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Garcinia kola Fruit Pulp: Evaluation of It's Nutrient, Phytochemical and Physicochemical Properties

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Authors' contributions

This work was carried out in collaboration between all authors. Author ANC designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors OO and AUB managed the analyses of the study. Author AUB managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Garcinia kola fruit pulp is often discarded as an agro-waste but few human populations consume it as food. Nutrient, phytochemical and physicochemical constituents of ripe *Garcinia kola* fruit pulp were evaluated on wet weight basis. Results on proximate composition indicated a high moisture content of 85.33%. Ash, fat and crude fiber had values less than 1%. The most abundant mineral element analyzed was potassium which had a value of 64.48 mg/100 g while vitamin C was the most abundant vitamin and had a value of 50.20 mg/100 g. Hydrogen cyanide, oxalates, phytates and tannins were found in low concentrations. Saponins and caroteniods were in appreciable quantities more than all other phytochemicals analyzed. *Garcinia kola* fruit pulp had a low pH of 2.60 with a titrable acidity of 0.81%. Reducing sugar content was 8.75% while non reducing sugar had a value of 1.75%. It's low pH value and the presence of antioxidant phytochemicals with low antinutritional factors can be harnessed by combining it with other fruits to produce mixed fruit juice or in nectar to serve as an acidifying agent.

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1. INTRODUCTION

Fruits are referred to as juicy seed-bearing structure of flowering plants that may be eaten as food [1]. A wide variety of edible fruits and seeds exists with some being underutilized throughout the world [2]. Different fruit parts are consumed primarily as food which may be the fruit pulp or the seed. These provide nutrients and beneficial phytochemicals which proffer health benefits. *Garcinia kola* tree grows in the humid rainforest near the coast as a medium sized tree which tolerates shade [3]. It belongs to the family Guttiferae. In Igbo land south- eastern Nigeria, it is called 'Akuilu' and is commonly called 'Orogbo' in the Yoruba language while its English name is 'Bitter kola' [4]. The fruit part most commonly consumed is the seed but rarely the fruit pulp. Bitter kola seed can synthesize some phytochemicals which are secondary metabolites that have a broad range of biological effects due to their antioxidant and protective properties [5]. There is a report that the fruit pulp is used in the treatment of jaundice and high fever in some localities, while the stem branches and roots are commonly used in the production of chew sticks [3].

Several reports have been given about the seeds such as its nutrients, phytochemicals and bioactive components as well as it's antimicrobial activity. The pulp has been reported to be a potential substrate for the production of ethanol [6]. There is limited knowledge on the complete nutritional value (including minerals and some vitamins), phytochemical and physicochemical properties of the fruit pulp which is discarded as an agro waste. Phytochemicals are plant metabolites which include both beneficial and antinutritional compounds. Physicochemical properties which include viscosity, pH, total soluble solids, acidity and total sugars influence acceptability and processing of fruits. It is in view of this that *Garcinia kola*-fruit pulp was evaluated for its nutrient, mineral, vitamin, phytochemical and physicochemical properties. It will promote its utilization as a food source rather than being discarded as an agro waste.

2. MATERIALS AND METHODS

2.1 Collection and Preparation of Samples

Garcinia kola-fruit was procured in the month of October 2015 from farms where they grow in Awo-Omamma in Oru-East Local Government Area of Imo State, Nigeria. It was harvested in its mature green state. Fruits were allowed to ripen before they were cut open and seeds were extracted while the pulp was recovered by scraping using a clean spoon. The orange color paste obtained was blended in master chef super blender to get a homogenous mixture and used for the analysis.

2.1.1 Proximate composition analysis

Proximate composition analysis of the blended fruit pulp was found by established methods described by [7]. Crude protein determination was done by the micro Kjedhal method, and nitrogen content was multiplied by 6.25 and expressed in percentage. Ash content was analyzed by the muffle furnace incineration gravimetric method at 550℃ while fat was determined by gravimetric solvent extraction method. Crude fiber was determined by the Weende method while moisture determination was done by drying the pulverized pulp in an oven at 65℃ to a constant weight. Carbohydrate was calculated by difference as nitrogen free extract using the formula: 100 - [% Moisture + % Ash + % Fat + % Crude fiber +% Crude protein]. Energy value of the fruit pulp sample was estimated in Kcal/100 g by multiplying the percentage of crude protein, lipid and carbohydrate by the factor of 4,9 and 4.

2.1.2 Mineral analysis

Minerals namely calcium, magnesium, phosphorus, sodium, potassium, iron and zinc were analyzed based on the role they play in symptoms associated with some metabolic and deficiency diseases. They were analyzed by dry ash extraction method [7]. 5 g of the fruit pulp was ashed in a muffle furnace and allowed to cool in a desiccator and 2 ml of 2 M HCl was added to it in a conical flask. Deionized water was added to each sample solution up to the 100ml mark. This was used for analyzing the various mineral elements. Sodium and potassium were analyzed by flame photometry; phosphorus was analysed by the Vanodomolybdate yellow colorimetric method, calcium and magnesium were done by Vernasate EDTA Complexometric titrimetry all described by [7]. Zinc was analyzed colorimetrically while iron was analyzed by Orthophenanthroline red ferrous complex method both described by [8].

2.1.3 Vitamin analysis

Vitamins A, C and E were determined by the methods described by [9] while vitamins B1, B2 and niacin were determined by the methods described by [10]. All vitamins were determined using a UV-spectrophotometer except Vitamin C. Vitamin A was extracted from 5 g *Garcinia kola* pulp using a mixture of absolute ethanol and 5% potassium hydroxide (10:1) which was boiled for 30 mins under reflux before cooling under running water. The resultant solution was transferred into a separating funnel and 150 ml petroleum ether was added. The lower aqueous layer was discarded while the supernatant was recovered and evaporated to dryness on a rotary evaporator before re-dissolving in 10 ml isopropyl alcohol. Similarly, 10 ml isopropyl alcohol was added to 1 ml Vitamin A to give a standard solution containing 100 mg of vitamin. Absorbance of test samples and standard were measured in a spectrophotometer at 540 nm.

Vitamin C was determined by homogenizing the sample in 50 ml EDTA solution before filtering. 20 ml of the filtrate was taken, 10 ml of 30% potassium iodide was added to it followed by 1% starch solution. The mixture was titrated against 0.1 M Copper sulphate solution.

Vitamin E was extracted from 5 g *G. kola* pulp using a mixture of 20 ml absolute ethanol and 20 ml ethanolic sulphuric acid solution (1:2) in a volumetric flask wrapped with aluminum foil. The mixture was boiled under reflux for 45 mins and cooled. 50 ml distilled water was added to boiled mixture and transferred to a separating funnel wrapped in aluminum foil. 150 ml diethyl ether was added. The lower aqueous layer was discarded while the supernatant was recovered. 1 ml of the supernatant was put into a test tube and 1 ml HNO_3 was added drop wise before the solution was boiled at 90°C in a boiling water bath for 3 mins and cooled. Similarly, 1 ml HNO_3 was added to 1 ml Vitamin E to give a standard solution containing 100 mg of vitamin. Absorbance of test samples and standard were measured with spectrophotometer at 470 nm.

2.1.4 Phytochemical analysis

Polyphenol was determined by Folin-Ciosptean spectrophotometric method [11] while oxalate was determined by titrimetric method [12]. Folin Dennis colorimetric method was used for the analysis of tannin [9]. Hydrogen cyanide was determined by alkaline picrate spectrophotometric method while phytate was determined using 2,2-Bipyrimidine solution and absorbance was measured in a spectrophotometer at 510 nm [13]. Alkaloid was determined using alkaline precipitation and gravimetric measurement while saponin was determined using double solvent extraction and gravimetric measurement described by [14]. Carotenoid was extracted using organic solvents and measured gravimetrically while flavonoids were analyzed by precipitation using ethyl acetate and gravimetric measurement described by [14]. Phytosterol was analyzed by precipitation and spectrophotometric measurement described by [15].

2.1.5 Physicochemical analysis

pH of the sample was determined by the method described by [16]. 1 g of pulp was homogenised by boiling in 10 ml deionized water of pH 7.0. 5ml of homogenate was used. pH of pulp was recorded using an electronic pH meter. The pH meter was standardized with the help of buffer solution.

Total Titrable Acidity was determined by the method of [17]. 20 g sample was mixed and filtered using muslin cloth. 5 ml of filtrate was dissolved in boiled distilled water and made up to 50 ml mark in a conical flask. 5 ml aliquot of sample was taken and titrated with 0.1 N NaOH using phenolphtalein indicator. Percentage titrable acidity was calculated using the formula:

$$= V x N x D x 0.0064$$

where,

V= Titre value obtained,
N= Normality of titrant,
D= Dilution factor (50)

Viscosity of the pulp was determined using Brookfield dial viscometer described by [17]. 100 ml of the pulp was put in a beaker and read using spindle number 2 at a speed of 30 rpm. Viscosity reading in Centipoise was calculated using the formula:

Dial reading x 10

Total soluble solid (TSS) of *G. kola* fruit pulp was determined using a refractometer (Bellingham and Stanley, London) by placing a drop of pulp solution on its prism. The percentage of TSS was obtained from direct reading of the refractometer. Total sugar of *G. kola* fruit pulp was determined colorimetrically by the anthrone method [18]. 5 g of pulverized pulp was boiled in 100 ml of 2 M HCl solution for 30 mins to hydrolyze sugars in it. After which, the solution was allowed to cool at room temperature and then filtered through Whatman No. 1 filter paper into a beaker. Aliquot of 1 ml of the filtrate was mixed with 6 ml Anthrone reagent in a test tube and boiled in a water bath for 10 mins and cooled. Similarly, a standard curve of glucose was prepared by taking 0.1, 0.2, 0.4, 0.6, 0.8 and 1 ml of standard glucose solution in different test tubes containing 10, 20, 40 60, 80 and 100 µg of glucose respectively, and the volume was made up to 1ml using distilled water. Then 6 ml of anthrone reagent was added to each test tube and mixed well before boiling in a water bath for 10 mins and then cooled. A reagent blank was prepared by mixing 1 ml distilled water with 6 ml anthrone reagent in a test tube before boiling in a water bath for 10 mins and cooled. the absorbance of these solutions were measured at 620 nm using the reagent blank to standardize the spectrophotometer to 0.

The amount of total sugar present was calculated from the standard curve of glucose. The percentage of total sugar was calculated using the formula:

$$\%\ \text{Total sugar} = \frac{100}{W} \times \frac{Au}{As} \times \frac{C}{1} \times \frac{Vt}{Va}$$

Where:

W- Weight of sample analyzed, Au- Absorbance of sample, As- absorbance of standard sugar solution, C- Concentration of standard sugar solution (mg/ml), Vt- total volume of hydrolyzed sample, Va-Volume of hydrolyzed sample analyzed

Reducing sugar content in *G. kola* fruit pulp was determined by dinitrosalicylic acid method [7]. Non reducing sugar was calculated using the formula:

% Non reducing sugar = % Total sugar - % Reducing sugar [7]

2.1.6 Statistical analysis

Calculations were done using SPSS version 20 for windows. Values are reported as Mean ± Standard Deviation.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition

Proximate composition of *Garcinia kola*-fruit pulp on wet weight basis is shown in Table 1. Moisture content was found to be 85.33% which is lower than 92.62% as reported [19] for *G. kola*-fruit pulp from Ondo State, Nigeria. Moisture content of the fruit pulp reported in this work was higher than moisture content of *Annona squamosa* (70%), *Vitex doniana* (16.66%) on dry weight basis, *Detarium microcarpum* (11.06%) on wet weight basis, *Ficus exasperata* fruit (7.58%), *Haematostaphis bateri* fruit pulp (3.56%) on dry weight basis [20,21,22,23,2], but comparable to moisture content of *Opuntia ficus* (87.07%) on wet weight basis [24]. The high moisture content of *G. kola*-fruit pulp was as a result of the pulp not being dried when compared with a moisture content of some fruits whose moisture content were determined on their dry weight basis. Most fruits are known to have a relatively high moisture content which makes them susceptible to microbial attack especially when they are not preserved in controlled cold storage conditions. High moisture content of *G. kola*-fruit pulp suggests that it will aid digestion such as movement of nutrients. This being that moisture content in foods represents its water content. Water serves as a carrier for nutrients and waste products [25].

Ash content of *G. kola* fruit pulp obtained were comparable to the ash and fat content of *G. kola*-fruit pulp from Ondo State, Nigeria [19] which had values of 0.26% and 0.38% respectively. Ash in *G. Kola* fruit pulp was lower than ash of *D. microcarpum* fruit pulp (4.47%) and *O. ficus* (4.03%) on wet weight basis [22,24]. Ash an index of mineral content therefore, indicates that *G. kola*-fruit pulp on wet weight basis may not be a good source of minerals except when dehydrated. Drying concentrates some nutrients. Previous researches have reported that the removal of water by heat affect nutrient content of food in various ways [26]. It does so by either increasing the concentration of some nutrients making them more available or decreasing nutrient concentration [27]. Fat content observed for *G. kola* fruit pulp was lower than that of *D. microcarpum* (2.23%) [22] but comparable to fat of *O. ficus* (0.40%) [24] on wet weight basis. It indicates that *G. kola*-fruit pulp will not provide a high amount of storable energy because of its low-fat content. However, most fruits are not good source of fat.

Crude fiber content observed was lower than crude fibre content of *O. ficus* (1.37%) and *D. microcarpum* (12.19%) as reported [24,22] while [19] reported 0.53%for *G. kola* pulp from Ondo State. Fiber aids digestion. It does this by changing the nature of the contents of the gastrointestinal tract and can change how other nutrients and chemicals are absorbed through bulking and viscosity [28]. It indicates that *Garcinia kola* fruit pulp may not be sufficient to perform this function. The percentage of crude protein was found to be comparable to 1% for *G. kola* fruit pulp from Ondo state [19] and 1.03% in *O. ficus* [24]. Carbohydrate content obtained was higher than carbohydrate (5.81%) of *G. kola* fruit pulp from Ondo State as reported [19] but lower than carbohydrate for *O. ficus* (92.57%) and *D. microcarpumm* (65.38%) on a wet weight basis [24,22]. Energy value was 57.05 KCal/100 g. It indicates that the fruit pulp has a low glycemic index hence, it will give low energy and this may be beneficial for humans who have poor metabolic control in their blood sugar such as in diabetes mellitus.

Table 1. Proximate composition of *Garcinia kola* fruit pulp on wet weight basis

Parameter	Value
Moisture (%)	85.33 ± 0.18
Ash (%)	0.34 ± 0.06
Fat (%)	0.45 ± 0.02
Crude fiber (%)	0.63 ± 0.01
Crude protein (%)	1.28 ± 0.06
Carbohydrate (%)	11.98 ± 0.16
Energy value kcal/100 g	57.05 ± 0.59

Values are Means ±Standard Deviation

3.2 Mineral Contents

The mineral contents of *Garcinia kola*-fruit pulp on a wet weight basis are presented in Table 2. Results indicated that *G. kola* pulp had appreciable potassium (64.48 mg/100 g) more than sodium (21.42 mg/100 g). The low sodium but higher potassium content may be of benefit to hypertensive patients because potassium lessens the effects of sodium [29]. Potassium intake has been reported to play a major role in regulating blood pressure [30]. Although sodium has been implicated in increasing blood pressure, it was quite low to elicit such reactions in the body when consumed. Sodium works in concert with potassium to maintain healthy water balance in the body [31].

Magnesium, phosphorus, iron and zinc content were found to be low. As such it may not be a good source of these mineral elements. Calcium was one mineral element which was found to be present in relatively good quantity besides sodium and potassium. Calcium content reported for *G. kola* fruit pulp was quite low when compared with that of many other fruits on dry weight basis. Consumption of calcium over time can help prevent osteoporosis and builds healthy bones and teeth. It is necessary for blood clothing, for sending and receiving nerve signals, squeezing and relaxing muscle [32].

Table 2. Mineral contents of *Garcinia kola* fruit pulp on wet weight basis

Mineral Element	Value
Sodium (mg/100 g)	21.42 ± 0.06
Potassium (mg/100 g)	64.48 ± 0.12
Magnesium (mg/100 g)	8.20 ± 0.05
Calcium (mg/100 g)	26.89 ± 0.03
Phosphorus (mg/100 g)	5.23 ± 0.08
Iron (mg/100 g)	1.21 ± 0.04
Zinc (mg/100 g)	0.85 ± 0.04

Values are Means ± Standard Deviation

3.3 Vitamin Contents

Vitamin composition of *Garcinia kola*-fruit pulp on wet weight basis is shown in Table 3. Vitamin A content obtained was higher than what was reported for *Vitex doniana* fruit pulp (0.27 mg/100 g) on dry weight basis [21]. Vitamin A is involved in immune function, vision, reproduction and cellular communication [33,34,35]. Vitamin B1 (thiamin), B2 (riboflavin) and niacin serve as co-enzymes which are involved in energy production. Niacin had the highest value of the three B vitamins analyzed in *G. kola*-fruit pulp. It is needed for the conversion of dietary proteins, fats and carbohydrate into usable energy and also serves as dietary antioxidant [36,37,38].

Vitamin C was found to be the most abundant of the vitamins analyzed. It's value was comparable to 55.10 mg/100 g of *D. microcarpum* fruit as reported [22] but higher than vitamin C content reported for *Garcinia kola*-fruit pulp from Ondo State (1.25 mg/100 g), *V. doniana* fruit pulp on dry weight basis (35.58 mg/100 g), *O. ficus* (5.17 mg/100 g) on wet weight basis [19,21,24]. It serves as an antioxidant [39], aids in the regeneration of other antioxidants within the body including vitamin E and plays a significant role in immune function and absorption of non heme iron [40]. Therefore with the presence of vitamin

C in *G. kola*-fruit pulp, its consumption may be of benefit in human nutrition.

Results indicated that *G. kola*-fruit pulp had vitamin E content and was lower than what was reported as vitamin E content of *D. microcarpum* (12.44 mg/100 g) [22]. Vitamin E is a fat-soluble antioxidant which stops the production of reactive oxygen species formed when fat undergoes oxidation [41]. What was present in *G. Kola* fruit pulp may contribute to dietary intake of vitamin E when consumed, hence preventing lipid peroxidation of unsaturated fatty acids in cells.

Table 3. Results on some vitamins of *Garcinia kola* fruit pulp on wet weight basis

Vitamin	Value
A (mg/100 g)	1.23±0.02
B_1 (mg/100 g)	0.45±0.04
B_2(mg/100 g)	0.07±0.004
Niacin (mg/100 g)	1.46±0.04
C (mg/100 g)	50.20±0.06
E (mg/100 g)	4.70±0.03

Values are Mean ± Standard Deviation

3.4 Phytochemical Contents

In Table 4, phytochemical contents of *Garcinia kola*-fruit pulp on wet weight basis is presented. Its hydrogen cyanide content was comparable to hydrogen cyanide content of *D. microcarpum* fruit (0.07 mg/100 g) [22] but lower than hydrogen cyanide content of *Icacina senegalenses* (3.39%) and *Ficus sycomorus* (3.05%) on dry weight basis [42].

Its oxalate content was quite lower than what has been reported for many known fruits. Low oxalates in foods is beneficial in human nutrition. Phytate content reported for *Garcinia kola*-fruit pulp (0.27 mg/100 g) was lower than what was reported as phytate content of *Garcinia kola*-fruit pulp from Ondo State (1.64 mg/100 g) [19], *I. senegalenses* (2.17%), *F. sycamorus* (1.08%) [42] but comparable to that of *D. microcarpum* (0.41 mg/100 g) [22]. Total phenols and flavonoid content of *G. kola* fruit pulp had values of 0.13 mg/100 g and 0.35 mg/100 g respectively. These values were quite lower than what was reported as total phenols, and flavonoid of *G. kola*-fruit pulp from Ondo State reported by [19] which had values of 9.94 mg/100 g and 1.15 mg/100 g respectively. Variations were observed for phytate, oxalate, total phenol and flavonoids in *Garcinia kola*-fruit pulp from Imo State and Ondo State, Nigeria. These variations could be as a result of environmental conditions, genetic changes, the age of maturity, post-harvest handling and season which exert significant differences in chemical composition of plants [43,44,24].

Carotenoid is an antioxidant phytochemical. Carotenoids are known to be very efficient singlet oxygen quenchers (O2) as well as potent scavengers of other reactive oxygen species (ROS) [45,46]. It indicates that carotenoid (4.13 mg/100 g) in the orange color fruit pulp of *Garcinia kola* discarded as an agro waste can be harnessed and incorporated in human diets so as to proffer health benefits that may be derived from it.

Tannin content was the same as tannin of *G. kola*-fruit pulp from Ondo State as reported [19]. Tannin of *G. kola*-fruit pulp was slightly lower than that of *D. microcarpum* (0.17 mg/100 g) [22]. Tannins belong to a large class called polyphenols and some have beneficial effects in biological systems such as cancer prevention [47]. High tannin concentration in foods may be deleterious due to its ability to bind proteins making them unavailable for digestion. The anti-nutritional activity of tannin depends on type and concentration present in food [48]. However, what was observed as tannin content of *G. kola*-fruit pulp is quite low to elicit negative reactions associated with it.

Alkaloid was found to be 1.39 mg/100 g comparable to 1.00 mg/100 g for *G. kola*-fruit pulp from Ondo State [19]. Similarly saponins (5.03 mg/100 g)was comparable to saponins in *G. kola*-fruit pulp from Ondo State which had a value of 5.12 mg/100 g [19] as well as *Syzygium samarangense* (4.77%) [49] but higher than saponin content of *Hibiscus sabdarifa* (1.46%), *I. senegalensis* (2.56%), *F. sycamorus* (1.75%), *D. microcarpum* (2.73 mg/100 g) [49,42,22].

Saponins have been reported to have varied activities such as anti-tumor, cholesterol lowering, immune potentiating, anticancer, antioxidant effects [50]. It is therefore envisaged that saponins present in *G. kola*-fruit pulp may proffer such health benefits when consumed.

3.5 Physicochemical Characteristics

Table 5 shows results on some physicochemical characteristics of *Garcinia kola* fruit pulp. pH is a major factor in fruit processing industry [51]. This is because variations in pH can impact flavor, consistency and shelf life [52]. The pH of the fruit pulp was found to be comparable to 2.80 in *Chaenomeles japonica* fruit [53] but lower than 4.27 in varieties of ripe *Lycopersicon esculentum* pulp and 6.85-6.96 in varieties of ripe *Mangifera indica* pulp [51,54]. Low pH of *G. kola*-fruit pulp indicates high acidity. This property can be harnessed by combining it with other fruits to produce mixed fruit juice or in nectar to serve as an acidifying agent.

Table 4. Phytochemical contents of *Garcinia kola* fruit pulp on wet weight basis

Phytochemical	Value
Hydrogen cyanide (mg/100 g)	0.06±0.01
Oxalate (mg/100 g)	0.03±0.001
Phytate (mg/100 g)	0.27±0.001
Total Phenols (mg/100 g)	0.13±0.01
Flavonoids (mg/100 g)	0.35±0.07
Carotenoid (mg/100 g)	4.13±0.06
Phytosterol (mg/100 g)	0.08±0.00
Tannin(mg/100 g)	0.05±0.002
Alkaloids(mg/100 g)	1.39±0.05
Saponin (mg/100 g)	5.0±0.16

Values are Means ± Standard Deviation

Table 5. Physicochemical characteristics of *Garcinia kola* fruit pulp on wet weight basis

Parameter	Value
pH	2.60 ±0.14
Titratable acidity (%)	0.81 ±0.01
Viscosity (Centipose)	55.0 ±1.41
Total soluble solids (°Brix)	14.25 ±0.35
Total sugar	10.50 ± 0.28
Reducing sugar	8.75 ± 0.21
Non-reducing sugar	1.75 ± 0.07

Values are Means ± Standard Deviation

Titrable acidity was found to be lower than 2.47 to 3.77% in varieties of *M. indica* [54], (3.5 to 4.5%) in *C. japonica* [53], 10.26% in *Syzygium javanica* [55] but higher than 0.438% to 0.459% in *L. esculentum* [51]. Viscosity of *G. kola* fruit pulp was higher than 1.14 -1.25 Centipose in *C. japonica* as reported [53]. Viscosity of fruit juices and fruit nectar is correlated to the amount of dispersed soluble solids in the aqueous medium. Total soluble solids in *G. kola* fruit pulp was lower than 62.79% in *S. javanica* [55], but higher 8.1 to 9.1% at 5°C storage in *C. japonica*, 7.83% at 3 days of storage in *L. esculentum*, 7.73 to 8.83% at 0 day of storage and 10.60 - 11.58% at 3 days of storage in *M. indica* [53,51,54]. Total soluble solids in ripe fruits are dependent on hydrolytic changes in starch concentration during ripening in post-harvest period [56]. The total sugar, reducing sugar and non reducing sugar contents of *G. kola* fruit pulp had values of 10.50%, 8.75% and 1.75% respectively.

4. CONCLUSION

Garcinia kola fruit pulp which is often disposed as an agricultural waste can be harnessed as edible human food. It had low anti-nutritional factors such as hydrogen cyanide, oxalate and phytates but had carotenoids, flavonoids as well as saponins and alkaloids which are known to proffer beneficial health effects. Appreciable quantities of antioxidant vitamins especially vitamin C were also reported in the pulp with low sodium but higher potassium. This will be of benefit for curbing health challenges such as hypertension. The low pH of *Garcinia kola* fruit pulp and the presence of antioxidant phytochemicals such as carotenoids, flavonoids and tannins together with saponins and alkaloids will be of benefit in combination with other fruits as acidifying agent in fruit nectar or modified in forms that may be organoleptically acceptable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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