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Proximate Composition and Nutritional Analysis of Seeds and Testas of *Dacryodes edulis* and *Garcinia kola*

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Authors' contributions

This work was carried out in collaboration between all authors. Authors RUBE, UOE, UME, GMI, EBU, NWN, OEE, SS and NUB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors UOE, SS and NUB managed the analyses of the study. Authors RUBE and UOE managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Dacryodes eludis and *Garcinia kola* are two plants amongst others that are rightly regarded as underutilized. The aim of this study was therefore to examine the seeds and testas of *G. kola* and *D. eludis* for the presence of nutrients, minerals, vitamins and anti-nutrients. The analyses were done using standard techniques and the resulting replicate readings subjected to analysis of variance (ANOVA) for significance. The results of the proximate composition revealed that both seeds and testas of the studied plants were very rich in nutrients. The moisture content was more in the testas than the seeds of both plants but was highest in the testa of *D. eludis* (41.00±0.01 g/100 g

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dry matter). The ash and protein contents were almost similar in both plants. Fat and fibre contents were higher in the *G. kola* while the testa of *D. eludis* had more carbohydrate (71.88±0.02 g/100 g dry matter). Consistently, *G. kola* had more vitamins than *D. eludis*. However, the most abundant vitamin was B which ranged from 213.07 to 224.70 (mg/100 mL) while the least in both plants was vitamin E that ranged from 2.08 to 3.14 (mg/100 mL). Mineral analysis showed the presence of minerals such as Na, K, Ca, Mg, Fe, Zn, Cu and P in *G. kola* and K, Ca, Mg, P and N for *D. eludis*. Anti-nutrients analysis revealed the presence of hydrocyanic acid, soluble and total oxalate, and phytate with *G. kola* having the highest concentrations of all the anti-nutrients. Analysis of replicate readings for all examined parameters showed significance ($p < 0.05$). There is a need to further studies aimed at their utilization in human and livestock nutrition and industry.

Keywords: Garcinia kola; Dacryodes eludes; anti-nutrients; vitamins; minerals.

1. INTRODUCTION

Plants not only form the integral part of the world's food chains, they are also a source of medicine, raw material, food, and so on for man and animals. Most of the plants parts such as fruits, seeds and vegetables, though very rich in amino acids, minerals and vitamins have limited use in human and livestock nutrition because of unknown levels of anti-nutrients they may contain. Despite renewed interests in medicinal plants across the world and the fact that *Dacryodes eludis* and by extension *Garcinia kola* are rich in nutrients, both plants are largely regarded as underutilized tree crops [1].

African pear (*Dacryodes eludis*) is a tree crop that is largely cultivated mainly for its oily fruit that is rich in amino acids and triglycerides [2]. It is indigenous to the equatorial and humid tropical climates of Central and West Africa, and Gulf of Guinea. Furthermore, two major types of African pear have been identified namely: *D. e. var. edulis and D. e. var. parvicarpa* [3-5]. Its extracts and secondary metabolites have been found to exhibit interesting activities such as antimicrobial, antioxidant and anti sickle-cell disease properties [4]. Studies abound that show that the seeds of *D. eludis* is rich in ash, dry matter, protein, fibre, metabolisable energy, ether extract, essential and non-essential amino acids, vitamins and minerals [1,6,7].

Garcinia kola on the other hand, is a medium sized tree that is extensively distributed across the West Africa countries. In Nigeria, the seeds of *G. kola* are usually consumed but not the testa for various medicinal purposes [8]. Studies have also shown that it is rich in phytochemicals, nutrients, minerals and vitamins [9-12].

From antiquity, plants have always been a source of food and medicine to not just man but also to animals. African pear also known as *Dacryodes eludis* is so versatile that the seeds have been used in the production of biodiesel with an extractable yield of 59%. Interestingly, the biodiesel obtained meet acceptable and allowable ASTM (American Society for Testing and Materials) and European Norm (EN) limits [13]. Iyawe [14], showed the seeds of *D. eludis* contain anti-nutrients such as oxalate, tannins and trypsin inhibitory activity in high concentration. Physicochemical properties of the seeds also showed valuable properties of industrial importance. In Nigeria, although the seeds of *G. kola* are very valuable, the thin testa is usually thrown away. On the other hand, the seeds and testa unlike the edible pulp of *D. eludis* are also usually thrown away despite their potential nutritive and medicinal properties. The aim of this study was therefore to examine the seeds and testa of both plants for potential nutrients and anti-nutrients.

2. MATERIALS AND METHODS

2.1 Collection, Identification and Preparation of Samples

Freshly harvested samples used in this study were purchased locally from dealer in Etim Ekpo Local Government Area of Akwa Ibom State and identified as *Dacryodes eludis* and *Garcinia kola*. The seeds and testas of the samples were then processed into powders and stored separately at 4°C for further analysis.

2.2 Proximate Composition Analysis

The freshly prepared samples were immediately subjected to proximate nutrient composition analysis and components analysed were moisture, ash, protein, fat and carbohydrate.

This was done as previously described by the Association of Official Analytical Chemists [15].

2.3 Moisture

Exactly 5 g each of the seeds and testas of both plants were weighed and oven dried to a steady temperature of 70°C. The amount of moisture in each samples were then expressed as loss in weight after cool weighing.

2.4 Ash Content

Five grams of each sample were placed in a crucible and heated to 550°C to eliminate organic components. The crucible and its contents were then cooled and weighed, and the ash evaluated as a proportion of the original dry weight of samples.

2.5 Crude Protein

This was done using the micro-Kjedahl method. The nitrogen proportion of the protein in 5 g of each of the sample was converted into ammonium sulphate by digestion with concentrated hydrogen tetraoxosulphate (VI) acid using copper sulphate as a catalyst. The liberated ammonia was collected in boric acid double indicator solution and the nitrogen quantified through standard hydrochloric acid titration until end point was reached. The amount of crude protein was then obtained by multiplying by a factor of 6.25.

2.6 Crude Fat

Crude fat was extracted from both plant samples using 5 g of the plant samples, petroleum ether and soxhlet extractor apparatus. The weight of the fat obtained after evaporating off the petroleum ether from the extract gave the crude fat in the samples and this was expressed as a percentage.

2.7 Crude Fibre

Five grams of the defatted samples were used to determine the fibre contents in samples via extraction by acid digestion, filtration and base digestion. The resulting residues were eventually ignited at 550°C. Fibre content was then expressed as a percentage lost on ashing and initial weight.

2.8 Carbohydrate

The amount of carbohydrate in each of the sample was then estimated as the difference from 100 of the sum of crude protein, fat, ash, and fibre.

2.9 Estimation of Anti-nutrients

The anti-nutrients examined in all the seeds and testas of both plants were hydrocyanic acid, phytic acid and oxalate. These were estimated using procedures previously described [16-18].

2.10 Hydrocyanic Acid (HCN)

Exactly 10 g of each of the sample was soaked in 300 ml of distilled water for 4 hours to allow for the liberation of the cyanide. The liberated cyanide was steam distilled into 20 ml (2.5% w/v) NaOH. About 8 ml of NH_4OH was added to the distillate before titrating with 0.02 M $AgNO_3$ to a faint and permanent turbidity. The HCN was then estimated using 1 ml of 0.02 $AgNO_3$ as the equivalence of 1.08 mg of HCN.

2.11 Phytic Acid

Two grams of each of the samples were extracted with 0.5 M HCl. Ferric chloride was used to precipitate the phytic acid to ferric phytate. NaOH solution was then used to convert the precipitate into sodium phytate and then digested with acid mixture containing equal portion of concentrated H_2SO_4 and $HClO_4$. The liberated phosphorus was then quantified colorimetrically at 620 nm after colour development with molybdate solution.

2.12 Oxalate

About 2.5 g of the sample was extracted with dilute HCl. The oxalic acid in the extract was precipitated with calcium chloride as calcium salts. The precipitated oxalate was washed with 25% H_2SO_4 and dissolved in hot water before titrating with $KMnO_4$.

2.13 Determination of Vitamins

Vitamins A, E, B and C were determined according to methods previously described [19-22].

2.14 Determination of Mineral Elements

The mineral elements were determined by the dry ash extraction method of AOAC [23].

2.15 Statistical Analysis

Replicate readings were subjected to one way analysis of variance (ANOVA) for each of the samples and the examined parameters. The replicate readings for both seeds and those of the testa for each sample were also compared using Student t-test for significance. Probability level was set at 95% (0.05).

3. RESULTS

The results of the study are presented in Tables 1 to 5. Table 1 shows the parts of the samples used, local names and scientific names. The proximate composition (g/100 g) of seeds and testas of both plants are shown in Table 2. The results indicates that the seed of *D. edulis* was richer than the testa in carbohydrate 71.88±0.02, protein 9.62±0.01, ash 5.50±0.02 and fat 8.0±0.10 while the testa was richer in moisture 41.10±0.01 and fibre 13.50±0.02. However, for *G. kola*, the result showed that the seed was richer in protein, fat and carbohydrate than the testa which had more fibre, moisture and ash than the seed. Statistical analysis of replicate readings showed significance ($p < 0.05$). However, comparism of all the parameters for the seeds and testas of each sample showed no significance for both studied samples ($p > 0.05$).

Table 3 shows the results of the vitamin analysis. The seed and testa of *G. kola* were richer than the seed and testa of *D. eludis* in vitamin B, C and E except for A which was just slightly higher for seed and testa of *D eludis*. Table 4 shows the anti-nutrients composition (mg/100 g dry matter) for seeds and testa of both plants. The testa of *G. kola* has the highest concentration of all the anti-nutrients examined for both plants. Both the seed and testa of *D. eludis* had much lesser concentration compared to *G. kola*. The highest anti-nutrient recorded was soluble oxalate with a value of 210.40±0.10 for the testa of *G. kola*. Statistical analysis of replicate readings showed significance ($p < 0.05$) while comparism of the seeds and testas showed no significance ($p > 0.05$).

Table 5 shows the mineral composition analysis of both plants studied. The results indicate that the seed and testa of *G. kola* are particularly rich in potassium, calcium, phosphorus & magnesium compared to the seeds and testa of *Dacryodes edulis*. Sodium, iron, zinc, and copper were not determined for seed and testa of *D. eludis* and similarly, nitrogen was not determined for the seed and testa of *G. kola*.

4. DISCUSSION

African pear fruit pulp is a widely eaten delicacy especially in eastern and southern Nigeria because of its abundant nutrients and minerals [24]. However, despite a number of studies highlighting the nutritional potentials of the seeds [24,25], it is still discarded after the edible pulp is eaten [24]. In an earlier study, where the possibility of replacing maize with pear seeds in feeds was examined, they reported the presence of proximate nutrients which are agreeable to our findings [9]. Interestingly, the proximate composition of the seeds and testa of *D. eludis* in

Table 1. Plants and parts under study

Scientific names	Family	Local name	Plant part used
Dacryodes edulis	Burseraceae	Eben	Seed/Testa
Garcinia kola	Guttiferae	Efiat	Seed/Testa

Table 2. Proximate composition of seeds and testa of *Dacryodes edulis* (g/100 g dry matter)

Proximate composition	DE		GK	
	Seed	Testa	Seed	Testa
Moisture	37.00±0.01^{a}	41.10±0.01^{a}	2.64 ± 0.02^{b}	4.60 ± 0.10^{b}
Ash	5.5±0.02	5.0±0.10	3.50 ± 0.10	4.84 ± 0.02
Protein	9.62±0.01	8.75±0.001	10.81 ±0.01	9.70 ± 0.10
Fat	8.0±0.10	6.5±0.01	14.90 ±0.10	12.60 ± 0.02
Fibre	5.0±0.10	13.50±0.02	12.60 ± 0.02	17.80 ± 0.02
Carbohydrate	71.88±0.02	66.25±0.02	57.94 ± 0.02	54.80 ± 0.02

^{a,b}ANOVA of replicate readings gave significant Mean±SD ($p < 0.05$). DE = D. eludis and GK = G. kola. Student t–test for both seeds and those of the testas showed no significance ($p > 0.05$)

Table 3. Estimation of vitamins of seeds and testa of *Dacryodes edulis* (Mean±SD)

Vitamins (mg/100 mL)	DE		GK	
	Seed	Testa	Seed	Testa
A	141.80 ±0.10[a]	134.19 ±0.10[a]	130.30 ± 0.10[b]	124.70 ± 0.02 [b]
B	213.07 ± 0.01	215.10 ± 0.10	224.70 ± 0.20	219.40 ± 0.02
C	5.12 ± 0.02	6.01 ± 0.01	127.10 ± 0.10	93.30 ± 0.10
E	2.08 ± 0.02	2.10 ± 0.10	3.14 ± 0.01	2.94 ± 0.02

[a,b]ANOVA of replicate readings gave significant Mean±SD ($p < 0.05$). DE = D. eludis and GK = G. kola. Student t–test for both seeds and those of the testas showed no significance ($p > 0.05$)

Table 4. Anti- Nutrients of seeds and testa of *Dacryodes edulis* (mg/100 g dry matter)

Anti-nutrients	DE		GK	
	Seed	Testa	Seed	Testa
HCN	1.58±0.01[a]	1.75 ±0.01[a]	6.10±0.10[b]	7.30±0.20[b]
Soluble oxalate	17.50±0.1	15.62±0.02	167.18±0.01	210.40±0.10
Total oxalate	30.02±0.02	24.62±0.02	44.80±0.10	101.70±0.10
Phytate	0.37±0.01	0.39±0.01	0.90±0.10	1.10±0.01

[a,b]ANOVA of replicate readings gave significant Mean±SD ($p < 0.05$). DE = D. eludis and GK = G. kola. Student t–test for both seeds and those of the testas showed no significance ($p > 0.05$)

Table 5. Mineral composition of seeds and testa of *Garcinia kola* (mg/100 g dry matter)

Minerals	GK		DE	
	Seed	Testa	Seed	Testa
Na	10.10±0.1[a]	18.20±0.02[b]	ND	ND
K	730.01±0.1	499.19±0.2	0.48	0.56
Ca	200.40±0.2	140.70±0.1	0.32	0.96
Mg	170.49±0.2	166.30±0.	0.14	0.14
Fe	4.20±0.1	1.50±0.01	ND	ND
Zn	3.70±0.02	3.50±0.01	ND	ND
Cu	2.50±0.1	1.32±0.01	ND	ND
P	720.14±0.01	520.10±0.01	0.17	0.18
N	ND	ND	1.54	0.40

[a,b]ANOVA of replicate readings gave significant Mean±SD ($p < 0.05$). DE = D. eludis and GK = G. kola. ND= Not determined

our study are comparable to those of the varieties of *D. eludis* already examined [1,26]. Furthermore, they reported the presence of calcium, phosphorus, potassium, magnesium, sodium, iron, manganese, zinc, copper, selenium and iodine. Elsewhere, the presence of vitamins like A, D, E, K, in addition to B_1, B_2, B_3, B_6 and B_{12}, biotin, cholin and folic acid have also been reported [27].

Garcinia kola also called Bitter kola is a popular plant in Nigeria which is extensively used as food and as medicine. Unlike the seeds of *D. eludis*, the seeds of *G. kola* are edible. In addition, medicinally, it is used to treat and suppress cough and also to relieve colic disorders [28]. Proximate composition (%) in an earlier study on *G. kola* also confirms the presence of moisture 59.46, fat 4.48, protein 2.48, ash 0.88, fibre 5.01 and carbohydrate 27.69 and minerals such as magnesium, calcium, potassium, phosphorus, sodium, iron, zinc, copper and cobalt [28].

Our findings for carbohydrate and fibre content were more similar to the proximate analysis (%) of *G. kola* by Mazi et al. [29] which showed that the presence of moisture 9.28, ash 4.173, fibre 3.940, fat 1.03, crude protein 11.27 and carbohydrate 70.31. However, other components were different. Furthermore, they reported the presence of vitamins B_1, B_2 and B_3, C, E, A, and minerals calcium, magnesium, potassium, sodium and iron that agrees with our study. In another study, the proximate analysis of the of powdered *G. kola* seed also indicated the presence of moisture, ether extract, crude fibre, crude protein, ash and nitrogen free extracts in the following proportion 7.40, 1.48, 2.94, 3.19, 4.39 and 80.58%, respectively [30]. The study also showed that the seeds also have good lipid lowering effects that could be useful in preventing cardiovascular diseases in humans [30].

From the vitamin analysis, vitamin A and B were the most abundant of all the vitamins examined. Apart from vitamin A that was more abundant in the seeds and testa of *D. eludis* than in *G. kola*, consistently, vitamin B, C and E were more abundant in the seeds of *G. kola*. When compared to the vitamin composition of oyster mushroom in an earlier study, vitamin A, B and C in both of our study samples are atleast two times higher in concentration [31].

Studies have shown that anti-nutrients such as oxalate, phytate, hydrocyanic acid in excessive amounts can bring about some adverse health effects on humans [14,32]. The anti-nutrients levels in *G. kola* in our study are higher than those found in *D. eludis*. The amount of anti-nutrients in *D. eludis* is comparable to those of commonly eaten vegetables previously reported but not those of *G. kola* [32-35]. Furthermore, the concentrations of soluble and total oxalates reported in our study were less than those reported in the seeds of small, medium and large *D. eludis* examined in Eastern Nigeria [14]. Interestingly, the levels of hydrocyanic acid in both plants samples were far less than those previously reported in cassava and *Citrus paradis* peels [36,37].

5. CONCLUSION

The findings in this study reveal that the seeds and testa of *D. eludis* and *G. kola* are indeed very rich in nutrients, minerals and vitamins, and also allowable levels of anti-nutrients. However, there is a need for further studies aimed at the utilization of these plants parts in human and animal nutrition.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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