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Nutritional and phytochemical profiles of three neglected fruit seeds from Ebonyi state

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Abstract
The present work explores the usefulness of soarsop (SS), dabai (DB) and monkey cola (MC) seeds by assessing their nutrient and phytochemical compositions. In Ebonyi State, these fruit seeds are usually discarded as waste after consumption of the edible pulps. Findings from this study indicate that MC seed recorded the highest protein (9.06%), ash (6.18%) and carbohydrate (65.5%) contents, while the highest fat contents of 32 and 35% were recorded for SS and DB seeds respectively, suggesting that these seeds can be classified as oilseeds. In terms of phytochemicals, flavonoids ranged from 84.3-100.3 mg/100g with SS recording the highest value and MC the lowest. Significantly high level of phenolic compounds (5305 µg/g, expressed as gallic acid equivalence) was recorded for DB, indicating that this seed could serve as a good source of natural antioxidants. The corresponding values for SS an MC were 2617 and 1115 µg/g respectively. Vitamin C content ranged from 0.35-0.65 mg/100g with SS recording the highest value and MC the lowest. Similar trend was observed for vitamin E and A contents of SS, which were 219.56 and 212.83 mg/100g respectively. The corresponding values for DB and MC were in the rage of 6.51-13.96 mg/100g and 3.7-10.36 mg/100g respectively. The above findings suggest that the three neglected seeds studied have the potential to be good sources of nutrients and phytochemicals.

Keywords: Dabai seed; Soarsop seed; Monkey cola seed; Phytochemicals; Nutrients

1. Introduction
Fruit and vegetables have been recognized as important sources for a wide array of non-digestible components and phytochemicals that individually, or in combination, may act synergistically to contribute to the nutritional and health benefits of foods. Epidemiological studies have shown that there is a positive association between intake of vegetables and fruits and reduced cardiovascular diseases and certain cancer [1, 2]. Besides the commonly consumed local fruits, some underutilized fruits are important especially in rural communities. However the seeds from these underutilized fruits are rarely consumed due to lack of information on their edibility status. Literature report suggest that neglected and underutilized fruit seeds do not receive much attention due to lack of information on nutritional compositions and physical qualities, and the lack of promotional campaign for these fruit seeds [2]. Dabai, Soarsop and Monkey cola seeds are among the neglected fruit seeds in Ebonyi state.

Dabai (*Canarium odontophyllum*) is a drupe with thin skin (epidermis) surrounding the flesh (mesocarp) and seed (endocarp) [3]. In Nigeria, the fruit is commonly prepared by steeping in hot water (about 60 °C) for a period of 10-15 minutes to soften the flesh, which is then salted and consumed. The texture is creamy and the flavour, comparable to that of ripe avocado. Dabai fruit has been reported to be rich in total phenolic compounds [4], protein, carbohydrate and fat, in addition to minerals such as potassium, phosphorus, calcium and magnesium [5].

Soursop (*Annona muricata L*.) is a fruit irregular in shape but most frequently ovoid or heart-shaped. The fruit pulp consists of white fibrous juicy segments surrounding an elongated receptacle; and a fruit may contain as few as 5 or as many as 200 or more seeds. Soursop fruit has been reported to be high in carbohydrates and vitamins, but relatively low in protein and fat [6].

Monkey cola (*Cola pachycarpa)* is the white variety of *sterculiaceae* family and a tropical species found in lowland forest of some West African countries including Gabon, Cameroon and Nigeria. The fruit is composed of up to 6 large, boat-shaped, shiny, pink or red glabrous carpel and few large seeds, each enclosed in a thick waxy white aril [7].

Dabai, Soursop and monkey cola (white variety) are among the numerous indigenous tropical fruits highly cherished for their pulps. In Ebonyi State where these fruits abound, the seeds are typically discarded after consumption of the fruit pulp obviously due to lack of information on their possible usefulness. Consequently, the present study explores the usefulness of dabai, soarsop and monkey cola seeds by assessing their nutritional and phytochemical attributes.

2. Materials and Methods
2.1 Source and Preparation of Raw Materials
Soursop (*Annona muricata L*.), dabai (*Canarium odontophyllum*) and Monkey cola (*Cola pachycarpa*) fruits were purchased from an open market in Abakaliki, Ebonyi State. The fruits of soursop and dabai were manually opened to expose the nuts, which were further cracked open with the aid of hammer, to obtain soursop and dabai seeds; while monkey cola fruit was peeled to expose the pulp (edible part) which was further sliced open using kitchen knife, to expose the seed (monkey cola seed). The seeds from the above three fruits were then sun dried to constant weight, milled in a blender and subjected to analyses as outlined below.

2.2 Proximate Composition
Proximate composition was evaluated according to AOAC official methods of analysis [8]. Crude protein content was determined using micro-Kjeldahl method, crude fat was determined by Soxhlet extraction method, ash by incinerating samples at 600 °C in a muffle furnace and moisture content in a convection oven; while carbohydrate was calculated by percentage difference.

2.3 Determination of Phytochemicals

Alkaloids were determined gravimetrically following the method described by Harbone [9]. Total phenols were evaluated colorimetrically at 725 nm using the Folin-Ciocalteau reagent [10], and results expressed as gallic acid equivalence; Total flavonoids were determined by the gravimetric method, according to the method described by Bohm and Koupai-Abyazani [11]; while Saponin was determined according to the gravimetric oven drying method described by Ene-Obong *et al*. [12].

2.4 Determination of Vitamins

Ascorbic acid (vitamin C) was determined using the titration method reported by Ene-Obong *et al.* [12]; while vitamins A and E were determined spectrophotometrically according to AOAC official methods of analysis [8].

2.5 Statistical Analysis

Analytical data were processed using analysis of variance [13]. Differences at $p \leq 0.05$ were considered significant.

3. Results and Discussion

3.1 Proximate composition of seeds

The proximate composition of soarsop (SS), badai (DB) and monkey cola (MC) seeds (Table 1) indicates that moisture content, an indicator of the time at which a sample can be stored without the development of moulds [14], ranged between 5.5-10.81% with MC recording the highest moisture content and SS the lowest. There was no significant difference ($p>0.05$) between the moisture contents of SS and DB.

Table 1: proximate composition of Soursop, Dabai and Cola lepidota seeds

Nutrient (g/100g)	Fruit seed		
	Soursop (SS)	Dabai (DB)	Monkey cola (MC)
Moisture	5.5 ± 0.2^a	5.76 ± 0.25^a	10.81 ± 0.34^b
Protein	7.87 ± 0.55^a	4.02 ± 0.23^b	9.06 ± 0.32^a
Fat	32.9 ± 0.3^a	35.0 ± 0.44^b	1.39 ± 0.15^c
Ash	2.22 ± 0.17^a	5.39 ± 0.16^b	6.18 ± 0.15^b
Fibre	7.6 ± 0.20^a	5.27 ± 0.27^a	7.1 ± 0.16^a
Carbohydrate	43.9^a	44.6^a	65.5^b

Values are means ± standard deviations of triplicate determinations. Values with different superscript on the same row are significantly different ($p< 0.05$)

Protein content of the seeds ranged from 4.02-9.06% with MC recording the highest value and DB the lowest; however, there was no significant difference ($P>0.05$) between the protein contents of MC and SS. Higher protein contents have been reported for water melon seed (30.11%), apple seed (33.79%) and pawpaw seed (31.26%) [15]; suggesting that the protein contents of SS, DD and MC seeds are on the low side. Table 1 also reveals that fat contents of 33 and 35% were recorded for SS and DB respectively. These values are higher than those of common oilseeds such as cottonseed (18-20%) and soybean (18-20%); and comparable to those of safflower seed (30-35%) and sunflower seed (35-40%) [16] The seeds of SS and DB can therefore be considered good sources of fat. Low amount of fat (1.39%) was recorded for MC. Carbohydrate contents of SS, DB and MC were 45.48, 43.77 and 66.25% respectively. The high level of carbohydrate calculated for MC indicates high caloric value. SS recorded higher value of carbohydrate than DB, however, this difference was not statistically significant ($p>0.05$). All three seeds can be considered good sources of carbohydrate. Ash content ranged from 2.22-6.18% with MC recording the highest ash content and SS the lowest (table 1). Ash content is a measure of the total amount of minerals present within a food, and constitutes an important quality attribute of foods. The ash contents presented in table 1 suggest that the seeds of DB and MC are significantly high in minerals compared to SS seed. Crude fibre on the other hand, ranged from 5.27-7.6%, with SS and MC recording higher fibre contents than DB. However, there was no statistical difference ($p>0.05$) among the fibre contents of all 3 seeds.

3.2 Phytochemical Composition

Phytochemicals are found at varying concentrations virtually in plants and their different parts. Table 2 shows the presence of saponin which ranged from 5.3-10.7%, with DB and SS recording statistically higher values than MC. Some of the general characteristics of saponins include foam forming in aqueous solution, haemolytic activity and cholesterol binding properties [17].

Table 2: Phytochemical Composition of Soursop, Dabai and Monkey Kola seeds

Phytochemical	Fruit seed		
	Soursop (SS)	Dabai (DB)	Monkey cola (MC)
Flavonoids (mg/100g)	100.3 ± 2.6^a	85.45 ± 3.5^b	84.30 ± 2.4^b
Alkaloids (mg/100g)	45.62 ± 1.53^a	43.18 ± 2.01^a	10.70 ± 1.12^b
Saponin (mg/100g)	10.3 ± 0.8^a	10.7 ± 0.51^a	5.3 ± 0.3^b
Phenols (µg/g)[1]	2617 ± 123^a	5305 ± 260^b	1115 ± 109^c

[1] Expressed as gallic acid equivalence

Values are means ± standard deviations of triplicate determinations. Values with different superscript on the same row are significantly different ($p < 0.05$).

Table 2 also indicates that levels of flavonoids in the seeds ranged from 84.3-100.3%; with SS recording significantly higher values ($p<0.05$) than DB and MC. There was no significant difference ($p>0.05$) between the values recorded by MC and DD. Flavonoids are potent free radical scavengers, which prevent oxidative cell damage, have strong anticancer

activity and protect against all stages of carcinogenesis [18]. Alkaloid content of the seeds ranged from 10.7-45.6mg/100g; with SS recording the highest value and MC the lowest (table 2). However there was no significant difference ($p>0.05$) between the alkaloid contents of SS and MC; while total phenolic compounds, expressed as gallic acid equivalence, ranged from 1115-5305µg/g, with DB recording value, about twice that of SS and five times that of MC (table 2). Phenolic compounds have been reported as natural antioxidants effective in inhibiting lipid oxidation by donating hydrogen atoms to lipid alkyl, alcoxyl and peroxyl radicals [19]. The concentrations of phenolic compounds generally indicate that all the seeds studied have significant antioxidant properties.

3.3 Vitamin Composition

The results for vitamin composition (table 3) indicate that levels of vitamin C in seeds ranged from 0.35-0.65mg/100g with SS recording the highest value. However, there was no significant difference ($p>0.05$) between the vitamin C contents of the 3 seeds. Ascorbic acid has a varied chemistry, and depending on conditions, can act as an antioxidant, a pro-oxidant, a metal chelator, a reducing agent or an oxygen scavenger. Higher vitamin C content (10-13 mg/100g) has been reported for the edible pulp of cola pachycarpa (MC in this study) [12], which suggests that the vitamin C of monkey cola is mostly concentrated in the edible pulp.

Table 3: Vitamin Composition of soursop, dabai and monkey cola seeds

Nutrient (mg/100g)	Fruit seed		
	Soursop	**Dabai**	**Monkey cola**
Vitamin C	0.65 ± 0.22^a	0.47 ± 0.13^a	0.35 ± 0.10^a
Vitamin E	219.56 ± 3.1^a	6.51 ± 1.0^b	13.96 ± 2.23^c
Vitamin A	212.83 ± 2.2^a	3.70 ± 0.82^b	10.36 ± 1.42^c

Values are means ± standard deviations of triplicate determinations. Values with different superscript on the same row are significantly different ($p < 0.05$)

Table 3 also indicates that the seed of SS is exceptionally high in vitamin E, compared to the DB and MC seeds; suggesting that SS could be a good source of vitamin E, and equally a good source of vitamins A and C (table 3). There was no significant difference ($p>0.05$) between vitamin C levels of SS, DB and MC; however significant differences ($P<0.05$) existed between vitamins E and A levels of these seeds.

4. Conclusion

The present study provides evidence that SS, DB and MC seeds have potential as good sources of nutrients and phytochemicals. The high fat contents recorded for SS and DB classify these seeds as oilseeds, while values of ash suggest that the seed of MC could be a good source of minerals. Levels of vitamins indicate that SS seed has appreciable amounts of vitamins, particularly vitamins E and A, while levels of phenolic compounds suggest that all seeds, particularly DB seed, are good sources of natural antioxidants. The above findings stress the importance of these neglected fruit seeds and constitute a starting point for further research which could lead to new sources of vegetable oils (SS and DB seeds) and to new sources of nutrients and phytochemicals for fortification of diets deficient in essential nutrients and phytochemicals.

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