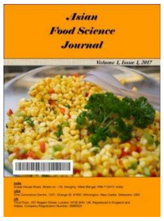

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Biochemical and Nutritional Parameters from Flour of Ackee *Blighia sapida* (Sapindaceae) Seeds

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Authors' contributions

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

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ABSTRACT

The limited information on the biochemical and nutritional benefits of edible ackee (*Blighia sapida*) seeds makes it underutilized in West Africa. This study was to investigate the nutrient content and antinutritional factors using standard analytical methods. The results revealed that ackee (*B. sapida*) seeds contain some percentage flavonoid (0.134.± 0.08 g/100 g), carotenoid (0.005 ± 0.01 g/100 g), polyphenol (0.851 ± 0.40 g/100 g), total sugar (67.98 ± 0.27 g/100 g), reducing sugar (86.93 ± 0.73 g/100 g), vitamin C (0.019 ± 0.49 g/100 g), moisture contents (6.22 ± 0.04 g/100 g), crude fibre (13.84 ± 0.08 g/100 g), ash (2.68 ± 0.09 g/100 g), crude protein (7.83 ± 0.04 g/100 g) and carbohydrate (75.77 ± 0.08 g/100 g). The antinutritional composition which include alkaloids, oxalate, phytate and tannin were 0.23 ± 0.02, 391.87 ± 0.07, 415.09 ± 0.70 and 795.00 ± 0.37

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mg/100 g respectively. These results indicated that ackee seeds are good source of nutritional compounds. However, they had considerable antinutritional factors. Thus, it would be better to treat them by thermal processing methods before using them for application in food systems to maintain food quality.

Keywords: Ackee (Blighia sapida); seeds; biochemical; nutritional; antinutritional factors.

1. INTRODUCTION

The ackee (*Blighia sapida* Köenig) belongs to the *Sapindaceae* and is a native plant of West Africa that was introduced to Jamaica in the 18th century. The fruit is a three-celled fleshy capsule containing three valves and three glossy black seeds. When ripe, the fruit splits longitudinally into three sections to reveal the seeds and the thick yellow flesh of the arils, which form the edible portion of the fruit and has a nutty flavor, [1,2].

The ripe arils of the ackee fruit, yellow to cream coloured, are nutty-flavored and edible [3]. The arils are the major component of the Jamaican national dish; ackee and saltfish [4]. The ripe fruit arils are eaten fresh, dried, fried, roasted or made into sauce or soup in some parts of West Africa [5]. Thus, ackee arils have been reported to have comparable proximate composition to many known legumes and oil seeds [6,7,3]. Various parts from ackee as the roots, bark, leaves, capsules and seeds were identified in the treatment of 22 diseases in Ashanti region of Ghana. [8]. However, ackee seeds have little commercial and nutritional significance in the West African sub-region.

Substantial scientific knowledge on the nutritional beneficial constituents from ackee seeds could ensure the development of more efficient ways to convert the fruit into useful products with improved commercial value. This study, therefore, aims to investigate the biochemical contents, nutritional and antinutritional factors of ackee seeds from Côte d'Ivoire that may be useful in its application as nutritional, industrial and pharmaceutical base.

2. MATERIALS AND METHODS

2.1 Raw Materials

The biological material used for this study is from ackee (*Blighia sapida*) seeds (Fig. 1). The ackee is a spontaneous plant which period of availability is may-June with local names, Kaa (*Center of* Côte d'Ivoire*)*, Finzan (north of Côte d'Ivoire), Atuanbi (south of Côte d'Ivoire); and Goihien (West of Côte d'Ivoire). The ackee seeds, predominant in north region, were harvested at Lakota (Center-West of Côte d'Ivoire (West Africa). They were immediately transported to the Laboratory of Biocatalysis and Bioprocessing of University Nangui Abrogoua (Abidjan, Côte d'Ivoire) and stored under prevailing tropical ambient conditions before the preparation of flours from raw.

Fig. 1. Blighia sapida seeds

All chemicals and reagents used were of analytical grade and purchased from Sigma Chemical Company (USA).

2.2 Sample Preparation

The ackee (*Blighia sapida*) seeds were thoroughly sorted to remove bad ones from the lot. The retained seeds were washed with clean water to eliminate adhering dirt and extraneous materials, then they were dried in an oven at 65°C for 48 hours. After these steps, the dried seeds were ground into powder, sieved with 250 µm mesh sieve and stored in bottles in an oven at 55°C for different analysis (Fig. 2).

2.3 Physico-chemical Composition Analysis

Dry matters were determined by drying in an oven at 105 ± 2ºC during 24 h to constant weight as described by Association of Official Analytical Chemists (AOAC) [9]. The total ash contents were determined by incinerating flour (10 g) in a furnace at 550 ± 15ºC for 12 hours, then weighing the residue after cooling to room temperature in a desiccator (AOAC) [9]. Crude protein was calculated from nitrogen (Nx6.25) obtained using the Kjeldahl method by AOAC [9]. The carbohydrate contents were determined by deference that is by deducting the mean values of other parameters that were determined from 100. Therefore % carbohydrate = 100 - (% moisture +% crude protein + % crude fat + crude fibre + % ash) [10,11]. The crude fibre contents were determined according to standard method (AOAC, [9]. Method described by Dubois et al. [12] was used to determine total sugars while reducing sugars were analyzed according to the method of Bernfeld [13], using 3.5 dinitrosalycilic acids (DNS).

Blighia sapida seeds

↓

Seeds sorting

↓

Converting (65°C ,48h)

↓

grinding (250µm)

↓

B. sapida flour

Fig. 2. Flow diagram of the process for producing *B.sapida* seed flour

2.4 Biochemical Analysis

Vitamin C (ascorbic acid) content was determined by the method of Pongracz et al. [14] and Barros et al. [15]. Total phenolics compound contents were determined as described by Hanson et al. [16] from the methanol extracts using Folin-Ciocalteu reagent [17]. carotenoid content was determined according to the method of Rodriguez-Amaya [18].

2.5 Antinutrients Analysis

Oxalate content was determined by the method of Day and Underwood [19]. Tannin content, flavonoid content and phytate content were estimated by the spectrophotometric method described respectively by Bainbridge et al. [20], Meda et al. [21] and INRA [22]. Alkaloid content was estimated by the filtration method of Harbone [23].

Each of the samples from ackee (*Blighia sapida*) flour was analyzed in triplicate for their biochemical composition, physico-chemical and antinutrients properties.

2.6 Statistical Analyses

Statistical analyses were carried out in triplicate. The results were processed by the software STATISTICA 7 (Stat soft Inc, Tulsa-USA, Headquarters). Thus, results were expressed as means ± standard deviation. The statistical differences among the means of data were calculated using one-way analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT). Differences at $P<0.05$ were considered significant.

3. RESULTS AND DISCUSSION

3.1 Biochemical Content

The biochemical composition of ackee (*Blighia sapida*) seed is shown in Table 1. The results show high content of reducing sugar and total sugar (86.93 ± 0.73 g/100 g and 67.98 ± 0.27 g/100 g) respectively. But they show low content of vitamin C (0.019 g/100 g), carotenoid (0.005 ± 0.01 g/100 g), polyphenol (0.851± 0.40 g/100 g) and flavonoid (0.134 ± 0.08 g/100 g),

Flavonoid is polyphenolic compound that is ubiquitous in nature, comprising a number of hydroxyl groups attached to aromatic ring structures that determine its antioxidative properties. The compounds exhibit a diphenylpropane (C6-C3-C6) skeleton and multiple sub-groups. The quantity of this compound is important in justifying the antioxidative properties of the seeds. The value found in this study is higher compared to those reported by Buratto et al. [24] which have analyzed the content of total flavonoids in Brazil nuts, they have obtained 0.34 g EQ/kg of dry sample. This value is also higher than those found in chia seed extracts. In a study by Lin and Tang [25] where it was evaluated the content of total flavonoids in vegetables, the values were 0.075 g EQ/kg for green peppers, 0.041g EQ/kg for yellow pepper and 0.306 g EQ/kg for white onion.

Table 1. Biochemical and nutritional contents from flour of ackee *B. sapida* seed

Biochemical		Nutritional	
Parameters	**Values (g/100 g DM)**	**Parameters**	**Values (g/100 g DM)**
Flavonoid	0.134 ± 0.08	Moisture	6.22 ± 0.04
Carotenoid	0.005 ± 0.01	Fiber	13.84 ± 0.08
Total sugar	67.98 ± 0.27	Ash	2.68 ± 0.09
Reducing sugar	86.93 ± 0.73	Protein	7.83 ± 0.04
Vitamin C	0.019 ± 0.49	Carbohydrates	75.77 ± 0.08
Polyphenol	0.851 ± 0.40		

Statistical analyses were carried out in triplicate

Phenolic compound is natural antioxidant found generally in several fruits of both trees and cereals. The compound has maximum concentration at the superficial layers of the kernel, which set-up the branch Proestos et al*.* [26]. Phenolics have been found as strong antioxidants towards hindering the influence of free radicals and ROS, which is the basis of several chronic human infections [27]. The presence of significant phenolic compound from ackee *Blighia sapida* seeds will encourage the utilization of the seeds for many purposes. The phenolics and flavonoids are important indicators of antioxidant capacity of ackee *Blighia sapida* seeds. These compounds play vital function towards preventing diseases and sustain a state of well being.

The roles of carotenoids in seed are less clear than in other tissues, but are emerging. Carotenoid production in the seed is important for ABA production and seed dormancy [28]. Furthermore, carotenoids contribute to the antioxidant system in seeds, which functions to limit free radical-induced membrane deterioration and seed ageing [29,30].

Carotenoids are the precursors of vitamin A and similar compounds. ß- carotene is one of most commonly known carotenoids which is a potent antioxidant as well as a dietary factor for growth. It is a precursor of vitamin A that has important role in vision, as the prosthetic group of the light sensitive proteins in retina, and a major role in the regulation of gene expression and tissue differentiation [31]. Deficiency of vitamin A is a major public health problem around the world. The prevention of vitamin A deficiency is one of the three micronutrient priorities of the World Health Organization (WHO), others are iron and iodine.

Vitamin C, or ascorbic acid, is a water soluble antioxidant that plays a vital role in protecting the body from infection and disease. It is not synthesised by the human body and therefore must be acquired from dietary sources – primarily fruits and vegetables. Losses of vitamin C are mostly as a result of leaching into the processing water, thermal destruction and oxidation [32]. It is to be noted that the requirement of vitamin C increases during pregnancy, lactation, adolescence, hyperthyroidism, infection and after surgery [33]. Maintenance of daily dietary intake of vitamin C leads to the prevention of scurvy which is the deficiency disease state of vitamin C. The fairly high ascorbic acid value from flour of ackee seed gives an indication that the seeds may be good source of ascorbic acid when compared to citrus fruits [34].

3.2 Nutritional Content

The result revealed that the moisture content from ackee *B. sapida* seed was 6.22 ± 0.04 g/100 g. This value is similar to 5.24 ± 0.05 g/100 g and lower than 11.0 g/100 g reported by Ogungbenle [35]. It is lower than the moisture content of different varieties of date palm as 14.81 ± 0.396 (Dora), 9.90 ± 0.042 (Dhaki), 12.3 ± 0.242 (Karbaline) respectively was reported by Faqir et al. [36]. The result of Rehman et al. [37] also shows higher content of 17.70 ± 0.03 g/100 g for hard date palm. It noticed that these differences may be due to the location, time, environments, longitivity and maturity of the sample used for the analysis. According to Rodrigues, [38] the great variability in the physical and chemical characteristics of plant can be attributed to many factors, including the region where the plant was grown, climatic differences, fertility, soil pH and annual rainfall. The low moisture content as saw in the sample is an evidence that the ackee *Blighia sapida* seed specimen may not be more inclined to decay, since nourishments with high dampness substance are more inclined to perishability. [39]. Moisture content of any food is an index of its water activity and is used as a measure of stability and susceptibility to microbial contamination [40]. It might be profitable in perspective of the specimen timeframe of realistic usability.

Crude fibre decreases the absorption of cholesterol from the gut in addition to delaying the digestion and conversion of starch to simple sugars, an important factor in the management of diabetes [41]. Dietary fiber serves as a useful tool in the control of oxidative processes in food products and as functional food ingredient [42]. The crude fiber content from flour of ackee seed was 13.84 ± 0.08 g/100 g. This value is higher than 4.34 ± 0.03 g/100 g and 4.00 ± 0.02 g/100 g obtained by Ogungbenle [35] and Rehman et al. [37]. This result is also higher than 9.4 ± 0.10 g/100 g reported by Gamal et al. [43]. It reported that fiber has some physiological effect in the gastrointestinal track [44] and low fiber in diet is undesirable as it may cause constipation. The high content of ackee seed fiber can enhance satiety, regulate intestinal transit, reduce energy consumption and promote weight loss in users [45].

Ash represents the mineral matter left after food material is burnt in oxygen [46]. It is used as a tool to measure the mineral content in any sample [46]. The ackee *B. sapida* had moderately high value of ash (2.68 ± 0.09 g/100 g), which indicates that the seed can serve as a viable tool for nutritional evaluation [47]. This result is within the acceptable ash content mean values of legumes of 2.4 to 5.0 % recommended by FAO [48]. The result of the ash content in the sample is a suggestion of a low deposit of mineral elements in the samples compare to the recommended values by the FAO. This may indicate that ackee seed would likely contain very high qualities essential minerals. Since ash content is an index to evaluate and grade the nutritive quality of foods [49].

The crude protein content from flour of ackee *Blighia sapida* seed (7.83 ± 0.04 g/100 g) was lower when compared to oven dried ackee arils (11.67 ± 0.37 g/100 g) [50] and to certain common legume *Phaseolus vulgaris* (20.9 g/100 g); *Lenus culinaris* (20.6 g/100 g) and *Cicer arietinum* (18.5 g/100 g) [51]. It is also lower than that of *Canavalia gladiate* (27.48 g/100 g) and *Canavalia ensiformis* (30.62 g/100 g) [52]. It is generally known that any plant that provides more than 12% of their caloric value from protein is considered to be a good source of protein. Thus ackee *B. sapida* is not a good source of protein.

The carbohydrate content (75.77 ± 0.08 g/100 g) from flour of ackee seed is higher than that of most legume like *Bambara groundnut* (65 g/100 g), broad bean (56.9 g/100 g), chick peas (60.9 g/100 g) etc [53]. Its value (75.77 ± 0.08 g/100 g) was also higher than that of soya beans (32 g/100 g), groundnut (21.0 g/100 g) etc. [53]. But this value is slightly lower than 80.67± 0.05 g/100 g obtained by Ogungbenle [35]. It reported that carbohydrate provides energy to the cells in the body, particularly the brain, which is the only carbohydrate-dependent organ in the body [46]. It is necessary for maintenance of the plasma level, it spares the body protein from being easily digested and helps to prevent the using up of protein. The fairly high carbohydrate content found in flour of ackee seeds suggests high caloric value.

3.3 Determination of Antinutritional Factors

The nutritional importance of a given food depends on the nutrients and anti-nutritional constituents of the food [54]. The result of the anti-nutritional factors from flour of ackee *B. sapida* seed is presented in Table 2.

Table 2. Antinutritional factors from flour of ackee *B. sapida* seed

Parameters	Values (mg/100 g DM)
Alkaloid	230 ± 0.02
Tannin	795.00 ± 0.37
Oxalate	391.87 ± 0.07
Phytate	415.09 ± 0.70

Statistical analyses were carried out in triplicate

The antinutritional composition of flour from ackee seeds (Alkaloid, tannin, oxalate and phytate content) was very high. The alkaloid content only was low with 230 ± 0.02 mg/100 g, however oxalate, phytate and tannin content was high with 391.87 ± 0.07, 415.09 ± 0.70 and 795.00 ± 0.37 mg/100g respectively.

Oxalate have been shown to have negative impact on accessibility of mineral which will prompt assimilation of fundamental minerals in body particularly calcium by framing insoluble salts [55]. According to Savage, [56] oxalate and its contents have deleterious effects on human nutrition and health, mainly by decreasing calcium absorption and aiding the formation of kidney stones. The formation of oxalate crystal is said to take place in digestive tract, [57], Nkafamiya et al. [58] have evaluated some oxalate content from seeds of the fruits of some wild plants. *Gemlina arborea* is one of them. They observed 9.16 ± 0.13 mg/100 g oxalate in seeds of *G. arborea* and 50 ± 0.06 mg/100 g in fruits. The calcium oxalate which is insoluble may cause kidney stone, [59] was also reported by Bello et al., [60].

Phytic acid is considered an antinutrient, as it interferes with the daily activities of human body like digestion and protein breakdown [61]. In this study concentration of phytic acid was found to be 415.09 ± 0.70 mg/100 g. Aberoumand [62] carried out the screening of phytochemical and anti-nutrients compounds of eight food plants sources. The phytate content of these plants ranged from 248.0 mg/100 g to 823.6 mg/100 g. It reported that phytates can reduce bioavailability of minerals; impaired protein digestibility caused by formation of phytate protein complexes and depressed absorption of nutrients due to damage to the pyloric caeca region of the intestine [63]. Thus, the antinutritional nature of phytic acid lies in its ability to chelate divalent minerals such as iron, calcium, copper and zinc, rendering them biologically unavailable [48]. It also inhibits protein digestion by forming complexes with them [64]. However, the phytate content can further be lowered by processing [65]. The knowledge of the phytate level in foods is necessary because high concentration can cause adverse effects on the digestibility.

Tannins are known to bind irreversibly to proteins of forming insoluble complexes with them and thus rendering them indigestible by intestinal enzymes thereby interfering with their bioavailability [66,67]. According to Jambunathan and Singh, [68], tannins are known to inhibit the activities of digestive enzymes and hence the presence of even a low level of tannin is not desirable from nutritional point of view. Arinathan et al. [69] studied antinutritional factors such as total free phenol, tannin, and hydrogen cynide. Tannin also has the ability to form a complex with vitamin B12 and makes it unavailable [70,63]. They are also known to interact with other anti-nutrients.

4. CONCLUSION

From the present study, we concluded that flour of ackee (*Blighia sapida*) seeds is a good source of biochemical and nutritional compounds. But the limitation to the full utilization of ackee seeds is the high concentrations of antinutritional factors (oxalate, phytate and tannin) and low alkaloid content which render it useless for human and animal nutrition. However, processing methods, such as boiling and others heat treatment would be better for reducing the levels of these antinutrients present in the flour of ackee raw seeds.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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