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Studies On The Chemical Compositions And Anti Nutrients Of Some Lesser Known Nigeria Fruits

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ABSTRACT

Fruit samples of Cola millenii, Strychnos innocua, Bombax glabra, Artocarpus heterophyllus, Parkia biglobosa and Gardenia erubescens were collected from various locations in Oyo and Osun states of Nigeria. The chemical compositions of these fruits were analyzed with a view to evaluating their levels of nutrient and antinutrients. The nutrients compositions of the fruits showed that the amount of crude fat ranged between 0.78 and 40.0g/100g; crude fibre, 1.23-14.57g/100g; crude protein, 4.54-34.1g/100g; Ash, 1.79-6.10g/100g and carbohydrate, 7.88-72.67g/100g. Concentrations of iron, manganese and zinc were highest in Cola millenii mesocarp; calcium and magnesium were highest in the yellowish pulp of Parkia biglobosa while potassium content was highest in Bombax glabra seed. Strychnos innocua juice contained the highest amount of sodium while Gardenia erubescens fruit contained the highest amount of copper. Ascorbic acid was highest in Cola millenii mesocarp with a value of 953mg/100g; Strychnos innocua juice contained highest levels of total sugar (168.49mg/g) and reducing sugar(83.25mg/g) while Cola millenii seed contained highest amount of starch (739.38mg/g). The results of antinutrient factors showed that tannin content ranged between 1.0 and 7.5mg/g catechin equivalent. Phytate, oxalate and trypsin inhibitor ranged from 0.20-6.65mg/g, 0.23-1.17g/100g, 9.64-58.2 TIU/g respectively. The fruit parts with low level of anti nutrient, high elemental composition, protein, lipid, carbohydrates and ascorbic acid could serve as supplementary sources of essential nutrient to man and livestock.

KEYWORDS

Cola millenii;
Strychnos innocua;
Bombax glabra;
Arthocarpus heterophyllus;
Nutrients;
Antinutrients.

INTRODUCTION

In most developing countries like Nigeria, food shortage is becoming evident as a result of population growth, competition for fertile land and poverty[55]. In addition to these, restriction on the importation of certain foods has lead to up-surge in prices of available staples, unstable government policies on agriculture, lack of agricultural inputs, poor loan scheme and incentive are responsible for food shortage. The diet of many rural and urban dwellers is deficient in protein and high in carbohydrates, the implication is high incidence of malnutrition and increase dietary disease, a situation in which children and especially pregnant and lactating women are most vulnerable[55]. While every measure is being taken by various levels of government to boost food production by conventional agriculture, a lot interest is currently being focused on the possibilities of exploiting the vast numbers of less familiar plants resources of the wild[1,9].

Many of such plants have been identified, but lack of data on their chemical composition has limited the prospect of their utilization[15]. Many reports on some lesser known seeds and fruits indicate that they could be good sources of nutrient for both man and livestock[3,21].

In order to contribute to the growing body of knowledge on this subject, the present study analyzed 6 lesser known fruits from oyo and osun states of nigeria, for their proximate composition, mineral elements, total sugar, reducing sugar, starch content and various anti nutrients like tannin, phytate, oxalate and trypsin inhibitor.

MATERIALS AND METHODS

Collection of fruit samples

Fruit samples were collected from various locations in oyo and osun states of nigeria. *Artocarpus heterophyllus* was collected in front of Agbala compound, beside olayonu hospital ogbomoso, *Cola millenii* behind department of botany, obafemi awolowo university, Ile-Ife. *Strychnos innocua* around kilometer 10, Igbeti Igboho road, *Bombax glabra,* in front of animal production and health laboratory, ladoke akintola university of technology(LAUTECH) ogbomoso. *Parkia biglobosa* from LAUTECH staff school compound, ogbomoso, *Gardenia erubescens* at budodera farm, ago kere, igboho.

Identification of samples

Fruits samples were identified by Mr A.A. Ademoriyo and authenticated by Mr B.O.Daramola of herbarium, department of botany, obafemi awolowo university, Ile-Ife, nigeria. Voucher specimens were deposited in the herbarium. *Artocarpus heterophyllus*; Moraceae(13535), *Bombax glabra*; Bombacaceae(15357), *Cola millenii* K.Schum; Sterculiaceae(15333), *Gardenia erubescens;* Rubiaceae (14609), *Parkia biglobosa*; Mimosaceae (3356) and *Strychnos innocua;* Loganiaceae(13780).

Preparation of samples

Artocarpus heterophyllus fruits were removed from the ripe pod, diced into pieces, dried at 50^0C, pulverized with the aid of a ball grinder, stored in airtight plastic containers inside the refrigerator. *Bombax glabra* seeds were removed from the opened pod, shelled, dried at 50^0C and kept in airtight container. *Cola millenii* seeds were removed from the pod, and shelled. Both the seeds and mesocarp were dried separately at 50^0C, ground to powder with ball grinder, labelled as *Cola millenii* seed and *Cola millenii* mesocarp and stored in airtight containers in the refrigerator.

Gardenia erubescens coat was peeled from the fruit, cut into pieces, dried at 50^0C, pulverized, stored in airtight container and kept in refrigerator. *Parkia biglobosa* pod was carefully opened, the yellowish pulp was scraped from the seed, dried at 50^0C and stored in airtight container labelled parkia pulp and kept in refrigerator. The ripe hard shell of *Strychnos innocua* was crushed. The fruit juice was squeezed inside plastic containers, labelled as S*trychnos innocua* juice and kept in freezer. The seeds were oven dried, ground to powder with ball grinder stored in airtight container labelleled as S*trychnos innocua* seed and kept in refrigerator.

Analytical procedure

Proximate analysis was determined by[11] method. Carbohydrate was determined by difference while nitrogen was converted to protein by multiplying it by a factor of 6.25.

Mineral

Samples were digested as described earlier[26]. Each sample(0.5g) was weighed in triplicate into Kjeldahl flasks and 10ml of conc. HNO_3 was added and allowed to stand overnight. The samples were then heated carefully until the production of brown nitrogen(iv) oxide fume has ceased. The flasks were cooled and(2-4ml) of 70% perchloric acid was added. Heating was continued until the solutions turned colourless. The solutions were transferred into 50ml standard flasks and diluted to mark with distilled water. The mineral content was then analyzed by Atomic absorption spectrophotometer(ALPHA 4 model, Fisons chem-tech, Analytical, UK).

Determination of carbohydrate components

Soluble sugar was extracted three times from 2 g samples with 80% ethanol using Soxhlet extractor and refluxed for 2 h as described by[13]. Reducing sugar was determined from the ethanolic extract by the ferricyanide method[11]. Two(2.0ml) extract and was added to 8.0ml of the ferricyanide reagent and the absorbance read at 380nm using glucose as the standard. The total sugar content of the samples was determined by hydrolyzing 25ml of the sugar extracted above in 100ml beaker using 5ml concentrated hydrochloric acid as described earlier[13]. Total sugar was then determined on 2ml of the hydrolysate using ferricyanide method[11]. The starch content of the samples was determined on 200mg residue of the ethanolic extract obtained above by refluxing the residue with 0.7 M HCl for 2.5 hr[11]. The acid hydrolysate was neutralized, made up to volume in 500ml standard flask with distilled water and then filtered through a whatman no 541 filter paper. The starch in the original sample was then determined as reducing sugar, using the ferricyanide method described above. The reducing sugar was then converted to starch content using the[11] equation.

Ascorbic acid

Ascorbic acid was determined colorimetrically as described earlier[26], after the formation of the Osazone which was dissolved in 85% H_2S04 to give an orange-red colored solution which is measured at 540nm using a(GENESYS 10 UV spectrophotometer, thermo electron corporation, England) and compared to a standard curve prepared from 0-100mg per litre of ascorbic acid.

Antinutritional factors

Tannin was determined by the modified vanillin-HCl method using mg/ml of Catechin in1% HCl-MeOH as standard, the coloured substituted product was measured at 500nm[45].

Phytate was determined by the anion exchange method as described by[28] using KH_2PO_4 as standard.

Trypsin inhibitor was determined by the method of[30] as modified by[6]. A synthetic substrate (BAPNA) was subjected to hydrolysis by trypsin to produce yellow coloured p-nitroanilide. The degree of inhibition by the extract was measured at 410nm.

Oxalate was determined titrimetrically as described earlier[27] by being precipitated as calcium oxalate and titrated against standard potassium permanganate. The oxalate was calculated as sodium oxalate equivalent.

RESULTS AND DISCUSSIONS

The proximate compositions of the fruits samples are reported in TABLE 1.

The moisture content ranged between 4.0g/100g for *Parkia biglobosa* pulp and 90.96g/100g for *Strychnos innocua* juice. Some of the fruit parts have relatively high moisture content which is typical of fresh fruits at maturity[20], while some have low moisture content, which are within the acceptable range for a good keeping period. The relatively low moisture contents is an indication that these fruits parts will have high shelf life especially when properly packaged against external conditions[19].

The crude fat ranged between 0.78g/100g for *Strychnos innocua* juice and 40.0g/100g for *Cola millenii* seed. Most of the fruit parts investigated have relatively high crude fat composition(6.10 g/100g to 40.0g /100g ether extract). *Strychnos innocua* juice and seed flour contain lower level of oil. Lipids are essential because they provide the body with maximum energy, approximately twice that for an equal amount of protein or carbohydrate and facilitate intestinal absorption and transportation of fat-soluble vitamins

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TABLE 1: Proximate compositions of the fruit parts(g/100g) dry weight

	Moisture	Crude fat	Crude fibre	Crude protein	Ash	Carbohydrate
Arthocarpus heterophyllus seed	8.25 ± 0.10^{e}	6.10 ± 0.14^{e}	1.23 ± 0.03^{g}	14.02± 0.50^{b}	3.60 ± 0.06^{e}	68.03 ± 0.27^{b}
Bombax glabra seed	65.98± 0.22^{b}	10.78±0.21^{d}	12.01± 0.11^{c}	34.09± 0.94^{a}	7.86 ± 0.62^{a}	15.92 ± 0.92^{e}
Cola millenii seed	10.00 ± 0.01^{d}	40.0 ± 1.16^{a}	4.03 ± 0.01^{f}	9.19 ± 0.62^{c}	3.00 ± 1.41^{e}	37.81 ± 0.71^{c}
Cola millenii mesocarp	19.0 ± 1.41^{c}	37.0 ± 1.41^{b}	10.0 ± 0.62^{d}	7.44 ± 0.01^{d}	2.00 ± 0.01^{f}	34.56 ± 0.62^{d}
Gardenia erubescens fruit	19.15±0.14^{c}	1.54 ±0.20^{f}	14.57± 1.10^{a}	5.68 ± 0.01^{e}	2.94 ± 0.04^{e}	70.69 ± 0.22^{a}
Parkia biglobosa pulp	4.00 ± 0.22^{f}	18.0 ± 2.60^{c}	12.00± 1.20^{c}	5.25 ± 0.04^{e}	4.00 ± 0.10^{c}	68.75 ± 0.89^{b}
Strychnos innocua juice	90.96 ±0.20^{a}	0.78 ± 0.08^{f}	7.85 ± 0.67^{e}	7.85 ± 0.67^{d}	4.65 ± 0.33^{c}	7.88 ± 0.09^{f}
Strychnos innocua seed flour	8.93 ± 0.97$^{e\,d}$	1.67± 0.01^{f}	13.39±0.86^{b}	15.67±2.42^{b}	1.79±0.15^{f}	71.94±2.25^{a}

Mean ± standard deviation of triplicate determinations
Mean with the same superscripts in the same column are not significantly different at 5% probability level

A, D, E and K[18]. Those with high lipid content are comparable with those of soybean oil, locust bean and cottonseed; 19.10g/100g, 20.30g/100g and 14.05g/100g crude fat respectively. These are commercially exploited and classified as oil seed[12]. This showed that some of these fruits are rich in oil and could be sources of edible vegetable oil if well annexed, hence could complement conventional vegetable oils, which are very expensive. The fruit parts most especially *Artocarpus heterophyllus* seed, *Bombax glabra* seed, *Cola millenii* seed, *Cola millenii* mesocarp, *Parkia biglobosa* pulp could also be sources of oil for soap and paint industries but the physicochemical properties of these oils must be ascertained. Those with low ether extract content are comparable to that of cereals like maize; 4.6g/100g and millet 4.0 g/100g[40]. Although those with low oil content are relegated as a source of oil commercially, they can be recommended as part of weight reducing diets.

The crude protein concentration ranged between 4.54g/100g for *Gardenia erubescens* fruit and 34.09g/100g for *Bombax glabra* seeds. Proteins are essential component of the diet needed for survival of animals and humans, their basic function in nutrition is to supply adequate amounts of required amino acids[44]. Protein deficiency causes growth retardation, muscle wasting, ederna, abnormal swelling of the belly and collection of fluids in the body[56]. The crude protein content of the *Cola millenii* seed was 19% higher than *Cola millenii* mesocarp. Unfortunately this is the part of the fruit usually thrown away as waste while the mesocarp is consumed. There was no significant difference in the crude protein content of *Strychnos innocua* juice and seed flour. *Bombax glabra* seed however had the highest crude protein content.

The crude protein compares favourably with that of melon seed; 33.8g/100g[2] and fall within the range of 21-34g/100g reported for cowpea[5]. The high protein content may enhance growth and maintenance of tissue, and will no doubt complement protein from cereals and other plant foods that are known to be low in protein and can replace melon seed as a source of protein in the diet of nigerians.

The crude fibre ranged between 1.23g/100g for *Artocarpus heterophyllus* seed and 14.57g/100g for *Gardenia erubescens* fruit. Fibre helps in the maintenance of human health and have been known to reduce cholesterol level in the body. The low levels of fibre in *Artocarpus heterophyllus* seed flour and *Cola millenii* seed flour may be desirable in their incorporation in weaning diets. Emphasis has been placed on the importance of keeping fibre intakes low in the nutrition of infants and pre-school children[24]. High fibre levels in weaning diet can lead to irritation of the gut mucosa, reduced digestibility, vitamin and mineral availability. Those with high fibre content are desirable in adult diet. Fibre diets promotes the wave-like contraction that move food through the intestine, high fibre food expand the inside walls of the colon, easing the passage of waste, thus making it an effective anti-constipation, it also lowers cholesterol level in the blood, reduce the risk of various cancers, bowel diseases and improve general health and well being. Presence of high crude fibre improves glucose tolerance and is beneficial in treating maturity on set diabetics[24] thus the incorporation of these fruits into human diets would increase the level of fiber intake and could be of tremendous benefit to the diabetic patients.

The ash content ranged between 1.79g/100g for *Strychnous innocua* seed flour to 7.86g/100g for *Bombax glabra* seed. The percentage ash of the sample gives an idea about the inorganic content of the samples from where the mineral content could be obtained. The ash content obtained is similar to a range of 1.63g/100g to 8.53g/100g in commonly consumed fruits[43]. Samples with high percentages of ash contents are expected to have high concentrations of various mineral elements, which are expected to speed up metabolic processes and improve growth and development.

The total carbohydrate determined by difference ranged between 7.90g/100g for *Strychnos innocua* juice to 71.94g/100g *Strychnos innocua* seed flour. *Artocarpus heterophyllus, Parkia biglobosa* pulp*, Gardenia erubescens* and *Strychnos innocua* seed flour can be considered as a potential source of carbohydrate when compared to the content of conventional source like cereals, 72-90g/100g carbohydrate[4] and could be good supplements to scarce cereal grains as sources of energy in feed formulations. High carbohydrate content of feed is desirable, the deficiency causes depletion of body tissue[14] The carbohydrate content of *Bombax glabra* and *Strychnos innocua* juice is low(7.9 to 15.92g/100g). Samples with low carbohydrate content might be ideal for diabetic and hypertensive patients requiring low sugar diets.

The concentrations of different mineral elements in the fruit samples determined by AAS are reported in TABLE 2. Calcium ranged between 1681 and 11650mg/kg. *Cola millenii* seed contained the lowest calcium concentration while *Parkia biglobosa* pulp the highest. The level in *Parkia biglobosa* pulp is higher than 7220mg/kg calcium in pulp of grape fruit but similar to 11650mg/kg calcium in grape fruit peel[42]. Calcium help in regulation of muscle contractions transmit nerve impulses and help in bone formation (Cataldo *et al*., 1999). The recommended dietary allowance(RDA) for calcium is 800mg/day[28], which means that about 68g dry weight of *Parkia biglobosa* pulp would provide the RDA for calcium. This shows that these fruit parts could be a better source of calcium than some conventional fruits.

Magnesium ranged between 2201.10 and 7000 mg/kg. *Artocarpus heterophyllus* seed contained the lowest magnessium concentration while *Parkia biglobosa* pulp the highest. Magnesium play a major role in relaxing muscles along the airway to the lung thus allowing asthma patients to breath easier. It plays fundamental roles in most reactions involving phosphate transfer, believed to be essential in the structural stability of nucleic acid and intestinal absorption while deficiency of magnesium in man is responsible for severe diarrhea, migraines, hypertension, cardiomyopathy atherosclerosis and stroke[10]. About 0.15g dry weight of *Artocarpus heterophyllus* seed and 0.05g dry weight of *Parkia biglobosa* pulp would be required to meet the 320mg/day RDA of magnesium.

Potassium ranged between 1810 and 4895mg/kg. *Strychnos innocua* seed contained the lowest potassium concentration while *Bombax glabra* seed the highest level. The concentration in *Strychnos innocua* seed is close to concentration of 1680, 1520 and 2130 mg/kg potassium reported for grape fruit juice, orange and pineapple pulp respectively[42], for RDA of

TABLE 2: Concentrations of mineral elements in the fruit parts(mg/kg) by AAS

	Ca	Mg	K	Na	Mn	Fe	Zn	Cu
Artocarpus heterophyllus seed	2281.15±26.09^{f}	2201.10±41.37^{g}	3418.55±18.17^{b}	1009±10.10^{f}	98.58 ± 2.40^{e}	197.95±1.40^{c}	201.00±1.42^{e}	72.85±3.50^{b}
Bombax glabra seed	5620±14.14^{d}	3665 ± 7.07^{e}	4895±7.07^{a}	1540 ±14.14^{c}	148.70 ± 0.85^{c}	390.15 ± 0.35^{e}	303.15 ± 2.90^{c}	78.98±0.01^{b}
Cola millenii Seed	1681.35±30.76^{h}	3934.01±87.19^{d}	4776.90±18.24^{a}	1387.90±0.99d	100.20±0.28^{e}	481.3±1.41^{c}	319.05±0.35^{c}	96.53±0.66^{ab}
Cola millenii mesocarp	11696.92±28.3^{a}	6916.7±19.38^{b}	3458.95±21.76^{b}	1834.16±28.25^{a}	973.48±60.26^{a}	1971.29±35.09^{a}	559.74±34.22^{a}	65.71±3.46^{b}
Gardenia erubescens fruit	9775±25.00^{c}	4055 ± 63.63^{c}	4755 ± 7.07^{a}	1165 ± 50^{e}	123.70±0.85^{ecd}	472.60 ± 0.07^{c}	277.80 ±2.90^{d}	113.7±0.64^{b}
Parkia biglobosa pulp	11650±70.71^{b}	7000 ± 10^{a}	3945 ± 7.07^{b}	1795 ± 8.00^{b}	661.56±23.19^{b}	1814.50±49.32^{a}	437.52±10.47^{b}	447.48±1.09^{a}
Strychnos innocua juice	5220±10.24^{e}	3618 ± 21.10^{e}	1930 ± 12.60^{c}	1810±16.40$^{a\,b}$	136.05 ± 3.67^{e}	158.73 ± 4.50^{c}	119.04 ± 2.71^{f}	45.35±0.05^{b}
Strychnos innocua seed	2094±32.48^{g}	3228.1 ± 32.10^{f}	1809.65±12.52^{c}	790.15±14.64^{g}	118.50 ± 2.97^{c}	440.9 ± 0.85^{c}	317.95 ± 3.61^{c}	82.52±0.06^{b}

Mean ± standard deviation of triplicate determinations
Mean with the same superscripts in the same column are not significantly different at 5% probability level

2000mg/day potassium to be met a range of 2.04g of *Bombax glabra* seed to 1.1 g of *Strychnos innocua* seed is required. Sodium ranged between 790 and 1834mg/kg. *Strychnos innocua* seed contained the lowest sodium while *Strychnos innocua* juice had the highest sodium concentration. The range is similar to 1430 and 1580 mg/kg sodium reported for grape fruit juice and orange juice[42]. For RDA of 1.5g/day of sodium to be attained 833g of *Strychnos innocua* juice will have to be consumed.

Manganese ranged between 98.56 and 973.48mg/kg. *Artocarpus heterophyllus* seed contained the lowest manganese concentration while *Cola millenii* seed coat the highest. The level of manganese in the seed and seed mesocarp is significantly different($p<0.05$). Manganese supports the immune system, regulates blood sugar levels and is involved in the production of energy and cell reproduction. It works with vitamin K to support blood clotting. Working with the B- complex vitamins, manganese helps to control the effects of stress. Birth defects can possibly result when an expecting mother does not get enough of this important element[9].

Iron(Fe) ranged between 158.73 and 1971.29mg/kg. *Artocarpus heterophyllus* seed contained the lowest Fe concentration and *Cola millenii* seed mesocarp the highest. The high ascorbic acid concentration of the seed mesocarp might be a strong promoter of the iron, but whether this iron will be available or not is another question. Iron is said to be an important element in the diet of pregnant women, nursing mothers, infants convalescing patients and elderly to prevent anaemia and other related diseases[43]. The recommended daily allowance of iron for men is 7mg / day and 12-16mg/day for women during pregnancy[39]. For RDA of Fe to be provided by *Artocarpus heterophyllus* seed an adult men and women would have to ingest 44g and 100g respectively, while ingestion of 3.5g and 8.0g(for men and women respectively) of *Cola millenii* seed mesocarp would be required to meet the RDA.

Zinc (Zn) content ranged between 119.04 and 559.74mg/kg. *Strychnos innocua* juice contained the lowest concentration of Zn while *Cola millenii* seed mesocarp the highest.

Zinc is said to be an essential trace element for protein and nucleic acid synthesis and normal body development. It plays a central role in growth and development, vital during periods of rapid growth such as infancy, adolescence and during recovery from illness. Zinc deficiency has been largely attributable to the high phytic acid content of diets leading to poor growth, impaired immunity, and increased morbidity from common infectious diseases and increased mortality[36]. All the fruits part investigated can supply the 12mg/day RDA of of zinc for men aged 19-64 years and woman 19-54 years of age[39]. It would require ingestion of a range of 0.1g of *Strychnos innocua* juice to 0.02g of *Cola millenii* mesocarp to meet the daily requirement.

Copper(Cu) ranged between 39.48 and 113.70 mg/kg. *Parkia biglobosa* pulp contained the lowest Cu concentration and *Gardenia erubescens* fruit the highest. Deficiencies of copper have been reported to cause cardiovascular disorders as well as anaemia and disorders of the bone and nervous systems[35]. According to[47], these essential elements are needed for growth, production of bones, teeth, hair, blood, nerves, skin, vitamins, enzymes and hormones. The healthy function of nervous transmission, blood circulation, fluid regulation, cellular integrity, energy production and muscle contraction are influenced by essential elements and too little of any essential element can lead to deficiency disease and too much of any can be toxic[48].

Chromium, lead, cadmium, cobalt, mercury, aluminium, thorium, and arsenic were not detected in the fruit samples by AAS.

The different carbohydrate constituents were reported in TABLE 3.

The total sugar content ranges between 16.47 and 168.49mg/g. The lowest total sugar content was recorded in *Strychnos innocua* seed but highest in *Strychnos innocua* juice. The difference in total sugar in the fruit juice is significantly different from other fruit part investigated.

The total sugar content in *Cola millenii* mesocarp and *Artocarpus heterophyllus* seed is closer to 50mg/g total sugar reported in the core of bread fruit from Nigeria while the levels in *Cola millenii* seed flour, *Bombax glabra* and *Parkia biglobosa* pulp is slightly higher[4].

TABLE 3: Levels of total sugar, reducing sugar, starch content and ascorbic acid in the fruit parts

	Total sugar (mg/g)	Reducing sugar mg/g	Starch content mg/g	Ascorbic acid mg/100g
Artocarpus heterophyllus seed	45.31 ± 3.4[e]	20.85 ± 0.53[c]	532.5 ± 25.98[c]	151.76 ± 0.14[e]
Bombax glabra seed	54.13 ± 0.23[c]	10.54 ± 0.56[e]	149.63 ± 6.30[f]	69.92 ± 0.06[g]
Cola millenii seed	54.63 ± 0.01[c]	14.67 ± 0.18[d]	739.38 ± 12.40[a]	144.26 ± 0.52[f]
Cola millenii mesocarp	47.08 ± 1.22[d e]	4.63 ± 0.26[g]	123.25 ± 0.01[g]	953.33 ± 0.78[a]
Gardenia erubescens fruit	76.47 ± 2.08[b]	53.89 ± 0.64[b]	255.94 ± 16.88[e]	186.27 ± 0.07[g]
Parkia biglobosa pulp	50.67 ± 0.60[d c]	4.27 ± 0.96[g]	151.88 ± 7.95[f]	215.00 ± 0.71[c]
Strychnos innocua juice	168.49 ± 3.67[a]	83.25 ± 0.09[a]	585.01 ± 6.50[b]	274. 73 ± 0.49[b]
Strychnos innocua seed	16.47 ± 0.43[f]	8.24 ± 0.21[f]	461.25 ± 15.90[d]	30.96 ± 0.03[h]

Mean ± standard deviation of quadriplicate determinations
Mean with the same superscripts in the same column are not significantly different at 5% probability level

The reducing sugar ranged between 4.27 and 83.25mg/g. *Parkia biglobosa* pulp contained the lowest reducing sugar while *Strychnos innocua* juice the highest reducing sugar. The reducing sugar content in a carbohydrate sources is partly responsible for browning as a result of Maillard reaction between the reducing sugar and the protein content of the sample. Mailard reaction might not pose any problem in those samples with low level of both protein and reducing sugar[4].

The starch content ranges between 123.25 and 739.38mg/g. The starch content in *Parkia biglobosa* pulp and *Bombax glabra* are not significantly different. *Cola milleni* mesocarp contained lowest level of starch while *Cola millenii* seed the highest level of starch content among the fruit parts investigated. The starch content of *Cola milleni* seed compares favourably with 720mg/g starch in breadfruit pulp in Brazil[44], 770 mg/g breadfruit pulp in Nigeria and higher than 563mg/g and 519mg/g starch in peel and core of Nigeria breadfruit respectively[7]. Also compared to conventional sources of calorie like yam(709mg/g), cassava (884g/g)[34] and green banana pulp(780mg/g)(Erdman, 1986). *Cola millenii* seed can be considered as a good source of starch. The high level of starch content could be explored as source of refined starch as binder in pharmaceutical industries.

Ascorbic acid is important water-soluble vitamin already implicated in most of the life processes but principally functions as an antioxidant. It is present abundantly in fruits and vegetables where the common man in the developing countries receives most of their daily intake[27]. The ascorbic acid content of the fruits parts ranged between 31mg/100g for *Strychnos innocua* seed and 953mg/100g for *Cola millenii* mesocarp. There exist a significant difference between the ascorbic acid of the *Cola millenii* mesocarp and that of the *Cola millenii* seed as well as *Strychnos innocua* seed and *Strychnos innocua* juice. This is in close agreement with[51] observation that the peel of mangoes contained 2 to six times as much vitamin C than their pulp. The relatively high amount of ascorbic acid in the *Cola millenii* mesocarp compared to other fruits part may be due to its acidity arising from the sour taste, since ascorbic acid occur more in acidic medium than at high pH values[33]. The *Cola millenii* mesocarp may then enhance absorption of non-heme iron. The values of the ascorbic acid reported for the fruits except the *Strychnos innocua* seeds are however higher than those recorded in lime, *(Citrus aurantifolia*); 46.5mg/100g edible portion, pawpaw (*Carica papaya*), 43.2mg/100g edible portion, lemon(*Citrus limon*); 35.2mg/100g edible portion, pineapple(*Ananas comosus*) 25.2mg/100g edible portion, sweet banana(*Musa paradisiaca*) species and 'agbalumo' (*Chrysophyllum albidum*); 48.0mg/100g edible portion[42].

The values reported are however similar to a range of 60.3 to 403.3mg/100g ascorbic acid reported for some wild fruits, *Ximenia americana* wild olive; to *Sclerocarya birrea*; Dineygarma[23]. The recommended daily intake(RDI) for ascorbic acid; 30mg/day for healthy women and 40 mg/day for men[39] can be supplied by 20g of *Parkia biglobosa* pulp, *Strychnos innocua* juice and *Gardenia erubescens* fruit usually consumed uncooked. Whereas less than 6g of these raw fruit parts can supply a daily intake of less than l0mg of ascorbic acid needed in a human diet to prevent the onset of scurvy[41].

The levels of the antinutritional factors are reported in TABLE 4. Tannin ranged between 1.0 to 7.5mg/g in the studied samples. The values are not significantly different except for *Gardenia erubescens* fruit. Tannin in fruits import an astringent taste that affect palatability, reduce food intake and consequently body growth. Tannins are known to inhibit the activities of digestive enzymes and nutritional effects of tannin are mainly related to their interaction with protein. Tannin protein complexes are insoluble and the protein digestibility is decreased[16].

The values reported are low to be of any nutritional importance except for *Gardenia erubescens* fruit that recorded the highest value. The value is however low when compare to 13.3, 19.1 and 99.2g/kg tannin reported for cashewnut, fluted pumpkin and raw breadnut respectively[25]. Studies on rats, chicks and livestock revealed that high tannin in diet adversely affects digestibility of proteins and carbohydrates, thereby reducing growth, feeding efficiency, metabolizable energy and bioavailability of amino acids[8]. From medicinal point of view, polyphenol to which tannin belongs has been reported to act as antioxidant by preventing oxidative stress that causes diseases such as coronary heart disease, some types of cancer and inflammation[50]. This shows that fruit like *Gardenia erubescens* is likely to have antioxidant activity.

Phytate ranged between 0.20 and 6.65mg/g. The values reported fall within the level of phytate in Thailand fruits commonly consumed by diabetic patients; longan, 0.37mg/g, dragon; 0.39mg/g, durian; 0.51mg/g, guava; 0.8mg/g, mango; 0.86mg/g and pineapple; 0.90mg/g[49]. The problem with phytic acid in foods is that it can bind some essential minerals nutrients in the digestive tract and can result in mineral deficiencies. There was a significant difference($P<0.05$) in the phytate composition of these fruit parts.

The level is however low and might not pose any health hazard when compared to a phytate diet of 10-60mg/g if consumed over a long period of time that has been reported to decrease bioavailability of minerals in monogastric animals[52].

Phytic acid also bind to phosphorus and convert it to phytate, while other mineral elements like calcium, zinc manganese, iron and magnesium are converted to the phytic complexes, which are indigestible substance, thereby decreasing the bioavailability of these elements for absorption. Phytic acids also have a negative effect on amino acid digestibility, thereby posing problem to non ruminant animals due to insufficient amount of intrinsic phytase necessary to hydrolyze the phytic acid complex, but the presence is also beneficiary because it may have a positive nutritional role as an anti oxidant and anti cancer agent[53].

Trypsin inhibitor unit ranges between 9.64 for *Cola millenii* mesocarp to 58.2 TIU/g for *Strychnos innocua*. *Cola millenii* mesocarp, *Strychnos innocua* juice, *Gardenia erubescens* fruit and *Parkia biglobosa* pulp are usually consumed uncooked. The presence of trypsin inhibitor in uncooked animal feed has long been known to cause diminished growth in rats, chickens and other experimental animals[31]. However this is

TABLE 4: Levels of Anti nutritional factors in the fruit samples

	Tannin mg/g	Trypsin inhibitor unit TIU/g	Phytate mg/g	Oxalate g/100g
Artocarpus heterophyllus seed	1.08 ± 0.03^{b}	44.17 ± 1.26^{b}	0.55 ± 0.10^{cd}	0.23 ± 0.01^{d}
Bombax glabra seed	1.20 ± 0.01^{b}	17.86 ± 0.57^{c}	0.54 ± 0.04^{cd}	0.46 ± 0.01^{c}
Cola millenii Seed	1.27 ± 0.06^{b}	14.86 ± 0.12^{e}	3.90 ± 0.30^{b}	0.56 ± 0.14^{c}
Cola millenii mesocarp	1.33 ± 0.06^{b}	9.64 ± 0.32^{g}	0.38 ± 0.02^{cd}	0.25 ± 0.10^{d}
Gardenia erubsecens fruit	7.5 ± 0.71^{a}	16.5 ± 0.54^{d}	0.24 ± 0.02^{d}	1.10 ± 0.10^{a}
Parkia biglobosa pulp	1.08 ± 0.20^{b}	15.55 ± 1.10^{e}	0.20 ± 0.05^{d}	0.93 ± 0.10^{b}
Strychnos innocua juice	1.01 ± 0.01^{b}	10.12 ± 0.22^{f}	0.72 ± 0.02^{c}	1.17 ± 0.10^{a}
Strychnos innocua Seed	1.12 ± 0.05^{b}	58.2 ± 1.60^{a}	6.65 ± 0.60^{a}	0.31 ± 0.01^{d}

Mean + S.D. of triplicate determinations.
Mean with the same superscripts in the same column are not significantly different at 5%

low when compared to a range of 15000 to 23000 TIU/g and 6700 to 23300 TIU/g reported for *Phaseolus vulgaris* and cowpea respectively[6,22]. Typsin inhibitor are heat labile and can be inactivated by heat treatment such as steaming and extrusion cooking[32]. The level of trypsin inhibitor in raw *Artocarpus heterophyllus* and *Cola millenii* seed might be destroyed by boiling, baking or roasting.

Oxalate is a concern because of its negative effect on mineral availability. High oxalate diet can increase the risk of renal calcium absorption and has been implicated as a source of kidney stones[17]. Oxalate ranged between 0.23 for *Artocarpus heterophyllus* seed and 1.17 g/100g for *Strychnos innocua* juice.

The levels of oxalate in the different fruit part is similar to 0.33g/100g oxalate in orange pulp, 0.28g/100g; Okro, 0.99g/100g; red pepper and 1.31g/100g; tangarine pulp[38]. The levels of oxalate in the studied fruit may not play important role in their nutritive values. The highest oxalate level of 1.17g/100g in *Strychnos innocua* juice would require ingestion of 3.85kg dry matter to provide the 45g reported to be toxic to mature sheep[37,38] have revealed that the possibility of oxalate poisoning in Nigeria from consumption of local fruits and vegetables is as remote as it in other parts of the world. Spinach that recorded 19.72g/100g oxalate can only be hazardous if there is calcium oxalate interaction in the body.

CONCLUSION

The data reported show that the various fruits part are rich in nutrients and can serve as potential sources of food nutrient for man and livestock. The low level of antinutrients and high level of ascorbic acid may enhance mineral availability in composite meals. Further study is however needed to determine the digestibility and bioavailability of these plant foods.

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