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Effect of processing method on proximate, minerals, phytochemcals and anti-nutrients present in Baobab seeds (*Adansonia digitata*)

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Abstract

Baobab (*Adansonia digitata*) is a deciduous tree with many useful plants. The objective of this work was to determine the effect of processing methods on proximate, mineral composition, phytochemical and anti-nutrient of control, boiled, roasted and fermented samples of baobab seeds. The result showed that the protein content of the seeds of different process ranged from (32.87%) roasted to (32.13%) control sample. The fat content ranges from (30.97%) roasted to (29.77%) boiled seeds. The ash content ranges from (0.60%) boiled to (0.57%) fermented. The moisture content ranges from (9.03%) boiled to (8.53%) control sample. The carbohydrate content ranges from (29.93%) boiled to (26.73%) roasted seeds respectively. While the mineral composition of the seeds measure in (mg/100g) ranges from: Ca (188.33) fermented to (173.33) boiled, Fe ranges from (12.87) fermented to (11.73) boiled, Na ranges from (446.67) fermented to (416.67) boiled, Mg ranges from (55.00) fermented to (46.67) boiled, K ranges from (43.33) fermented to (33.33) boiled, Cu ranges from (0.83) fermented to (0.60) boiled seeds respectively. While the phytochemicals and antinutrient factors of the seeds measured in (mg/100g) ranges from: Alkaloids ranges from (30.00) control sample to (20.00) fermented, Flavonoids ranges from (61.67) fermented to (48.33) boiled, Steroids ranges from (20.00) fermented to (15.00) control sample, Tannins ranges from (140.00) roasted to (128.33) boiled , Saponins ranges from (45.00) control sample to (33.33) fermented, Protease Inhibitors ranges from (0.83) control sample to (0.40) fermented seeds respectively. The baobab seeds are a very proteinous with high mineral composition. Therefore, these seeds can be useful in the preparation of diets for people with low-level of mineral elements and also as dietary supplement in weaning food to improve quality of diets of infants and children.

Keywords: Baobab seeds; *Adansonia digitata*; Proximate; Minerals composition; Phytochemicals; Anti-nutrients

1. Introduction

Baobab or *Adansonia digitata* L. belongs to the Malvacea family [1] and is a deciduous tree native to Arid Central Africa [2]. It distribution area is large and this species can be found in most of Sub-Sahara Africa's semi-arid and sub-humid regions as well as in western Madagascar [3]. It has been introduced to area outside Africa and grown successfully [4]. The baobab tree provides food, shelter, clothing and medicine as well as material for hunting and fishing [5] cited in [6]. Every part of the baobab tree is reported to be useful [6]. The leaves, either fresh or dried and pulverized are used for preparing soup which is poured over the dish of porridge made from sorghum (*Guineesia*) or millet (*Pennisetum elusine*) flour. Seeds are used as a flavouring agent, or roasted and eaten as snacks [7]. Fermented and ground baobab

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seed is one of the food condiments used to flavour soups in northern Nigeria. Roasted seeds could replace groundnut (peanut) to some extent as side dishes [8]. Its fruit pulp has very high vitamin C content (seven to ten times that of orange) and can be used in seasoning, as an appetizer and to make juices. Seeds contain appreciable quantities of crude proteins, digestible carbohydrates and oil, whereas they have high level of lysine, thiamine, calcium and iron. They can be eaten fresh or dried, ground into flour and thus added to soups and stews. Baobab leaves are superior nutritional quality to fruit pulp, and contain significant level of vitamin A. Baobab (*Adansonia digitata*), locally called Kuka (Hausa) and Luru (Yoruba) is a high yielding, draught resistant and all season plant. This gives it an advantage over other legumes that are seasonal, high rainfall and fertilizer demanding crops. Several local processing and preparation method can be used to enhance the bioavailability of micronutrients in Baobab (which is another non-conventional legumes). These methods include thermal processing, mechanical processing, soaking, fermentation, dehulling, germination or combination of two or more methods [9].

This study was embarked upon to study the effect of processing on chemical composition, phytochemicals, minerals and anti-nutrients factors content of Baobab (*Adansonia digitata*) seeds.

2. Material and methods

The baobab fruits (*Adansonia digitata*) were collected from the bush at Komi Reserve Forest, Saki, Oyo State.

2.1. Preparation of materials

Materials were collected from the bush at Koomi Area in Oyo State. The woody pericarp of the baobab fruit was broken. The dried pulp was scraped from the seeds by soaking in clean water for few hours. The seeds were washed thoroughly, cleaned, drained and dried in a shade for few minutes. The seeds were divided into four portions. The first portion was placed separately and the remaining portions were boiled at a temperature of 100^{o} C (boiling point of water) for 31/2 hours respectively. The baobab seeds were then dehulled and dried in a shade for 48 hours. The first portion was a control sample, the second portion was boiled baobab seeds, the third portion was roasted at a temperature of 140 ^{o} C for 15 minutes, while the fourth portion was placed inside a calabash and then covered with fresh banana leaves and put in a dark room to ferment by the natural microflora present in the dehulled seeds at 25-30 ^{o} C for 6 days. The fermented seeds were then dried in the air oven at 85 ^{o} C for 24 hours to 96% dry matter. The control sample, boiled, roasted and fermented seeds were milled into fine flours using milling machine. The flours were sieved and stored safely until used for various analysis.

The fruit were divided into four portions. Sample A (control), Sample B (boiled seeds at 100^{0}C for 15 minutes), Sample C (roasted seeds) and Sample D (fermented seeds)

2.2. Determination of nutritional composition

The recommended methods of the Association of Official Analytical Chemicals [10] were used for the determination of moisture ash, crude fibre and protein content and mineral carbohydrate was calculated by difference as the sum of the moisture fat, protein and ash contents were subtracted from 100 as outlined in [10]. The sample calorific value was estimated (in kcal) by multiplying the percentages of crude protein, crude lipid and carbohydrate by the recommended factors (2.44, 8.37 and 3.47 respectively) as used in vegetables analysis by [11].

2.3. Determination of antinutritional and phytochemical composition of *Adansonia digitata* seeds sample

The methods describe by [12] and [13] adopted for the determination of alkaloid, oxalate, phytate, saponins, tannin, total flavonoid and phenoic compounds.

2.4. Statistical analysis

Quantitative data were expressed as means and standard deviation (SD) of at least three measurements. Each experimental set was compared with one way analysis of variance (ANOVA) procedure using Statistical Package for Social Sciences (SPSS) version 11.5 (SPSS Inc. Chicago IL. USA) Duncan's new multiple range test was used to determine the differences of means P values <0.05 were regard as significant.

3. Results and discussion

Table 1 The proximate analysis of baobab seeds

Samples	**A**	**B**	**C**	**D**
	Control	Boiled	Roasted	Fermentation
Protein	32.13d ± 0.15	32.67d ± 0.15	32.87a ± 0.15	32.25b ± 0.15
Fat	30.43b ± 0.31	29.77c ± 0.15	30.97a ± 0.21	30.13bc ± 0.15
Ash	0.57a ± 0.23	0.60a ± 0.20	0.57a ± 0.23	0.57a ± 0.23
Moisture	8.53c ± 0.15	9.03a ± 0.15	8.87ab ± 0.21	8.63bc ± 0.15
Carbohydrate	32.33b ± 0.32	29.73a ± 0.29	26.73c ± 0.70	27.70b ± 0.70

Values are means of triplicate assay ± standard deviation values on a row with different subscripts are significantly different from each other

Result of the proximate composition of baobab seeds in table 1 shows that the protein content obtained in this study is significantly differed, with values ranging from 32.87a± 0.15, 32.57b± 0.15, 32.13^{c} ± 0.15 and 30.67^{d} ± 0.15 in roasted seeds, fermented seeds, control sample and boiled seeds respectively. These values are similar to those reported by [14] in *A. digitata* seeds but relatively higher than those reported for *Neocraya macrophylla* (20.37%) by [15].

The crude protein content in roasted seeds was 32.87^{a} ± 0.15g/100g determined in dry matter, this content of seeds is higher when compared with common cereals like whole wheat flour, parboiled rice and eggs in which case the protein content is 8.55%, 7.7% and 12.6% respectively [16] that makes *Adansonia digitata* seeds great supplement to cereal based foods. According to [17] plant foods are that provide more than 12% of its calorific value from protein are considered good source of protein and this indicates that the seed under investigation is a potential source of protein of dietary protein supplement to meet the recommended daily requirements for humans [18].

The high crude fat content obtained in this study is significantly differed, with values ranging from 30.97^{a} ± 0.21, 30.43^{b} ± 0.31, 30.13^{bc} ± 0.15 and 29.77^{c} ± 0.15 in roasted seeds, control samples, fermented seeds and boiled seeds respectively. These values are in agreement with the report for *A. digitata* seeds by [14]. These averages are nutritionally significant because it is an excellent source of mono and polyunsaturated fatty acids [19]. The high content of mono and polyunsaturated fatty acids suggests that baobab seed oil would be useful as food oil [19]. The oils are used in typical treatment of various conditions such as hair dandruff, muscle spasms, varicose vein and wounds [20, 21]. Therefore, due to the high lipid content, the seeds could be use as a potential source of oil.

The ash content of baobab seeds in this study is significantly differed, with values ranging from 0.60^{a} ± 0.20, 0.57^{a} ± 0.23, 0.57^{a} ± 0.23 and 0.57^{a} ± 0.23 in boiled seeds, control samples, roasted seeds and fermented seeds respectively. This values is not in agreement with the one reported for *A. muricata* seeds (2.29%) [22].

The moisture content of the baobab seeds was significantly decreased from 8.53^{a}± 0.15 in control sample to 8.87^{ab} ± 0.21 and 8.63^{bc} ± 0.15 in roasted seeds and fermented seeds while it increased to 9.03^{a} ± 0.15 in boiled seeds respectively. The lowest value was recorded in control sample (8.53^{bc} ± 0.15) which may be attributed to non-removal of the seed coats. The lower value in fermented seeds (8.63^{bc} ± 0.15) is because the fermenting organism utilized water for their metabolisms and then reduced bulk of the seeds. The low-level of moisture content of the seeds below 10% implies that seeds can be stored for longer time without spoilage [23].

The carbohydrate content obtained in this study was significantly differed, with values ranging from 29.93^{a} ± 0.29, 28.33^{b} ± 0.32, 27.90^{b} ± 0.70 and 26.73^{c} ± 0.70 in boiled seeds, control samples, fermented seeds and roasted seeds respectively. This lower value of carbohydrate in roasted seeds was comparable to that reported by [7] and the lower value in fermented seeds is in agreement with the reports for *A. digitata* seeds by [24,14] and relatively higher than 8.64%DW in *Neocarya macophylla* seeds and 19.20%DW in Africa locus bean by [15 and 25] respectively. The decrease is likely due to the use of the nutrient especially its metabolites, the simple sugar, as a source of energy [26]. The main

function of carbohydrate is for energy source. However, the result shows that the seeds of *Adansonia digitata* could supplement the energy requirements for some of our daily activities.

Table 2 The minerals analysis of baobab seeds.

Samples	**A**	**B**	**C**	**D**
Calcium	180.00^{a}± 5.00	173.33^{C} ± 2.289	186.67^{a} ± 2.89	188.33^{a}± 2.89
Iron	12.33^{b} ± 0.15	11.73^{c}± 0.21	12.73^{a}± 0.15	12.87^{a}± 0.15
Sodium	426.67^{b}± 7.64	416.67^{c}± 2.89	435.00^{b} ± 5.00	446.67^{a}± 2.89
Magnesium	51.67^{ab}± 2.89	46.67^{b}± 2.89	55.33^{ab} ± 2.89	55.00^{a}± 5.00
Potassium	40.00^{a}± 5.00	33.33^{b}± 2.89	41.67^{a}± 2.89	43.33^{a}± 2.89
Copper	0.67^{bc}± 0.06	0.06^{c}± 0.10	0.77^{ab}± 0.06	0.83^{a}± 0.06
Ca – Calcium	Fe = Iron	Na = Sodium	Mg = Magnesium	K - Potassium

Values are means of triplicate assay ± standard deviation values on a row with different subscripts are significantly different from each other.

Results of the findings of this study in table 2 shows that the mineral composition of the seeds are higher in seeds subjected to fermentation. The calcium content of the seeds were significantly differed with values ranging from 188.33^{a} ± 2.89, 186.67^{a} ± 2.89, 180.00^{b} ± 5.00 and 173.33^{c} ± 2.89 in fermented seeds, roasted seeds, control samples and boiled seeds respectively. The value obtained is relatively higher than 38.45mg/100DW reported for wild melon seeds by [27]. The increased in calcium content of fermented seeds was because of hydrolysis of complexes between tannin-protein and protein-enzymes by the fermenting micro flora. These values are not in agreement with those reported in *A. digitata* seeds by [28]. The recommended daily allowance [29] for calcium is 1000mg in adult. Hence, the result of this study showed that consumption of this seeds would supply adequate amount of calcium needed by the body to play a part in muscle contraction and relaxation, blood clotting, synaptic transmission and absorption of vitamin B_{12} in the body.

The iron (Fe) content of the seeds was significantly differed with values ranging from 12.87a± 0.15, 12.73^{a} ± 0.15, 12.33^{b} ± 0.15 and 11.73^{c} ± 0.21 in fermented seeds, roasted seeds, control samples and boiled seeds respectively. Iron is utilized in the body for transportation of oxygen to the tissue and melanin formation [30]. The value recorded for iron in this study indicates that when compared with the recommended daily intake 18mg for iron [31], consumption of the seeds could not cover the daily requirement. Hence it should be taken in large quantities and could be incorporated with cereals rich in iron so as to increase the level of iron in diet when consumed. Therefore, iron is essential trace element in the body for hemoglobin formation, normal functioning of the central nervous system and in oxidation of carbohydrates, protein and fats [32]. It is also an important element in the diet of pregnant women, nursing mothers, infants, convulsive patients and elderly to prevent anemia and other related diseases, but prolong consumption result in liver failure [30]. Hence, the high contents of iron shows that the seeds could help in boosting the blood level in anemic conditions [33].

The sodium (Na) content of the baobab seeds are significantly differed with values ranging from 446^{a} ± 2.89, 435.00^{b} ± 5.00, 426.67^{b} ± 7.64 and 416.67^{c} ± 2.89 in fermented seeds, roasted seeds, control samples and boiled seeds respectively. The values obtained in this study is relatively higher than that reported in 3.80mg/100g for African locus bean, 23.15mg/100gDW for Wild melon seeds and 19.6mgDW in *Adansonia digitata* [34 and 27] respectively. The high value of sodium in fermented seeds is the most adequate for the normal retention of protein during growth stage. Hence, sodium enhances blood pressure. The daily dietary allowance of sodium is 200 - 500mg [29]. The results obtained shows that seed has an appreciable amount of sodium required by human body.

The values of magnesium content of the seeds are significantly differed ranging from 55.00^{a} ± 5.00, 53.33^{ab} ± 2.89, 51.67^{ab} ± 2.89 and 46.69^{ab}± 2.89 in fermented seeds, roasted seeds, control samples and boiled seeds respectively. These values are not in agreement with those reported for *Schlerocaryabirrea* seeds (206.14mg/100g), 210.36mg/100g for *Hasta lapasta* seeds and *A. digitata* seeds by [35]. Magnesium (Mg) is an important mineral element which activates enzymatic systems responsible for calcium metabolism in bones and in the nerves electrical potential [36]. The recommended dietary allowance of magnesium for adult was 350mg [29]. Hence, the upper limits of 65mg for children

ages 1-3 years, 110mg for 4-10years and 350mg for adults are suggested as tolerance limit for the content of soluble magnesium in foods and drinking water [37]. Magnesium is therefore required in the body for metabolism of carbohydrates, fat and protein.

The potassium content of the baobab seeds are significantly differed, with values ranging from $43.33^{a} \pm 2.89$, $41.67^{a} \pm 2.89$, $40.00^{a} \pm 5.00$ and $33.33^{b} \pm 2.89$ in fermented seeds, roasted seeds, control samples and boiled seeds respectively. This is nutritionally relevant considering that potassium plays a principal role in neuromuscular functions. Potassium deficiency affects the collecting tissues of the kidney, resulting in the inability to concentrate urine and also alterations of gastric secretion and intestinal motility [38]. The recommended dietary allowance of potassium was ranged from 500mg/day in early infant to 2000mg/day for adulthood [33]. Potassium is also an important element which helps in maintenance of acid-base balance in the body and normal functioning of nervous system [39].

The copper content of the seeds are significantly differed with values ranging from $0.87^{a} \pm 0.06$, $0.77^{ab} \pm 0.06$, $0.67^{bc} \pm 0.06$ and $0.60^{c} \pm 0.10$ in fermented seeds, roasted seeds, control samples and boiled seeds respectively. The concentration of copper was lower than 5.10mg/100gDW and 4.74mg/100g for wild melon seeds and S*clerocarya b irrea* seeds reported by [27]. This is of capital importance to indicate that copper have a range of intake over which its supply is adequate to the body. The recommended dietary allowance of copper was 1.5 to 3.0mg/day for adults and adolescents. However, beyond this range, deficiency and toxic effects are observed because a high supplementation of copper had been related with liver damage [40] with decrease in blood hemoglobin concentration and pack cell volume. The lower value of copper in the seeds makes it safe for consumption.

The highest value of mineral elements was recorded in the fermented seeds. This indicates that fermentation process especially 6 days has a greater effect on the baobab seeds by increased in the mineral contents and which was found to be higher than other processing method studied in these findings. The high quality of potassium, magnesium and calcium and the extra quantity of sodium plus the contents of essential elements iron, manganese, zinc and copper allow the seeds to be considered as excellent source of bio-elements [41]. Therefore, fermented seeds can be recommended to be used in the preparation of diets for person with low levels of these mineral elements.

Table 3 The phytochemical and antinutrient analysis of baobab seed.

Samples	**A**	**B**	**C**	**D**
Alkanoid	30.00a ± 5.00	26.67ab ± 2.89	30.00a ± 5.00	20.00b ± 5.00
Flavonoids	56.67ab ± 2.89	48.33b ± 7.64	58.33a ± 2.89	61.67a ± 2.89
Steroids	15.00a 5.00	16.67a ± 2.89	18.33a ± 2.89	20.00a ± 5.00
Tannis	133.33ab ± 2.89	128.33b ± 7.64	140.0a ±5.00	138.33a ± 2.89
Saponin	45.00a ± 5.00	38.33ab ± 5.77	35.00b ± 5.00	33.33b ± 2.89
Protease	0.83a ± 0.15	0.70ab ± 0.10	0.57bc ± 5.00	0.40c ± 0.10
Inhibtors				

Value are means of triplicate assay I standard deviation values on a row with different subscripts are significantly different from each other.

Result of the phytochemical and anti-nutrients in table 3 shows that the alkaloids content of the seeds were significantly differed with values ranging from $30.00^{a} \pm 5.00$, $30.00^{a} \pm 5.00$, $26.67^{ab} \pm 2.89$ and $20.00^{b} \pm 5.00$ in control sample, roasted seeds, boiled seeds and fermented seeds respectively. Alkaloids are the most efficient therapeutically significant plant substance [42]. [43] reported that alkaloids are effective for its detoxifying and antihypertensive properties. Hence, its presence in high quality in the seeds makes it a potential source as alkaloids possess a significant pharmacological property.

The flavonoids content obtained in this study was significantly differed, with values ranging from $61.67^{a} \pm 2.89$, $58.33^{a} \pm 2.89$, $56.67^{ab} \pm 2.89$ and $48.33^{b} \pm 7.64$ in fermented seeds, roasted seeds, control samples and boiled seeds respectively. The flavonoids compounds are well known for their good antioxidant activity. [44] reported that it modifies the body's reaction to allergens, viruses and carcinogens by exhibiting anti-inflammatory and antimicrobial activity.

The steroids content of the baobab seeds was significantly differed with values ranging from $20.00^{a} \pm 5.00$, $18.33^{a} \pm 2.89$, $16.67^{a} \pm 2.89$ and $15.00^{a} \pm 5.00$ in fermented seeds, roasted seeds, boiled seeds control sample respectively. The steroidal compounds are of importance in pharmacy because of their relationship with such compounds as sex hormone [45]. It has reported that flavonoids and steroids are free radical scavengers that prevent oxidative cell damage, and have strong anticancer activities [46; 47] and thought induce mechanism that affect cancer cells and inhibit tumor invasion [48]. These activities could be attributed to their ability to neutralize and quench free radicals [47; 46; 49] and it is also due to their oxidative properties, presence of conjugated ring structures and carboxylic group which are been reported to inhibit lipid peroxidation [50]. The presence of flavonoids in the seeds, suggest the ability of this by-product to play an important role in preventing disorders associated with oxidative stress.

The tannins content of the baobab seeds was significantly differed, with values ranging from $140.00^{a} \pm 5.00$, $138.33^{a} \pm 2.89$, $133.33^{ab} \pm 2.89$ and $128.33^{b} \pm 7.64$ in roasted seeds, fermented seeds, control sample and boiled seeds respectively. The value obtained was relatively higher than the one reported [51] for Artocarpusheterophyllus seeds (108mg/100gDW). Tannin acts as anti a nutritional factor by provoking an astringent reaction in the mouth by making food unpalatable. Tannin is non-toxic and can generate physiological responses in animals that consume them [52]. Tannins are known to be useful for the prevention of cancer as well as treatment of inflamed or ulcerated tissues [53]. Therefore, the presence of tannin in the seeds suggested the ability of the seed to play major roles as antifungal, antidiarrheal, antioxidant and antihemorrhoidal agents [54].

The saponin content of the baobab seeds was significantly differed with values ranging from $45.00^{a} \pm 5.00$, $38.33^{ab} \pm 5.77$, $35.00^{b} \pm 5.00$ and $33.33^{b} \pm 2.89$ in control sample, boiled seeds, roasted seeds and fermented seeds respectively. This values are relatively higher than those recorded in *Neocarya macrophylla* seed (3.35 ± 1.34g/100gDW) and *Sclerocarya birrea* seeds (10.510g/100gDW) reported [55]. Saponin exhibits cytoxic effects and growth inhibitions against a variety of cells, making them have anti-inflammatory and anticancer properties. Saponins are also believed to react with the cholesterol rich membranes of cancer cells, thereby limiting their growth and viability [56]. [57] also reported that it had anti-hypercholesterol, anti-inflammatory, cardiac depressant properties, and appears to inhibit cancer cells without destroying the normal cells. Thus, phytochemicals have been considered a crucial nutritional component without official recommendations of how much is to be taken with ability to prevent chronic diseases such as cancer, cardiovascular diseases, diabetes and ageing [58]. The protease inhibitor of the baobab seeds was significantly differed with values ranging from $0.83^{a} \pm 0.15$, $0.70^{ab} \pm 0.10$, $0.57^{bc} \pm 0.06$ and $0.40^{c} \pm 0.10$ in control sample, boiled seeds, roasted seeds and fermented seeds respectively. The low values of protease inhibitor in the seeds suggest that the seed is safe to consume.

4. Conclusion

Baobab (*Adansonia digitata*) seeds have been recognized as a high yielding, draught resistant and all season plants which give it an advantage over other seasonal crops. Baobab seeds have a nutritional and medicinal value and it may be useful as a dietary supplement to be sprinkled over food as a dry powder and as a food additives or could be incorporated into many traditional dishes to improve the quality of diets of infants and children. Baobab seeds can be eaten fresh, or may be dried and ground into flour which can either be added to soups and stews as a thickener, or roasted and ground into a paste or boiled for a long time, fermented and then dried for use. The baobab seeds are under-utilized seeds as a result of poor understanding of their nutritional, dietary supplementation and economic values as well as anti-nutritional factors. The *Adansonia digitata* seeds have recorded high mineral elements composition, thus, it can be recommended in the preparation of diets of people with low-level of these mineral elements.

From the result of the analysis, it can be shown that the advantages of the effects of fermentation appear greater than those of the other processing methods studied in these findings. The nutrient density, shelf life, flavors and aroma of baobab flours were enhanced by fermentation. The crude lipid is relatively high which suggests as a potential source of food oils but should be consumed with caution so as to avoid obesity and other related diseases. The low moisture contents of the seeds would hinder the growth of microorganisms and promote longer shelf life of the seeds. The lower the moisture content of a given food, the higher are the nutrients and its keeping quality. This study also revealed the presence of various medically important phytochemicals in baobab seeds. Phytochemicals are plant compounds that are under research with unestablished effects on health and not scientifically defined as essential nutrients.

The effect of the processing methods reduces the anti-nutrient factors in the seeds, thus, makes the baobab seeds a safe food to consume. Anti-nutrients are substances to which we are exposed to through food and water, which reduces food nutrients needed for good health [59]. The *Adansonia digitata* seeds are rich reservoirs of free radical scavenging

molecules such as alkaloids, tannins, flavonoids and other metabolites which are basically rich in antioxidant and anticancer activities. It has been established that only high content of anti-nutrients prevent the absorption of mineral like iron, magnesium, potassium and calcium which are essential for metabolism in the body. Reduction of anti-nutrients is necessary especially when their levels are higher than those generally regarded as safe for human consumption.

However, the baobab seeds are a proteinous food with large quantity of mineral elements, high level of phytochemicals and trace amount of anti-nutrients. Therefore their utilization should be strongly recommended.

5. Recommendations

Considering the result of the analysis, the baobab seeds could be recommended in the preparation of diets for people with low level of mineral elements and can be incorporated as dietary supplements in weaning foods to improve the quality of diets of infants and children. Whenever baobab seeds are to be processed into flours, the fermentation method should be used because:

- It was found to be the most suitable method to be used as it increases the minerals content of the seeds.
- It reduces the moisture level of the seeds thereby promoting longer shelf life of the seeds
- It also saves time and requires non-expensive equipment.

Compliance with ethical standards

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Disclosure of conflict of interest

All the authors hereby declared that there is no conflict of interest before, during and after the conduct of this research.

References

[1] Bermer B, Bremer K, Chase MW, Reveal JL, Soltis DE, Soltis PS, Stevens PF, Andreberg AA, Fay MF, Goldbaltt P, Judd WS, Kallerrsjo M, Karehed J, KRON KA, Lundberg J, Nickrent DL, Olmstead RG, Oxelman B, Pires JC, Rodman JE,Rudall PJ, Savolainen V, Sytsma KJ, VanderBank M, Wurdack K, Xiang JQY, Zmarzty S. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants:APG II.Botanical Journal of the linnean Society. 2013; 141: 399-436.

[2] Yazzie D, Vanderjagt DJ, Pastuszyn A, Okolo. A., of baobab (*Adansonia digitata* L.) Leaves. Journal of Food Composition and Analysis. 1994; 7: 189-193.

[3] Diop AG, Sakho M, Dornier M, Cisse M, Reymes M. Me baobab afrucainetutilisation. Fruits. 2005; 61: 55-69.

[4] Sibibe M, Williams JT. Baobab-*Adansonia digitata*. Fruits for the future. Int. Center Underutil. Crops, Southampton, UK. 2002; 96.

[5] Venter F, Venter J. Baobab in making the most of indigenous tree. Briza publications, Pretoria, South Africa. 1996; 26-27.

[6] Gebauer J, El-Siddig K, Ebert G. Baobab (*Adansonia digitata* L.): A review on a multipurpose tree with promising future in the Sudan. Gartenbanwissenschaft. 2002; 67: 155-160.

[7] Addy EO, Eteshola E. Nutritive value of a mixture of tigernut tubers(Cypesusesculentus L.) and baobab seeds (Adansoniadigitata L.).J. Sci. Food Agric. 1984; 35: 437-440.

[8] Uphof J.C Dictionary of Economic Plant. Cramer Wiirzburg, U.S Strechert-hanfner, New York,1968 pp591.

[9] Ologhobo DA, Fetuga BL. Trypsin inhibitor activity in some lima bean variety as affected by different processing method.Nutr Rep Int. 1983; 27:41-48.

[10] AOAC. Official Method of Analysis of AOAC International (OMA). AOAC International, Gaithersburg, MD. 2005

[11] Asibey-Berko E, Tayie FAK. Proximate analysis of some underutilized ghanaian vegetables. Ghana J. Sci. 1999; 39:91-92.

[12] Ijarotimi SO, Oluwole AA, Ariyo O. Comparative study on nutrient composition, phytochemical, and functional characteristics of raw, germinated, and fermented Moringa oleifera seed flour. Fd. Sci. and Nut. 2013; 1(6):452-463.

[13] Oladele KA, Osundahunsi FO, Adebowale AY. (2009). Influence of carbohydrate processing techniques on the nutrients and antinutrients of tigernut (Cyperus esculentus L.). World J. Dairy Food Sci. 2009; 4(2):88-93.

[14] Nnam NM,Obiakor PN. Effect of fermentation on the nutrient and anti-nutrient composition of baobab (*Adansonia digitata*) seeds and rice (Oryza sativa) grains. Ecol. Food Nutr. 2003; 42: 265-277.

[15] TidjaniAmza, Issoufou Amadou, Mohammmed T, Kamara Kexue Zhu, Huimin Zhou. Chemical and Nutrient Analysis of Ginger bread plum (Neocaryamacrophylla) seeds. Advance Journal of Food Science and Technology. 2010; 2(9): 191-195.

[16] Eknayakea S, Janzs ER, Nair BM. Proximate composition, mineral and amino acid content of mature Canavaliagladiata seeds. Food Chem. 1999; 66(1): 115-119.

[17] Watt BK, Merill AL. Composition of foods. Agricultural Handbooks No. 8. Washington DC. U.S. Department of Agriculture. 1963.

[18] FND. Dietary Reference Intake for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein and Amino Acid (micro-nutrients). FND, National Academy of Science USA. 2002.

[19] Osman MA. Chemical and Nutrient Analysis of Baobab (Adansoniadigitata) Fruit and Seed Protein Solubility. Plant Foods for Human Nutrition. 2004; 59: 29-33.

[20] Zimba N, Wren S, Strucki A. Three major tree nut oil of Southern Central Africa:their uses and future as commercial base oils:International Journal of Aromatheraphy . 2005; 15: 177-182.

[21] Chivandi E, Erlwanger KH, Davidson BC. A comparison of the Lipid and fatty acid profiles from the kernels of the fruit (nuts) of Ximenia caffra and Ricinodendron from Zimbabwe. 2008.

[22] Fasakin AO, Fehintola EO, Obijole OA, Oseni OA. Compositional analyses of the seed of sour sop, Annonamuricata L., as a potential animal feed supplement. Sci. Red. Essays. 2008; 3(10): 521-523.

[23] Onyeike EN, Olungwe T, Uwakwe AA. Effect of heat treatment and defatting on the proximate composition of some Nigerian local soup thickeners. Food Chem. 1995; 53(2): 173-175.

[24] Addy EOH, Salami LI, Igboeli LC, Remawa HS. Effect of processing on nutrient composition and anti-nutritive substances of African locust bean (Parkiafilicoidea) and baobab seeds (*Adansonia digitata*).Plant Food Hum, Nutr. 1995; 48: 113-117.

[25] Osagie AU, Okoye WL, Olawayeso BO, Awodu AO. Chemistry quality parameters and fatty acids composition of oils of some underexploited tropical seeds. Nigerian Journal of Applied Sciences. 1986; 4: 151-162.

[26] Achinewhu SC. Some biochemical and nutritional changes during the fermentation of the fluted pumpkin (Telfariaoccidendtials).QualitasPlantarum: Plant Food Hum. Nutr. 1986; 36: 97-106.

[27] Umar KJ, LG Hussan, H Usman, Wasagu RSU. Nutritional Composition of the Seeds of Wild Melon (Citrullusecirrhosus).Parkistan Journal of Biological Sciences. 2013; 16: 536-540.

[28] Abiona D, Adedapo Z, Suleiman M. (2015) "Proximate Analysis, Phytochemical Screening and Antimicrobial Activity of Baobab(*Adansonia digitata*) Leaves," IOSR JAC. 2015; 8(5): 60- 65.

[29] RDA. Recommended Dietary Allowance. 10th Edition, National Academic Press, Washington DC, USA. 1989.

[30] House WA. Trace Element Bioavailability as exemplified by Iron and Zinc. Field Crops Research. 1999; 60: 115-141.

[31] FAO/WHO. Codex Alimentarius Commission Food Additives and Contaminants. Joint FAO/WHO Food Standards Programme, ALINORM 01/12A. 2001; 1-289.

[32] Adeyeye EI, Okokiti MK. Proximate composition and some nutritional valuable Minerals of two varieties of Capsicum annum (Bell and Cherry peppers). Discovery Innovation. 1999; 11: 75-81.

[33] National Research Council (NRC). Recommended Dietary Allowance. National Academy Press, Washington DC. 1989.

[34] Hassan LG, Mohammed MU, Umar KJ, Sokoto AM. Nutritional Composition of Vegetable Spaghetti (Hasta la Pasta) fruits. Nigeria Food Journal. 2009; 27(2): 41-49.

[35] Hassain LG, Umar KJ. Proximate and Mineral composition of seeds and pulp of African locust bean (Parkiabiglobosa L.).Nigerian Journal of Basic and Applied Sciences. 2004; 13: 15-27.

[36] Ishida H, Suzuno H, Sugiyama N, Innami S, Todokoro T. National evaluation of chemical composition of leaves stalks and stem of sweet potatoes Ipomeabatataspoirs. Food Chem. 2000; 68: 359-367.

[37] Food and Nutritional Board. Dietary Reference Intakes of Calcium, Phosphorus, Magnesim, Vitamin D and Fluoride. Washington DC. National Academy Press. 1997.

[38] Donatien K, Hagrétou S-L, Bréhima D, Clarisse SC, Mamoudou HD, Mogens J. A review of baobab (*Adansonia digitata*) products: Effect of processing techniques, medicinal properties and uses. African Journal of Food Science. 2011; 5(16) : 833-844.

[39] Oshodi AA, Ipinmoroti KO, Fagbemy TN. Chemical composition, Amino Acid Analysis and Functional Properties of Bread nut (Artocarpusaltillies) Flour. Nahrung/Food. 1999; 43: 402-405.

[40] Garcia-Rico L, Leyva-Perez J, Jara-Marini ME. Content and daily intake of copper, zinc, lead, cadcium, and mercury from dietary supplements in Mexico. Food Chem. Texicol. 2007; 45(9): 1599-1605.

[41] Chadare F, Linnemann A, Hounhouigan J, Nout M, Van Boekel M. (2008) Baobab food products: a review on their composition and nutritional value, Crit Rev Food Sci Nutr. 2008; 49(3):254-274.

[42] El-Mahmood A, J Doughari. Phytochemical screening and antibacterial evaluation of the leaf and root extracts of Cassia alata Linn, Afr J Pharm Pharmacol. 2008; 2(7): 124-129.

[43] Ekeleme UG, Nwachukwu NC, Ogodo AC, Nnadi CJ, Onuabuchi IA, Osunocha KU. Phytochemical screening and antibacterial activity of Cnidpscoiusaconitifolius and associated changes in liver enzymes in wistar rats. Aust. J. Basic Appl. Sci. 2013; 7(12): 156-162.

[44] Cushnie TP, Lamb AJ. Antimicrobialactivity of Flavonoids. Int. J. Antimicrobial. Agents. 2005; 26(5): 343-356.

[45] Okwu DE. Evaluation of the chemical composition of Indigenous Species and Flavoring Agents. Global Journal of Pure and Applied Science. 2001; 7: 455-459.

[46] Pourmorad F, Hosseininelir SJ, Shahabimajd N. Antioxidant activity, phenol and flavonoid content of some selected Iraninan medicinal plants. Afri. J. Biotech. 2006; 5: 1142-1145.

[47] UgwuOkechukwu PC, NwodoOkwesili FC, Joshua Parker E, BawaAbubakar OssaiEmmaneul C, Odo Christian E. Phytochemical and Acute Toxicity Studies of MoringaOleifera Ethanol Leaf Extract. International Journal of Life Sciences Biotechnology and Pharma Research. 2013; 2(2):1-8.

[48] Rafat HS, Cillard BS, Cilliad NT. Hydroxyl Radical Scavenging activity of flavonoids. Journal of Phytochemistry. 2008; 26: 2489-2491.

[49] Omale J, PN Okafor. Comparative antioxidant capacity, membrane stabilization, polyphenol composition and cytotoxicity of the leaf and stem of Cissusmultistriata. Afr. J. Biotechnol. 2005; 7(17): 3129-31.

[50] Rice-Evans CA, Miller NJ, Bolwell PG, Bramley PM, Pridham JB. The relative activities of plant-derived polyphenolic flavonoids, free radicals Res. 1995; 22: 375-383.

[51] Bello, K.M., Oyawoye, E.O., Bogoro, S.E. & Dass, U.D., 2011. The performance of broilers fed varying levels of palm kernel cake. Int. J. Poult. Sci. 10, 290–294.

[52] Barbehenn RV, Constabel CP. (2011). Tannins in plant– herbivore interactions, Phytochem. 2011; 72(13): 1551-1565.

[53] Li H, Wang Z, Liu Y. Review in the studies on tannins activity of cancer prevention and anticancer. Thong-Yao-Cai. 2003; 26(6): 444-448.

[54] Asquith TN, Butter LG. Interaction of condensed tannin with selected proteins. Phytochemistry. 1986; 25(7): 1591-1593.

[55] Umaru HA, Adamu R, Dahiru D, Nadro MS. Level of Antinutritional Factors in Some Wild Edible Fruits of Northern Nigeria. African Journal of Biotechnology. 2007; 6(6): 1935-1938.

[56] Roa RR, Babu RM, Roa MRV. Saponin as anti-carcinogens. The J. Nutr. 1995; 125: 717-724.

[57] Fagbohun ED, Egbebi AO, Lawal OU. Phytochemical screening, proximate analysis and in vitro antimicrobial activities of extract of Cnidoscoiusaconitifolius leaves. Int. J. Pharm. Sci. Rev. Res. 2012; 13(1): 28-33.

[58] Aruoma OL. Methodological consideration for characterizing potential antioxidants actions of bioactive compounds in plant foods. MutatRed. 2003; 523 (524): 9-20.

[59] Reddy MJ, Pierson A. Antinutritional and Natural Toxicants. Scientific American. 1998; 36: 1-10.