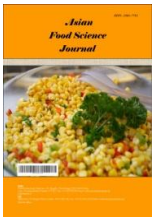

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Updating the Data Base of Indigenous Raw Food Materials by Analyzing Their Chemical Compositions

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Introduction: The porosity of recent data on the chemical compositions of indigenous food might contribute to poor food choices thereby promoting food and nutrition insecurity. This study provides data on the proximate, mineral and antinutrient compositions of raw, *Triticum aestivum*, *Musa paradisiaca, Xanthosoma sagittifolium*, *Ipomea batata*, *Zea mays and Sphenostylis stenocarpa*.
Methodology: The raw food materials were purchased in Nigerian markets. Corn grains and African yam bean (AYB) seeds were sorted to remove impurities and separately milled into fine flours. Green matured plantain fruits, cocoyam, yellow and orange fleshed sweet potatoes tubers were separately washed to remove adhering soil particles, peeled and sliced into a thin thickness of about 2 cm and then dried in a food dehydrator (40- 50°C) for 24 hr. After drying, they were separately milled into fine flours. Chemical properties were analyzed using standard laboratory methods. Data generated were computed using means and standard deviations.
Results: The ranges of the proximate compositions of the food materials were as follows: Moisture 4.3-11.8%, ash 0.6 -2.8%, dietary fibre 3.2-17.5%, fat 0.8-4.3%, protein 2.8 - 20% and available carbohydrate 48.5 -72.5%. The mineral contents of the samples were in the following ranges; iron 0.8-5.4 mg/100 g, zinc 0.51-2.43 mg/100 g, calcium 8-109 mg/100 g, potassium 135-325 mg/100 g, sodium 3-12 mg/100 g, phosphorus 84- 688 mg/100 g, magnesium trace -119 mg/100 g. The antinutrients were as follows: trypsin inhibitors 1.85 IU/mg, phytate ranged from 5.1-6.57 mg/g,

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oxalate 0.21-0.29 mg/g, saponins 0.03-0.02 mg/100 g, raffinose 0.88- 2.18%, stachyose 1.93 – 3.16%, lectins 32.5 Hu/100 g and tannins 0.9 mg/g.

Conclusion: Knowing the nutrient contents of raw food materials will help food producers/processors and consumers combine foods leveraging on the comparative advantage of each nutrient to make up for limited nutrient(s). Also, knowledge of the antinutrient compositions of raw food staples will aid decisions on adequate processing methods to be employed in reducing or eliminating them.

Keywords: Chemical compositions; indigenous food; antinutrient compositions; corn grains; African yam bean.

1. INTRODUCTION

Food is one of the basic needs of man and one of the major determinants of health. Eating right is essential to achieving good health. The knowledge of the nutrient and antinutrient compositions of raw food material can influence food choices and preparatory methods. Knowing the best way to prepare food is essential to achieving proper utilization of the nutrients in food and consequently good health and nutrition will be achieved. In addition, it has been proposed that the fight against malnutrition and diet-related diseases in developing countries should be focused on the use of mixtures of tubers, cereals and legumes indigenous to them [1]. But it will be difficult to make better food choice without knowledge of their nutrient compositions. In this study, African yam bean (AYB), cocoyam, wheat, plantain, yellow corn, white corn, orange fleshed sweet potatoes and yellow fleshed sweet potatoes were analyzed for their proximate, mineral and antinutrients.

African yam bean which is botanically known as *Sphenostylis stenocarpa* is described as a perennial climbing plant that is 1-3 m high. It is grown as an annual plant. It has a trifoliate leaf with oval leaflets which is 2.7 to 13 cm long and 0.2 to 5.5 cm broad [2]. AYB is well known in Nigeria and some other African countries. Though it is under-utilized, and it is among the crops that might go extinct if its use is not promoted [3]. The cultivation of AYB is not a problem because it grows well on deep, loose sandy and loamy soils with good organic content and good drainage.AYB is a good source of food for both humans and animals. In Southeastern Nigeria, the seeds are roasted and eaten with palm kernel seeds. The seeds are also eaten as porridge but preparatory difficulties like long cooking time, be any flavour and bitter taste have limited the use of AYB [3]. The food use of AYB is further constrained by the presence of antinutrients and indigestible oligosaccharides particularly raffinose and stachyose [4,5]. Processing have been reported to improve the nutrient contents [5].

Corn or maize are used interchangeably. Corn (*Zea mays*) is one example of cereals among other examples like rice, wheat, rye, oats, barley and sorghum, most of the foods eaten by humans comes from cereals. Botanically, corn is called *Zea spp.* and belongs to the grass family of Gramineae. Corn varies in colour, weight and chemical composition as a result of genetic and environmental factors and cultural practices. It has a fibrous root, it is a cross-pollinated plant, with erect, thick, and strong stalks having both nodes and internodes [6,7]. Maize grains have variable colours like white, yellow, black, red and mixtures of other colour. The predominant colour is white and yellow. Maize is one of the most important crops in sub-Saharan Africa, its yield is limited by drought as its mostly rain-fed [8]. The most common types of corn include flint, flour, dent, popping, sweet and waxy corn [9].

Cocoyam (*Xanthosoma sagittifolium)* is one of the six most important root and tuber crops worldwide. In Nigeria, it is eaten like yam as they have similar methods of preparation, but cocoyam is not valued and its use is underutilized [10,11]. In Nigeria, cocoyam is popularly called “ede” in Igbo language. It has the good tendency of not getting spoilt easily as it can be stored for a long time with ease and cheap storage facility. Nigeria produces about 37% of the cocoyam produced in the world with an annual production of 26.587 million tonnes. Yet it is underutilized in the same country [12,13]. Cocoyam *Colocasia* (taro) and *Xanthosoma* (tannia) are the two most important genera of the family *Araceae*. Two popular species *Colocasia esculenta* and *Xanthosoma sagittifolium* are generally grown for food. It is ranked third in use and importance after cassava and yam [14,15]. The economic importance of Cocoyam is limited by inadequate information on the nutrient

composition of its products as well as limitation of varietal food preparatory method [16].

Sweet potatoes (*Ipomoea batatas)* are one of the roots and tuber crops of the tropics. They are perennial crops farmed at subsistence level. The world production of sweet potatoes is high accounting for about 110.75 million tons grown in 2013 in 111 countries, although, it is highly perishable [17]. They strive well in humid and sub-humid tropics. Sweet potatoes are easy to farm, producing high yields of dry matter per unit area of land and labour. It adapts easily to variable environments. The colour of sweet potatoes differ both in skin and flesh, it could be white, yellow or orange-fleshed, while the skin could be purple, white, yellow, red or orange in colour [18,19]. Even though Nigeria is the third world's largest producers of sweet potatoes after China and Uganda, it is still regarded as an under-utilized crop [20]. The fresh leaves and roots of OFSP can be consumed after cooking through different means like frying, boiling, roasting and baking.

Plantains are banana. The word plantain is used to refer to a large group of bananas that has about 100 cultivars [21], Plantain is a starchy fruit which has wide use in Nigeria. It is known as "Unene" in the Igbo language, "OgedeAgbagba" in Yoruba language and "Ayaba" in Hausa language. It has edible fruits that can cooked using varietal methods like boiling, roasting, frying among others (Raw materials Research and Development Council [22]. In Nigeria, plantain is produced widely in the south. Nigeria has annual plantain production of about 2.4 million metric tons making her the giant of Africa in plantain production, though; the production is mostly for local consumers and not exports [23]. Plantains are planted mainly in the backyards or in a mixed cropping system by peasant farmers and sometimes in the monocropping system.

2. MATERIALS AND METHODS

2.1 Sample Collection

Cream coloured African yam bean seed was purchased from new park market in Enugu, Enugu State, Nigeria. yellow and white corn grains, yellow fleshed sweet potatoes tuber, cocoyam corm, white wheat flour and unripe plantain fruits were purchased from market in Calabar metropolis, Cross River State. Orange fleshed sweet potatoes were purchased from Karu market, Abuja all in Nigeria. Yellow corn, white corn and African yam bean (AYB) seeds were sorted to remove impurities and separately milled into fine flours. Green matured plantain fruits, cocoyam, yellow and orange fleshed sweet potatoes tubers were separately washed to remove adhering soil particles, peeled and sliced into thin thicknesses of about 2 cm and then dried in a food dehydrator (40- 50°C) for 24 hr. After drying, they were separately milled into fine flours for chemical analysis.

2.2 Proximate Analysis

The methods described by the Association of Official Analytical Chemist in 2012 [24] were used in determining moisture, ash, total fat and crude protein content of the samples. Dietary fibre was carried out by Prosky, Asp, Furda, DeVries, Schweizer and Harland in 1988 [25] method as described by AOAC Method 985.29. Carbohydrate was determined by difference.

2.2.1 Determination of moisturecontent

Two grams (2 g) of the sample was weighed into a previously weighed crucible. The crucible plus the sample was taken and transferred into the oven set at 100ºC to dry to constant weight for 24 hours. The crucible plus the sample was removed from the oven, cooled for 10 minutes and reweighed. The sample in the crucible was returned into the oven for further drying. The drying, cooling and weighting were done at intervals of 4 hours until a constant weight was obtained. The moisture content was calculated as a percentage of the ratio of moisture loss to the weight of the samples analyzed. The expression represented below was used in the calculation:

$$\text{Moisture (\%)} = (w_1 – w_2/ w_1) \times 100$$

Where,

W_1 = weight (g) of the sample before drying
W_2 = weight (g) of the sample after drying

2.2.2 Determination of ash content

Total ash content was determined as total inorganic matter by incineration of a sample at 600ºC (AOAC, 2012). Two grammesh 2 g of the sample was weighed into a pre-weighed porcelain crucible and incinerated overnight in a muffle furnace at 600°C. The crucible was removed from the muffle furnace, cooled in desiccator and weighed. Ash content was calculated according to the following formula:

$$Ash\ (\%) = (\text{weight of ash})/(\text{Weight of sample}) \times 100h\ (\%) = \frac{\text{weight of ash}}{\text{Weight of sample}} \times 100$$

2.2.3 Determination of dietary fibre

The fibre contents were determined using the method as described by Prosky et al. [24]. After ashing, 5 g of dried and defatted food samples were subjected to sequential enzymatic digestion by heat-stable bacterial α-amylase in harsh conditions (pH 8.2, 100ºC) to give gelatinization, hydrolysis and depolymerization of starch and protein for the enzymatic incubation step. The samples were precipitated following the addition of ethanol. The precipitated samples were filtered and weighed. Total dietary fibre was then determined by subtracting the weight of protein and ash from the weight of the precipitate.

2.2.4 Determination of crude fat

Crude fat was estimated by employing solvent extraction using a Soxhlet extraction unit. About 1 g of the samples were weighed and placed in a thimble. Some 120 ml petroleum ether was poured into a previously dried and weighed round bottom flask. The Soxhlet extractor apparatus was set up with the flask and the condenser. The extraction apparatus was set up with the flask sitting on the spaces provided on the hot plate. The hot plate was plugged and set to gentle heating, the other evaporated and as it condensed, it dropped into the thimble where it extracted the other soluble constituents (fat constituent) into the flask. The colour deepened as time increases. The thimble was then removed and dried in the oven. The petroleum ether in the flask was evaporated. The flask was then dried in an air circulating desiccator. The round bottom flask and the lipid extract were then weighed. The flask and its content were dried again to obtain constant weight. Amount of lipid was obtained from the difference between the weight of the flask before extraction and after extraction. Crude fat was calculated using the formula:

$$\frac{(weight\ of\ flask + oil) - (weight\ of\ flask) \times 100}{weight\ of\ sample}$$

2.2.5 Determination of crude protein

About 1 g of the sample powder was weighed out into 50 ml Kjeldahl digestion flask. Some 20 ml concentrated H2SO4, 1 tablet of Kjeldahl catalyst and anti-bombing chips were added. The mixture was incinerated to gentle boiling on the digestion rack and then heated further for 3 hours. The digest was removed, cooled, quantitatively transferred to a 100 ml volumetric flask and made up to mark. Erlenmeyer flask containing 10 ml of the boric acid indicator solution was placed at the tip of the condenser extended below the surface of the solution. About 10 ml of the sample digest was introduced into the sample tube and steam heated, 10 ml of 40% NaOH solution was added to the digest and the digest was steamed and distilled into the boric acid-indicator solution, it changed to green. A blank determination was also carried out alongside that of the sample except that 1 g sample was replaced with 1ml distilled water. The crude protein content was calculated as follows:

$$\text{Protein (\%)} = (A\text{-}B) \times N \times 1.4007 \times 6.25$$

Where,

A= volume (ml) of 0.2 N HCl used sample titration
B = volume (ml) of 0.2 N HCl used in blank titration
N= Normality of HCl
W = weight (g) of sample
14.007 = atomic weight of nitrogen
6.25 = the protein-nitrogen conversation factor

2.2.6 Calculation of available carbohydrate content

The available carbohydrate content of the samples was calculated by eliminating the percentage of the other food nutrients. Mathematically,

Available Carbohydrate = 100 – (crude protein + lipid + ash + moisture+ dietary fibre).

2.3 Mineral Determination

This was carried out using Atomic Absorption Spectrophotometry (AAS), Inductively Coupled Plasma Atomic Emission Spectrophotometry (ICP-AES) and Uv visible spectrophotometry [26].

2.3.1 Determination of calcium and magnesium by atomic absorption spectrophotometer

Into a volumetric flask was pipetted an aliquot of the test solution. To make a final concentration of 0.1% w/v $LaCl_3$, about 1% w/v of $LaCl_3$ was added. Ca and magnesium determination using AAS was made ready by diluting the solution to an appropriate volume with1N HNO_3. Ca and Mg were measured using the AAS at a specific wavelength of 422.7 and 285.2 respectively. The absorbance of the prepared standard was measured against reagent blank. The measurement was carried out according to the following order: water, reagent (0 ppm, to set zero), sample blank, (standard from the lower concentration to highest). The system was washed with water after reading each test solution.

Calculation:

$$\text{Ca (mg/100 g)} = \frac{(C0)\ \text{x total volume (ml) dilution x 100}}{\text{Weight of sample (g) x 1000}}$$

2.3.2 Determination of Sodium and Potassium by AAS [26]

Sample preparation started with wet ashing, $CsCL_2$ solution was added to an aliquot portion to make a final dilution of 1% w/v $CsCl_2$. It was diluted to an appropriate volume. The wavelength (nm) were Na (589.0) for 0.5-1.5 ppm and K (766.5) for 1-4 ppm)

Calculation:

$$\text{Na or (mg/100 g)} = \frac{\text{Co x V x D x 100}}{\text{W x 1000}}$$

Where,

Co = concentration of the sample from the calibration curve (mg/l)
V = total volume (ml)
D = dilution factor
W = weight sample (g)
1000= conversion ml to L

2.3.3 Determination of zinc and iron by ICP-AES method (AOAC, 2000)

The instrumental parameter of the ICP-AES system was adjusted in accordance with the manufacturer's manual. About 30 min prior to measurement, the instrument adjusted to working condition. The sensitivity and stability of the system were checked. Two (2 g) gram of sample was weighed into a 250 ml beaker. Ten (10 ml) milliliters of 50% HNO3 was added to the test portion and mixed. The beaker was covered with a watch glass and heated to 95°C and allowed to reflux for 15 mins. The digest cooled, then 5 ml conc. HNO3 was added, covered and the solution left to reflux for another 3 min at 95°C. The solution was evaporated to 5 ml and drying of sample avoided. After cooling, 2 ml of water and 3 ml of 30% H_2O_2 was added and covered with watch glass. This was heated slowly to initiate peroxide reaction until effervescence subsided. The solution was let to cool, then 7 ml of 30% H_2O_2 was added, 1 ml at a time while warming. About 5 ml conc. HCL and 10 ml of water were added after the solution cooled down. It was covered with a glass and left to reflux for 15 min without boiling. It was cooled and diluted to 100 ml with water and mixed thoroughly. Particulate matter in digest was removed by filtration.

Calculation:

Cs= (1c-B)x D x R

Where,

B = reagent blank concentration (mg/L)
Cs = concentration of element in test portion (mg/100 g)
D = Dilution factor
1c= test solution digest concentration from instrument (mg/L)
R = wet weight/ dry wt ratio for test portion

2.3.4 Determination of phosphorus by Uv visible spectrophotometry [26]

The instrument was set up according to the manufacturer's instruction. Samples were prepared by dry ashing as described previously. The ash was dissolved in 5 ml IN HNO_3 and heated on a hot plate for 3 mins to aid dissolving. The crucibles were rinsed by washing twice with 1N HNO_3. The solution was diluted to 100 ml with 1N HNO_3 and filtered through Whatman ® filter paper No. 42. About 10 mls of 0.1 mg/ml phosphate standard solution was pipetted to obtain 1 mg P and 5 ml test solution into a 100 ml volumetric flask.

Phosphorus (P), Phosphorus content was given by the formula,

$$\text{P (mg/100 g)} = \frac{(\text{Abssam x 1 x Vo X 100})}{(\text{Absstd x Vp x W})}$$

Where,

Abssam = absorbance of Sample

Abssd= Absorbance standard (1mg/ml)
Vo = total volume (ml)
V_p= volume of diluted sample (ml)
W = sample weight (g)

2.4 Determination of Antinutrients

2.4.1 Phytate determination

Phytate was determined by a simple and rapid colorimetric method [27].

Five grams (5 g) of the milled sample was weighed into a 250 ml conical flask, 100 ml of 2.45 HCL was added and extracted for 1 hour at room temperature 25°C±28°c and centrifuged. Supernatant was decanted. 1 ml of 2.4% extract supernatant was diluted to 25 ml with distilled water. Ten milliliters (10 mls) of diluted sample was passed through the AG1-X8 chloride anion exchange column (0.5 g). Phytate was eluted with 0.7M NaCl. 3 ml of 0.7M eluent fraction was pipetted into 15 ml conical test tubes, and mixed on a vortex mixer for 5 seconds, and centrifuged for 10 minutes. Absorbance of supernatant was read at 500 nm using water to zero the spectrophotometer. Series of sodium phytate dilutions were made from 5-40 µg phytate in distilled water. Three milliliters (3 ml) of the solution was pipetted into 115 ml. One milliliter (1 ml) of Wade reagent was added within 30 minutes of elution. It was mixed on a vortex mixer for 5 seconds and centrifuged for 10 minutes. The absorbance of the supernatant was read at 500 nm using water to zero the spectrophotometer. Phytate content was estimated from the standard curve.

2.4.2 Determination of trypsin inhibitors

Trypsin inhibitor was determined using the method described by Kakade, Racis, Mcchee and Puski [28].

One hundred milligrams (0.01 g) of sample was weighed; 20 ml cold (4°C) methanol was added. It was vortexed and centrifuged at 3,000 rpm for 20 minutes.

An aliquot of 0.01 to 5 ml of supernatant was taken for assay. Some 0, 0.05, 0.1, 0.2, 0.3, 0.4 and 0.5 ml of tannic acid standard solution was pipetted into test tubes and made up to 5 ml by adding 5, 4.95, 4.9, 4.8, 4.7, 4.6 and 4.5 ml of distilled water (These correspond to concentrations of 0, 1, 2, 4, 6, 8 and10 ppm.) 0.3 ml Folin-Denis reagent was added, 0.6 ml of Na_2CO_3 solution was added. The solution stood for 25-30 mins. The absorbance of blue color was read at 760 nm.

% Tannins was calculated from standard curve as follows:

$$\%\text{tannins} = \frac{(A-I)\ xVx100xD.F}{BxWx106}$$

A= Absorbance of sample.
I= Intercept
V= Total volume of extract
B= Slope of standard curve
W= Weight of sample

2.4.3 Oxalic acid determination

Oxalate was determined by the method of Oke [29]. One gram (1 g) of the flour was extracted thrice by warming it at 40-50 degree centigrade with constant stirring with magnetic stirrer for 1 hour with 20 ml of 0.3 N HCl The extract was diluted to 100 ml with distilled water. 5 ml of the extract was made alkaline with 1 ml of 5 N NH4OH. This was made acidic with glacial acetic acid and phenolphthalein served as an indicator (2 drops). 1 ml of 5% calcium chloride was added and the mixture could stand for 3 hours, centrifuged using (IEC Centra GP8) at 1400 rpm for 15 minutes. The supernatant was discarded, and the precipitate was washed thrice with hot water, thorough mixing and centrifuging each time. 0.2 ml of 3 N H2SO4 was pipette to each test tube. The precipitate was dissolved by warming in water at 70°C for 30 mins. The content of each test tube was titrated with freshly prepared 0.01 N Potassium permanganate solutions. Titration was done at room temperature 29°C until the colour of the solution become pink. The solution stood until it became colourless. It was warmed at 70 degrees C and titrated until a pink color persisted for 30 seconds.

Calculations:

$$\text{Oxalate content=W x } \frac{100}{5}$$

W= Mass of oxalate in 100ml

2.4.4 Determination of saponins

Saponins determination was carried out by Fenwick and Oakenfull procedure [30]. The sample was finely ground and dried at constant weight. Some 40 g were weighed and placed in the Soxhlet reflux extractor with acetone for 24 hours. The solvent was changed for methanol and vextraction was continued for another 24

hours. The methanolic extract was cooled and made to 250 ml with methanol. At this point there was a modification to the method, proposed by Miriam Monforte (CICY, Merida, Yucatan, Mexico). Instead of bringing the sample up to 250 ml as suggested in the original method it was concentrated. In this, methanolic extract was transferred into a rotary evaporator and concentrate until dry. The residue was concentrated again in a minimum of methanol and transferred to a reweighed vial. The vial was weighed with the dry sample and the weight of the residue was calculated.

Fine drops of a standard solution of saponins were placed on the chromatography plates. The points of extract were placed so that each one is at the side of standard saponins drops. The plates were revealed and the drops with aspersion and a solution of sulphuric acid in methanol, it heated at 110°C for 30 min. The intensity of the saponins stains was measured with a densitometer and the peak areas were calculated on the plotter with a planimater. The results were expressed as the relation (R) of the peak areas of the unknown sample in respect to those of the standard. R^2 was plotted against the volume of the drop of methanolized extract on the plate. The downslope of the line (was calculated by the least squares method), divided by the gradient of a line derived from a master curve, to give the concentration of saponins in the extract and thus the saponins content of the sample.

2.4.5 Determination of lectins by spectrometric method

Lectins was determined according to the method described by Onwuka [31]. Two grammes (2 g) of the sample were weighed into 40 ml normal saline solution buffered at P^H 6.4 with 0.01 m phosphate buffer solution. It could stand at room temperature for 30 mins and centrifuged to obtain the extract. Half of a mililitre (0.5 ml) of the extract was diluted in a test tube, 1 ml of heparinized rabbit blood was poured. The blank was prepared by adding 1 ml of blood into a test tube and allowed to stand for 4 h at room temperature. 1 ml of normal saline was added to all the test tubes and it was allowed to stand for 10 min. after which the absorbance was read at 620 nm.

Lectin unit/g= (b-a) x F

Where,

b = absorbance of the blank

F= experimental factor given by
F= (1/w x f/va) D

Where

W= weight of sample
VF= total volume of extract
VA= volume of extract used in the assay
D= dilution factor

2.4.6 Raffinose and stachyose determination

Raffinose and stachyose (oligosaccharides) were determined by the method described by Tanaka, Thanakul, Lee, and Chichester [32].

Five grams each of both raw and processed flour were extracted with 50 ml of 70% (v/v) aqueous ethanol and kept on an orbital shaker at 130 rpm for 13 h. Extracts were further washed with 25 ml of 70% (v/v) ethanol. The filtrates obtained were then concentrated on a water bath. The concentrated sugar syrup was dissolved in 5 ml of distilled water. Separation of oligosaccharides was done by thin layer chromatography (TLC). A 100 g silica gel was dissolved in distilled water and stirred well until the slurry was homogeneous. The TLC plates were washed, dried and cleaned with chloroform to remove any grease from the plates. TLC plates were then coated with the slurry and air-dried. Spotting of the sugar samples was done by using capillary tubes. Each sample was spotted twice separately and dried using electronic hand drier. The plate was developed by using a solvent system of n-propanol, ethyl acetate and distilled water (6:1:3), and dried. The separated sugars' colours were developed with iodine crystals. The separated spots were compared with the standard sugar spots. The separated sugars that appeared were stachyose, raffinose and sucrose. The stachyose and raffinose spots were scrapped, eluted in 2 ml of distilled water, kept overnight and filtered through Whatman No.1 filter paper. The filtrates were then subjected to quantitative estimation. The eluted individual oligosaccharide was estimated. One ml of the eluted and filtered sugar solution was treated with one ml of concentrated HCl. The tubes were boiled in water bath for exactly 6 min. After cooling, absorbances of the oligosaccharide contents were read using spectrophotometer 259 at 432 nm. The absorbance values were used to calculate the concentration and mass of the oligosaccharides. Average values of duplicate estimations were calculated, and the oligosaccharide contents expressed on a dry weight basis.

2.5 Statistical Analysis

An IBM Statistical Package for Social Sciences (SPSS) database version 20.0 computer was used to analyze the data. Where means was used to analyze the continuous variables and standard deviations were calculated to show the statistical variability.

3. RESULTS AND DISCUSSION

Table 1 presents the proximate compositions of raw white and yellow corn, cocoyam, plantain, yellow fleshed sweet potatoes, orange fleshed sweet potatoes, wheat and AYB. AYB had the highest (17.5%) dietary fibre value than all the other samples, followed by cocoyam (12.5%). Wheat (3.2%) had the least dietary fibre content. combining AYB and cocoyam/plantain /orange fleshed sweet potatoes or corn will have comparative advantages as variety will not only be added to the diets, but the health benefits associated with food high in dietary fibre will also be gained. Studies have shown that consumption of foods high in dietary fibre will help in the prevention and management of chronic non-communicable diseases like diabetes [33]. On the other hand, yellow (4.3%) and white corn (4%) had the highest fat content than other samples, while the values for the other samples ranged from 0.8% in orange fleshed sweet potato to 1.6% in the AYB. Despite the level of fat in the corn, it is still regarded as low indicating that rancidity will be less prevalent, thus the keeping quality of the flours will be high [34]. There was wider variation in the protein content of the samples. Corn, wheat, cocoyam, plantain, and orange fleshed sweet potatoes had very low protein contents, but African yam bean had appreciable protein content of 20% followed by wheat (10.4%). Cocoyam had the least protein contents of 2.8% this makes the combination of AYB and others flours imperative, because protein intake will be higher. The available carbohydrate contents of the samples ranged from 78.7% in orange fleshed sweet potatoes to 48.5% in AYB. The low energy carbohydrate of AYB flour can be improved by combining it with other flours with better energy contents.

3.1 Mineral Composition of Raw African Yam Bean, Corn, Cocoyam, Plantain and Orange Fleshed Sweet Potatoes (Dry Weight Basis)

The result of the mineral contents of the raw food materials used in this study is presented in Table 2. The iron contents of the samples ranged from 0.8 mg/100 g in cocoyam to 5.4 mg/100 g in AYB. AYB flour had the highest (2.43 mg/100 g) zinc value. Cocoyam had the least value for zinc (0.51 mg/100 g), this micronutrients are of public health importance as iron is essential in the synthesis of hemoglobin while zinc is an important component of protein and DNA synthesis, wound healing, growth and immune system function [34]. YFSP had the highest calcium value of 109 mg/100 g. Cocoyam had the least calcium value (8 mg/100 g) like that of plantain (9 mg/100 g). Foods rich in calcium are mainly of animal origin; but considering the high level of calcium in yellow fleshed sweet potatoes, this food could be regarded as an important source of calcium, deficiency of calcium leads to increased risk of developing osteoporosis [34]. As for potassium, its content in wheat flour was the lowest (136 mg/100 g) among other flour samples, while corn had the highest value (351 mg/100 g), followed by yellow fleshed sweet potatoes (48 mg/100 g) .Among the analyzed samples, only AYB had just a trace of magnesium. It is not surprising that corn had the highest magnesium content (119 mg/100 g because cereal is one of the food sources of magnesium. The importance of magnesium cannot be over emphasized as it plays a role in the synthesis of DNA, RNA, carbohydrate, and fat. It is important for nerve transmission and muscle contraction [34,35]. Magnesium level in other samples varied from 16 mg/100 g in plantain and OFSP to 19 mg/100 g in cocoyam. As for sodium, OFSP had the highest sodium value of 12 mg/100 g. The other samples generally presented low contents. These contents were 5 mg/100 g for corn, 5 mg/100 g for plantain 3 mg/100 g for AYB 3 mg/100 g for cocoyam and 3 mg/100 g for wheat. The recommended intake of sodium for adults is 1500 mg/day, consuming 2300 mg/day of sodium will lead to toxicity and perhaps the development of high blood pressure [34]. There was a wide variation in the phosphorus values of the samples; AYB had the highest value of 688 mg/100 g, while other samples ranged from 88 mg/100 g in plantain to 234 mg/100 g in corn. The consumption of AYB might be beneficial in maintaining bone health as the deficiency of phosphorus results in problems with the bones such as weak bones and bone loss [36].

3.2 Anti-Nutrients and Toxic Substances Compositions of Raw AYB and Corn

Table 3 presents the anti-nutrients and toxic substances compositions of raw AYB flour and

Table 1. Energy (KJ/Kcal) and proximate composition of raw African yam bean, white and yellow corn, cocoyam, plantain, orange fleshed sweet potatoes (% dry weight basis)

Flours	% Moisture	% Ash	% Dietary fibre	% Fat	% Protein	% Av. CHO
Yellow Corn	7.8 ± 0.02	1.6 ±0.03	9.4 ± 0.1	4.3 ± 0.5	8.4 ± 0.21	68.1
White corn	4.1±0.00	1.5 ±0.10	9.7 ± 0.3	4. 0± 0.3	9.41 ± 0.	71.3
Plantain	11.6 ± 0.00	2.6 ±0.05	10.3 ± 0.02	1.2 ± 0.03	3.3 ± 0.18	71.1
Cocoyam	10.7±0.00	2.8 ± 0.01	12.5 ± 0.01	1.3 ± 0.03	2.8 ± 0.11	69.9
OFSP	12.2 ± 0.25	1.9 ± 0.09	9.9 ± 0.02	0.8 ± 0.01	3.5 ± 0.19	78.7
YFSP	9.0 ±0.01	1.5 ± 0.00	10.6 ± 0.03	1.0 ±0.00	3.5 ±0.01	74.4
African yam bean	10.2 ± 0.02	2.7 ± 0.02	17.5 ± 0.47	1.6 ± 0.10	20.00 ±1.4	48.5
Wheat	11.8±0.6	0.6±0.0	3.2±0.3	1.5±0.4	10.4±0.7	72.5

Means of three replications. Values are expressed as mean ± SD. OFSP – Orange Fleshed Sweet Potatoes, YFSP – Yellow Fleshed Sweet Potatoes

Table 2. Mineral composition of raw cocoyam, corn, yellow and orange fleshed sweet potatoes k(Y/OFSP) and plantain flours (mg/100 g) (Dry weight basis)

Minerals	AYB	Corn	Cocoyam	Plantain	OFSP	YFSP	Wheat
Iron	5.4 ± 0.01	3.1 ± 0.02	0.8 ± 0.01	1.4 ± 0.02	3.4 ± 0.02	2.36 ± 0.02	2.0±0.6
Zinc	2.43 ± 0.01	1.82 ±0.01	0.51 ± 0.01	1.36 ± 0.01	1.4 ± 0.01	1.18 ± 0.02	1.80±1.69
Calcium	44 ± 0.01	24 ± 0.02	8 ± 3.00	9 ± 1.89	45 ± 0.00	109 ± 0.00	19±9.0
Potassium	295 ± 4.9	351 ± 1.00	298 ± 10.1	325 ± 20.2	146 ± 15.0	145 ± 0.01	135±1.0
Sodium	3 ± 5.0	5 ± 2.10	3 ± 1.87	4 ± 0.48	12 ± 0.48	ND	3±1.00
Phosphorus	688 ± 13.2	234 ± 6.42	221 ± 7.42	88 ± 10.06	146 ± 2.11	84 ± 0.01	110±31
Magnesium	Trace	119 ± 0.01	19 ± 8.00	16 ± 0.01	16 ± 0.01	48 ± 0.1	60±20

Means of three replications. Values are expressed as mean ± SD. OFSP – Orange Fleshed Sweet Potatoes, YFSP – Yellow Fleshed Sweet Potatoes

Table 3. Anti-nutrients and toxic substances composition of raw AYB and corn (dry weight basis)

	AYB	Yellow corn	White corn
Trypsin inhibitors (IU/mg)	1.85±0.04	-	ND
Phytate (mg/g)	5.1 ± 0.16	6.57±0.32	6.33 ±0.20
Oxalate (mg/g)	0.21 ± 0.01	0.29±0.10	0.24±0.32
Saponin (mg/100g)	0.03± 0.02	0.2±0.4	ND
Tannins (mg/g)	0.9±0.3	-	ND
Raffinose (%)	2.18± 0.02	0.88±0.01	ND
Stachyose	3.16 ± 0.03	1.93±0.01h	ND
Lectins (Hu/100g)	32.46±3.00	-	ND

**Means of 3 replicates. Values are expressed as mean ± S.D. ND- Not Determined*

corn flours. Trypsin inhibitor of the raw AYB was quite high (1.85 IU/mg) and might not be safe for consumption if not well processed before consumption [37]. Studies have shown that antinutritional factors (ANF) like the trypsin inhibitors can affect health by reducing digestion and absorption of dietary protein [38]. The level of phytate observed from AYB (5.1 mg/g), yellow corn (6.57 mg/g) and white corn (6.33 mg/g) flours were high. Food with a high level of phytate might be capable of chelating calcium or limiting the bioavailability of iron or zinc [39,40]. Oxalate levels were 0.21 mgg in AYB, 0.29 mg/g in yellow corn and 0.24 mg/g in white corn. These levels are considered high [41] as such, they might cause irritation in the mouth or interfere with iron or calcium absorption [42]. The level of saponin was 0.3 mg/100 g in AYB and 0.2 mg/100 g in corn. These levels are within the lethal dose and as such might cause hemorrhage and erosion of the mucosa of the small intestine or necrosis of liver cells and renal tubules when consumed without proper processing [43]. Tannins content was 0.9 mg/g in AYB which is outside the safe range of tannins [44] suggesting that consuming the flour in the raw form might form complex with protein, starch, cellulose or minerals impairing their absorption [45]. Raffinose was quite high (2.18%) in AYB than it was in (0.88%) in corn. Stachyose values also followed similar trend with raffinose. It was 3.16% in AYB and 1.93% in corn. These oligosaccharides are responsible for the toxicological and nutritional problems like diarrhea, gas production with belching, flatulence, abdominal bloating and pain reported mainly in AYB. The lectinslevel in AYB was 32.46 Hu/100 g, studies have shown that cooking is required to reduce or eliminate the lectins in foods [46].

4. CONCLUSION

Indigenous foods like cocoyam, plantain, AYB, orange and yellow fleshed sweet potatoes, white and yellow corn and wheat that were analyzed for proximate, mineral and antinutrient composition is shown to have variable nutrients. Combining these foods in the right quantity leveraging on their nutrient compositions will help fight malnutrition. With the knowledge of the antinutrient compositions, adequate processing techniques will be employed to eliminate them.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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