometer (Varian SpectrAA 220), the concentrations of Mg, Ca, Cu, Mn, Zn, Fe, K, and Na were calculated by reading their absorbance's at 285.2, 422.7, 324.8, 279.5, 213.9, 248.3, 766.5, 589.0 nm respectively. The total phosphorus was determined using the ascorbic acid blue colour procedure of Lewu *et al*. (2010) by reading the absorbance at a wavelength of 880 nm on a UV-vis spectrophotometer (FullTech-UV3000).

Quantitative Vitamin Determination

Retinol (vitamin A) and Ascorbic acid (vitamin C) were determined by spectrophotometric method as described by Rutkowski et al. (2006). Riboflavin (vitamin B2) was determined by fluorimetric method as described by Zandomeneghi et al. (2007), thiamine (vitamin B1) was determined flourimetric technique as described by Yu et al. (2015) and niacin (vitamin B3) was assayed for by colorimetric method as described by Nwanisobi and Egbuna (2015).

Determination of Antinutrients

Determination of cyanide content

Cyanide content was determined by the method of Williams and Wang (1980) as described by Nwokoro et al. (2009). 5g of the powdered sample was weighed into a 100mL beaker and 5mL of distilled water was added to make the powder into paste, the paste was then dissolved in 50mL of distilled water in a conical flask and corked, this was allowed to stand overnight to extract the cyanide, this was then filtered. 1 mL of the extract was placed in a test tube and 4mL of alkaline picrate reagent was then added and corked, this was placed in a water bath and incubated for 5mins. The colour tuned from yellow to reddish brown and the colour intensity read on a spectrophotometer at 490nm.

Oxalate determination

The determination of oxalate was done by method described by Oke (1966) as modified by Adeniyi et al. (2008). 2 g of the sample was digested with 10 mL 6M HCl for 1hr and made up to 250 mL in a volumetric flask. The pH of the filtrate was adjusted with conc. NH_4OH solution until the colour of solution changed from pink to a faint yellow. Thereafter, the filtrate was treated with 10 mL of 5% $CaCl_2$ solution to precipitate the insoluble oxalate. The suspension was then centrifuged at 2500 rpm, after which the supernatant was decanted and precipitate completely dissolved in 10 mL of 20% (v/v) H_2SO_4. The total filtrate resulting from the dissolution in H_2SO_4 is made up to 300 mL. An aliquot of 125 mL of the filtrate was heated until near boiling point and then titrated against 0.05 M of standardized $KMnO_4$ solution to a faint pink colour which persisted for about 30s after which the burette reading was taken. The oxalate content was finally evaluated from the titre value using stoichiometric formula.

Determination of Phytate

Phytate content was estimated by method Harland et al. (1988), 0.5mL of the extract was placed in a test tube with a cap, 1mL of ferric solution was added and capped, the tube was dipped into a water bath for 30mins and cooled in ice for 15mins, the tube was allowed to adjust to room temperature. The content of the tube was then well mixed and in a centrifuge and spined for 30mins at 3000g. 1mL of the supernatant was transferred into another tube and 1.5mL of bipyridine solution was added and allowed to stand for 10mins and the absorbance read at 519nm

Statistical Analysis

The results obtained were expressed as mean ± standard deviation for triplicate (3) determinations. Mean differences between the two varieties of Cocoyam were compared using student's t-test. The data were analyzed using SPSS version 16 for windows (IBM Corp, USA). $p<0.05$ was set as the level of significance. The charts were plotted using Graphpad Prism 8.

Results:

Proximate composition of *C. esculenta* and *X. sagittifolium* quantitatively indicated the presence of the major food classes as presented in fig.1.0

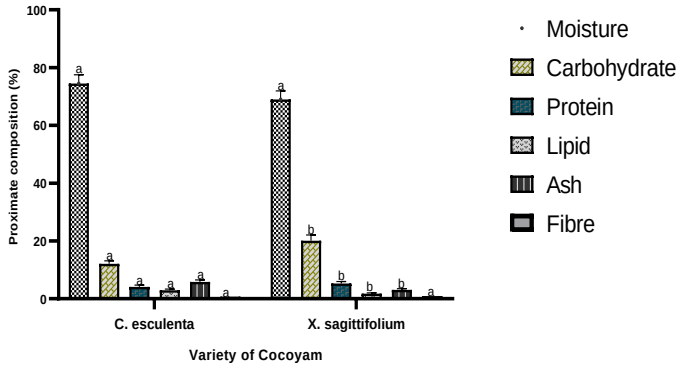

Fig. 1.0A: Proximate composition of *C. esculenta* and *X. sagittifolium*. The results are expressed as mean ± standard deviation for triplicate (3) determinations. Identical bars representing same parameter but with different superscript letters on the error bars are significantly different ($p<0.05$).

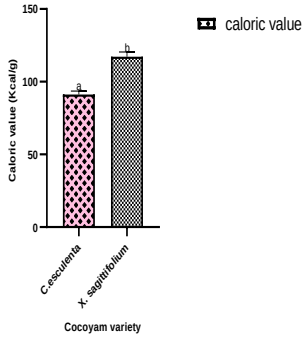

Fig. 1.0B: Caloric value of *C. esculenta* and *X. sagittifolium*. The results are expressed as mean ± standard deviation for triplicate (3) determinations. Identical bars representing same parameter but with different superscript letters on the error bars are significantly different ($p<0.05$).

The result for the quantitative mineral determination are presented in Fig.2.0 A and B respectively A and B for macro and micro-minerals respectively

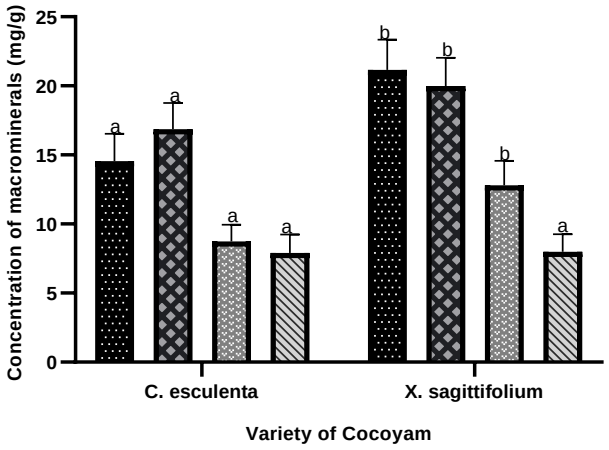

Fig. 2.0A: Quantitative macromineral values of of *C. esculenta* and *X. sagittifolium*. The results are expressed as mean ± standard deviation for triplicate (3) determinations. Identical bars representing same parameter but with different superscript letters on the error bars are significantly different ($p<0.05$)

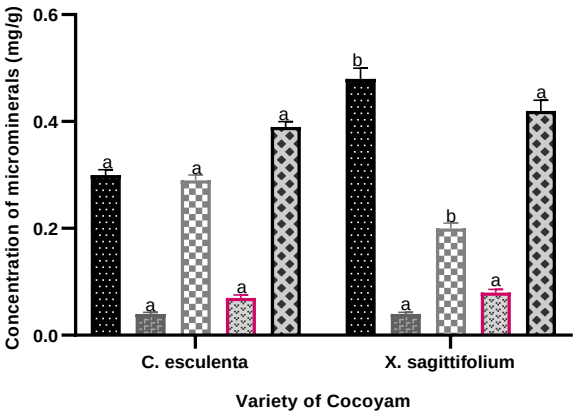

Fig. 2.0A: Quantitative macromineral values of of *C. esculenta* and *X. sagittifolium*. The results are expressed as mean ± standard deviation for triplicate (3) determinations. Identical bars representing same parameter but with different superscript letters on the error bars are significantly different ($p<0.05$)

Quantitative determination of vitamin indicated the presence of retinol, ascorbic acid, riboflavin, thiamin and niacin. The result is presented in Fig. 3.0

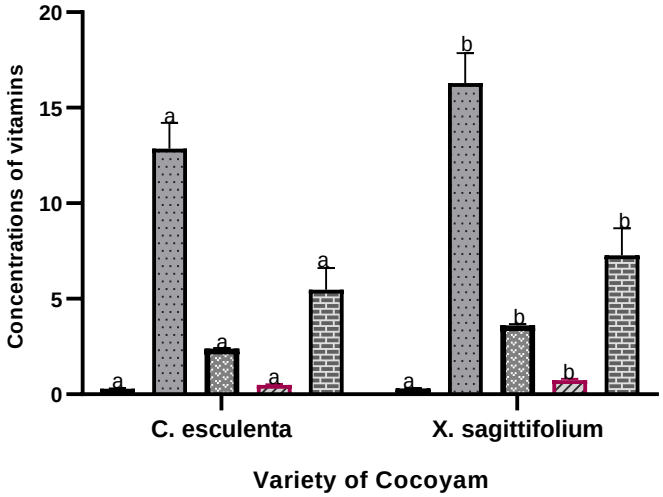

Fig. 3.0: Quantitative vitamin concentration of of *C. esculenta* and *X. sagittifolium*. The results are expressed as mean ± standard deviation for triplicate (3) determinations. Identical bars representing same parameter but with different superscript letters on the error bars are significantly different ($p<0.05$)

The concentration of antinutrients in both *C. esculenta* and *X. sagittifolium* are within permissible limit and does not portend any serious health risk. The concentrations are presented in table 4.0A and B

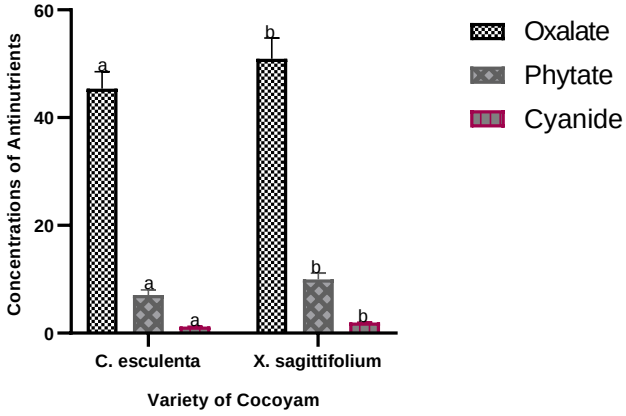

Fig. 4.0A: Quantitative antinutrient concentration (mg/g) of of *C. esculenta* and *X. sagittifolium*. The results are expressed as mean ± standard deviation for triplicate (3) determinations. Identical bars representing same parameter but with different superscript letters on the error bars are significantly different ($p<0.05$)

Discussion

The foundation of nutritional information is the proximate analysis. It offers vital data that are empirical. The nutritional importance of some greatly under patronized food based on culture and religious beliefs like the Cocoyam is necessary, because it will in no lesser way create awareness, eliminate the cultural hurdle and increase the consumption rate of this food item. The major indicators of nutritional values include carbohydrate, protein, fat, ash, and moisture. Proximate

analysis of both varieties of cocoyam indicated the presence of these food classes. Carbohydrates often termed the "staff of life" are primary metabolites essential for survival, biochemical sources of energy and building blocks for most secondary metabolites (Kpomah and Arhoghro, 2012; Holesh *et al*., 2023). The biomolecules that can hydrolyzed to yield a six-carbon monomeric unit (glucose) which may be exploited immediately through the glycolytic pathway or stored as glycogen in the muscles and liver for future use (Kpomah & Odokwo, 2020). Proteins are vital primary metabolites accountable for the biosynthesis of hormones, enzymes, and blood plasma. They are immune promoters and can help in cell division as well as growth. Lipids are other building blocks for secondary metabolites. They produce extra energy per gram than carbohydrates and proteins. Dietary fats are needed not only for their high energy value but also for fat-soluble vitamins and essential fatty acids contained in the fats of natural foods. Lipids also aid the regulation of blood pressure and play a vital role in the synthesis and repair of essential cell parts. Fibres are constituents of plant food which are neither digested nor absorbed by the digestive system. Specifically dietary fibre has been shown to slow down the rate of glucose absorption into the bloodstream, thereby reducing the risk of hyperglycemia, and also reduce the level of plasma cholesterol and prevent colon cancer and cardiovascular diseases (Barber *et al.,* 2020). The ash content of plant based food can influence the different physiognomies of food including physiochemical and nutritional properties, it is a direct reflection of the mineral composition Dietary ash is vital in establishing and maintaining the acid-alkaline balance of the blood system as well as controlling hyperglycemia conditions (Harris and Marshall, 2017). Adequate and balanced nutrition as depicted by the presence of all major food components in both varieties of Cocoyam can promote good health and boost immunity against a wide range of diseases. The optima calorific value of the two varieties may also help obese patients to come down on their body weight.

Mineral analysis of both varieties of cocoyam indicated that they contains potassium which is the principal ion of intracellular fluid, sodium which is the main cation of extracellular fluid, together both function to uphold the electrical potential of the nervous system and hence proper functioning of the nerve cells (Kpomah *et al.,* 2018). Both cations are also vital in the maintenance of water and electrolyte balance and by extension of acid/base balance in the body (Ambati *et al.,* 2022) The results from both variety also indicated the presence of calcium which is an indispensable constituent of bones and teeth, it is also a vital factor for many metabolic reactions e.g. nerve function, muscle contraction, regulations of heart beats and blood clotting during injury (Veldurthy *et al.,* 2016). Magnesium which is also a constituent of bones and teeth was also detected in both varieties magnesium is needed for the proper functioning of muscles and nervous tissues, it is also a co-factor of many enzymes (kinases) particularly those of glycolysis and many ATP-dependent reactions (oxidative phosphorylation, cell replication, nucleotide metabolism and protein biosynthesis), (Jahnen-Dechent and Ketteler, 2012). Biological function of zinc are largely categorized into three viz. catalytic activity, as it is a co-factor for over 300 enzymes catalyzed reactions, structural function, as over 90% of zinc can be found in bones and teeth, regulatory functions (Roohani *et al.,* 2013; Bialek and Zyska). Zinc augmentation at 5mg/day for two weeks is also reported to exert strong aphrodisiac potential (Kpomah *et al.,* 2012), zinc supplementation has also been recommended as an adjunct therapy during the treatment of diarrhea in children (Dissanayake *et al.,* 2009). The importance of iron in health and disease was recognized by man from ancient time. It is essential component of all living organism, where it play key role in haemoglobin formation and oxygen transport (Andronicos, and Latunde-Dada, 2019). Thus Proper and appropriate balance of these minerals in the human body can promote disease resistance which may in turn translate into optima functioning of all cells, tissues, organs and systems of the body. The availability of this minerals in varying proportions in both varieties of cocoyam is good for health.

Vitamins are organic molecules required in small dosage for proper bodily functions, they are basically of two class namely the fat soluble and water soluble. Thiamine is a water soluble vitamins that functions as a cofactor for numerous enzymes involved in energy metabolism. Thiamine-dependent enzymes are of importance in the biosynthesis of neurotransmitters and for the synthesis of reducing substances used in oxidant stress defenses, as well as for the synthesis of riboses used as nucleic acid precursors. The role of thiamine in cerebral metabolism cannot also be overemphasized (Fattal-Valevski, 2011). Ascorbic acid has been known as antioxidant by most people, although, it physiological function is much more, encompasses many different processes ranging from enabling of iron absorption through participation in hormones and carnitine biosynthesis and other important roles in epigenetic processes (Dosedel *et al.,* 2020). Niacin, is a nutritional precursor of two major bioactive molecules nicotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP). Both biomolecules are vital cofactors in most cellular redox reactions, they are thus important in maintaining cellular metabolism and respiration (Ficca-Meyer and Kirkland, 2016). Riboflavin play vital role in bodily functions and have been widely implicated as antioxidant, anti-aging, anti-inflammatory, anti-nociceptive and anti-cancer properties. In addition, the combination of riboflavin with other compounds or xenobiotics can have marked physiological effects such as protective properties, and lessened toxicity effect of drugs in several treatment regimen (Suwannasom *et al.,* 2020). Vitamin A is a fat soluble vitamin that is vital for numerous bodily functions but generally narrowed down into the following basics of proper vision, immune boaster, reproduction and healthy skin (Alashry and Morsy, 2021). The availability of these nutritionally important vitamins in both varieties of cocoyam is that regular intake of this staples can help eliminate the danger of avitaminosis in our rural tropical areas where the poverty level is endemic.

One substantial disadvantage of cocoyam meal is the occurrence of antinutrients, largely, oxalates, phytate and cyanide. Findings in our studied indicated that oxalate content in *C. esculenta and X. sagittifolium* vary from 45.36 to 50.94 mg/g this is consonant with Ramanatha *et al.* (2010) and review by Boakye *et al.* (2017). High oxalate content in tropical food is of basic concern in food safety as it has been implicated in interfering with the metabolism of some essential minerals in bodily function by forming water soluble salts with NH_4^+, Na^+, K^+ ions, similarly it also binds Ca^{2+}, Fe^{2+} *and* Mg^{2+} thereby affecting the bioavailability of these minerals (Noonan, 1999; Bargagli *et al.,* 2020). Ingestion of oxalic acid at a dose of 10-15 g may cause fatality also primarily due to it interference also with carbohydrate metabolism by inhibiting succinic dehydrogenase (Noonan, 1999; Huang *et al.,* 2020). Fortunately the levels in both variety are far below this toxic range considering the maximum daily consumption rate 0.418 kg for an adult of 60 Kg (Odey *et al.,* 2021). Although high oxalate foods have

been acknowledged to wield a harmful effect on calcium and iron absorption. The adverse effect is however greater if the oxalate: calcium ratio exceeds 9:4. The adverse effects of oxalates must be considered in terms of the oxalate: calcium ratio in a food for toxicity inferences to be made, fortunately also the ratios for *C. esculenta and X. sagittifolium* are far below the 9:4 as their ratios are 3:1 and 2:1 respectively. Hence both varieties are relatively less toxic. The oxalate levels have also been shown to be drastically reduced by processing methods like grating, soaking, steaming, boiling, drying and fermentation (Ramanatha *et al.*, 2010; Amandikwa, 2012; Aniekwe, 2015).

Phytate, often times works in a broad pH-range as a highly negatively charged ion, and therefore its occurrence in the diet has a negative impact on the bioavailability of divalent, and trivalent mineral ions such as Zn^{2+}, $Fe^{2+/3+}$,Ca^{2+}, Mg^{2+}, Mn^{2+}, and Cu^{2+} just like oxalate (Weaver and Kannan, 2002; Gemede, 2014). The complaisant nature of phytate rich foods to initiate mineral deficiency is a function of other food being consumed alongside (IUFoST, 2008). Phytate is also known to form complexes with proteins at both low, and high pH values. These complex formations modify the protein structure, which may result in decreased protein solubility, enzymatic activity, and proteolytic digestibility (Greiner and Konietzny, 2006). Phytate in the diet has been reported to have beneficial effects in the prevention of kidney stone formation (Grases, 2000), protect against diabetes mellitus, atherosclerosis and coronary heart disease as well as against a variety of cancers. (Thompson, 1993; Vucenik Shamsuddin, 2003; Gemede, 2014; Kpomah and Odokwo, 2020). Phytate exerts the beneficial effects in the gastrointestinal tract and other target tissues through its chelating potentials, this property is also been harnessed to treat heavy metal poisoning (Gemede 2014)

The presence of cyanogenic glycosides in certain food products, and their subsequent ingestion as HCN at high levels, can have negative health implications, including nausea, vomiting, diarrhoea, dizziness and weakness (Quinn *et al.*, 2022) and even death at a dose of 3–6 mg HCN/kg body weight. Long term exposure to high levels of HCN is associated with neurological conditions such as konzo and tropical ataxic neuropathy (Nzwalo and Cliff, 2011). The levels of HCH in both varieties are also far below the 10 ppm set by most regulatory for cyanide content in ready to eat foods (Quinn *et al.*, 2022). However, certain levels of glycosides have been associated with some health benefits (Kpomah *et al.*, 2016).

Conclusion

Food insecurity resulting in malnutrition is major challenge to the growth and productivity of tropical developing countries where most staples are carbohydrate dense but deficient in essential minerals. Cocoyam is hypothesized to have loftier nutritional value over other major root and tuber staples of tropical developing countries, particularly with respect to their protein digestibility, mineral composition (Lim, 2016).

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