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Chemical Composition, Cacium, Zinc and Phytate Interrelationships in Baobab (*Adansonia digitata*) Seed Flour

[1]H.O. Adubiaro, [2]O. Olaofe, [2]E.T. Akintayo and [1]O.O. Babalola
[1]Science Technology Department, Federal Polytechnic Ado-Ekiti, Ekiti State
[2]Chemistry Department, University of Ado-Ekiti, Ekiti State

Abstract: The chemical, nutritive and antinutritive values of Baobab seed flour were determined. The seed has very high content of protein 48.3% and moderately high content of carbohydrate 21.9%. The most abundant mineral in the seed flour is K 536 mg/100 g followed by Mg 352 mg/100 g. The least abundants are Zn (3.40 mg/100 g), Cu (4.26 mg/100 g) and Mn (5.23 mg/100 g). The levels of Na/K, Ca/P and Ca/Mg in the seed flour are desirable when compared with the recommended values. The antinutritional factors showed the presence of flavonoid, tannic acid, saponin and alkaloid with value ranging from 0.65 to 6.48%. Other antinutrients are cyanide, polyphenols, phytate and oxalate. Their low values showed that the seeds may be recommended for human consumption. The prediction of Zn availability was determined using Phy:Zn, Ca:Phy and Ca xPhy/Zn molar ratios which indicate an adequate availability of Zn.

Key words: *Adansonia digitata*, antinutritional, chemical, mineral, nutritive

INTRODUCTION

Baobab (*Adansonia digitata*) belongs to the family, Bombacaceae, sub-family of malvaceae. It is known as osé in Yoruba land. The Baobab tree is found in areas of South Africa, Botswana, Namibia, Mozambique and in arid and semi arid zones of America, Africa and Asia where 44 species have been reported (Becker *et al*., 1984). In Nigeria, *Adansonia digitata* specie can be found growing majorly in the Northern part. The pulp covering the seeds of *Adansonia digitata* is used in the preparation of local condiments "fura-de-nunu" and "daddawa Higgi" in Machika local government area of Adamawa state, Nigeria (Nkafamiya *et al*., 2006). The fruit is a large, egg-shaped capsule (often>120 mm), covered with yellowish brown hairs. The fruit consists of a hard, woody outer shell with a dry, powdery substance inside that covers the hard, black kidney-shaped seeds.

Phytic acid (myo-inositol hexa phosphate) is a theromolabile rachitogenic agent (Aletor, 1993). It is an important constituent of certain legumes, cereals and forage plants which is capable of chelating divalent cationic minerals like calcium, iron, magnesium and zinc (Liener, 1983). They are extremely insoluble even at pH 3-4 and are not readily absorbed from the intestinal tract. Such chelates make the elements nutritionally unavailable thereby inducing dietary deficiency. Phytic acid has been implicated in the reduced adsorption of calcium from the gastro intestinal tracts and consequently causing rickets when chicks are fed with cereals such as sorghum (Nelson *et al*., 1968). Similarly, zinc and iron deficiency symptoms have been reported in man and chicken when fed with diets high in phytic acid.

Nwokolo and Bragg (1977) have shown that there is a significant inverse relationship between phytic acid and the availability of calcium, magnesium, phosphorus and zinc in feed stuffs like soybean palm kernel, rape seed and cotton seed meals. High levels of phytic acid in monogastric animals can reduce the absorption of calcium by up to 35% as well as chelating with iron, magnesium and zinc. Phytic acid can react with protein to form phytate-protein complex (O'Dell and Savage, 1960). This complex, incorporates about 16% of the protein in beans, through the reaction is pH dependent. Formation of phytate - cation protein complex is believed to account for the decreased mineral bioavailability observed in animals consuming diets high in phytic acid.

Studies investigating the significance of the Phy:Zn, Ca:Phy and Ca x Phy:Zn interaction for human zinc status are limited because information on the Zinc and Phytate content of foods is not available (Adeyeye *et al*., 2002). Though the pulp of Baobab is already being used as seasonings in local drinks e.g. (Fura-de-nono), the seeds are thrown away, so the aim of this work is to ascertain the nutritive and antinutrive values of this seed, so as to encourage its use and inclusion in human food.

MATERIALS AND METHODS

The Baobab seeds were collected from Fulani women in Northern part of Nigeria after they had removed the pulp for use in making "fura - da-nono" drink.The seeds were sundried powderedand stored in polythene bags until use. The research was conductedin th year 2009 at Federal University of Technology, Akure, Ondo State, Nigeria.

Corresponding Author: H.O. Adubiaro, Science Technology Department, Federal Polytechnic Ado-Ekiti, Ekiti State

Chemical composition and antinutrional analysis: Chemical composition and antinutrional analysis were carried out according to the procedure of Association of Official Analytical Chemist (AOAC, 1995).

Mineral composition: One gram of the seed flour was weighed into the crucible. The sample was ashed in a muffle furnace at 550°C until completely ashed. The ash was dissolved into 10% ($^{V}/_{V}$) HCl, heated to boiling, cooled and filtered and made up to 100 mL mark in a volumetric flask with deionized water and the mineral analysis was determined by Atomic Absorption Spectroscop (AAS) (Vogel, 1962).

Calculated fatty acid = (0.8×crude fat) g/100 g (Aremu *et al*., 2006)

Calculated metabolisable energy = (% protein × 17 + % fat × 37 + % carbohydrate × 17) KJ/100g)

RESULTS AND DISCUSSION

Table 1 shows the proximate composition, bulk density, calculated metabolisable energy and calculated fatty acid values of Baobab. The moisture content 4.20 is low compared with most tropical crop seeds. Tiger nut (*Cyperus esculentus*) 9.47% (Monoago And Unwakwe, 2009) and whole meal flour (*Triticum durum*) 7.93% (Adeyeye and Aye, 2005). The low moisture content in the seed flour suggests that the seed will have a long shelf life (Oyenuga, 1968), since the low moisture content may prevent microbial spoilage and pest attack during storage. The crude fat value of Baobab 16.90% is also low when compare with that of *B. glabra* seed of 34.8% (Olaofe *et al*., 2006), *Cucumeropsis edulis* 43.8% (Ige *et al*., 1994) and pumpkin seed 47.7% (Aiseigbu, 1987) but this value agree with that of pitanga cherries 15.63% (Amoo *et al*., 2006). The crude fat of this seed shows that it will be a good source of fat which provides a major portion of man's energy. The crude protein of this seed 48.3% is higher than some tropical tree seeds, breadnut 19.25% (Oshodi *et al*., 1999), *Bombcopsis glabra* 16.56% (Olaofe *et al*., 2006) benniseed 22.5% (Oshodi *et al*., 1999) and locust bean 24.1% (Adeyeye *et al*., 2002). The high protein content of baobab show that it would be useful as alternative source of protein in livestock feeding and also in man, especially in Nigeria where the scarcity and the cost of the conventionally used plant protein sources have nearly paralyzed most of the industries. The value of the ash 3.83% in this seed show that it may have a reasonable quantity of mineral elements for building healthy body and proper functioning of body tissues. The considerable amount of crude fibre 4.82% in this seed show that it will enhance easy movement of bolus in the large intestine. Relatively high energy value 1820 KJ/100 g of Baobab seed indicates that it is a concentrated source of energy and within the recommended energy dietary allowances for children (FAO, 1990).

Table 1: Proximate Composition of Baobab (*Adansonic digitata*) seed flour

Parameter	Concentration
Moisture	4.20±0.40
Crude fat1	6.90±0.23
Crude protein	48.3±0.40
Ash	3.83±0.26
Crude fibre	4.82±0.16
Carbohydrate (by diffeence)	21.90±0.21
Bulk density	0.45±0.33
Calculated fatty acid (g/100 g)	13.30
Energy (KJ/100 g)	1820

Each value represents means±standard deviation of three replicate determinations

Table 2: Mineral and Antinutritional factors in Baobab (*Adansonia digitata*) seed flour

Mineral and Antinutrents (Mg/100 g)	Concentration
Ca	242.00
Mg	352.00
K	536.00
Na	8.42
Na/K	0.04
Fe	22.0
Mn	5.23
Zn	3.40
Cu	4.26
P	480
Ca/P	0.50
Tannic acid	2.05
Polyphenols	0.32
Cyanide	0.32
Phytate	6.66
Oxalate	0.33
Alkaloid (%)	6.40
Saponin (%)	2.06
Flavonoid	0.65

Table 2 presents the mineral composition of the seed. The most abundant minerals are K (536 mg/100 g), Mg (352 mg/100 g), Ca (242 mg/100 g), P (480 mg/100 g) and Fe (22 mg/100 g). The observation that K is the most abund ant mineral element is consistent with the observation of Olaofe and Sanni (1988) and Oshodi *et al*. (1999) who reported K to be the most abundant mineral in Nigerian agricultural products. High amount of calcium, potassium and magnesium (as macro elements) may help to lower the blood pressure (Ranhotra *et al*., 1998). Several clinical studies have shown potassium, magnesium and calcium to be effective pressure lowering agents (Osborne *et al*., 1996; Zewel, 1977) hence consumption of this seed flour may help achieve this purpose.

The iron content of the seed flour is 22.0 mg/100 g. This shows that this seed flour is very rich in Fe. Iron is very important for the formation of haemoglobin and normal functioning of the central nervous system (Vyas and Chandra, 1984). The iron contents of this seed flour is higher than that of African pear 6.41 mg/100 g (Ibanga and Okon, 2009), triticum durum flour 4.93 mg/100 g (Adeyeye and Aye, 2005) that of locust bean 1.9 mg/100 g (Adeyeye *et al*., 2002) and that of chickpea seed 7.72 mg/100 g. But the values are lower than that of Bombcopsis glabra 30.0 mg/100 g (Olaofe *et al*., 2006).

The Ca/P and Ca/Mg weight ratios is 0.50 and 0.69, respectively. The values are low when compared with the recommended 1.0 and 2.2, respectively (NRC, 1989). The low values of Ca/Mg and Ca/P may be due to the low calcium content or high content of phosphorus of the seed flours. Ca, P and Mg are important in the formation of bones and teeth as well as in controlling the level of Ca in the blood of animals (NRC, 1989; Osborne and Voogt, 1978). The calcium supplementation in the diet based on the seed flour may be necessary to prevent Ca deficiency diseases like rickets.

Table 2 also presents other antinutritional factors in the seed flour. The oxalate content of the seed is low (0.19 mg/100 g) when compared with that of Chinese gourd 1.48 mg/100 g. Oxalic acid has the ability to bind some divalent metals such as Ca and Mg and has therefore been suspected of interfering with the metabolism of these minerals. According to Blood and Henderson (1974), the ingestion of an excessive amount of oxalate could cause gastrointestinal irritation, blockage of the renal tubules by calcium oxalate crystals, muscular weakness or paralysis. Plants generally tend to accumulate high oxalate levels during the early stages of growth (Aletor, 1993). We are not expecting any nutritional discomfort with the level of oxalate in this seed.

Polyphenols and tannins in legumes are known to inhibit the activities of digestive enzymes (Jambunathan and Singh, 1981) and nutritional effects are mainly related to their interraction with protein and minerals. They also reduce the absorption of nutrients such as vitamin B_{12} (Liener, 1989). Tannin-protein complexes are insoluble and this decreases the protein digestibility (Carnovale *et al.*, 1991). The concentrations of polyphenols for *Baobab (Adansonia digitata*) is 0.49%. This value is lower than that of mucuna species which ranges from 4.34 to 7.75 (Adebowale *et al*., 2003) and that reported for conventional legume *Vigina radiate* 1.45%. The concentration of tannic acid 1.22% for the seed flour is lower than that of chickpea seed 4.88% (Tarek, 2002).

Phytates (hexaphosphate of myo-inositol) are common antinutrients in plant seeds. They chelate di-and trivalent mineral ions, such as Ca^{2+}, Mg^{2+}, Zn^{2+} and Fe^{3+} resulting in reduced bioavailability of trace minerals to consumers (D'Mello *et al*., 1991). Phytate concentration of the seed flour is 7.13%. This value is higher than that of mucuna species 1.23 to 2.56% (Adebowale *et al*., 2003) and that of sesbania seeds 1.89 to 2.37% (Hossain and Becker, 2001). The saponins are diverse group of compounds containing an aglycone linked to one or more biological effects in animals including erythrocyte haemolysis, depressed growth, reduced feed intake and effect on nutrient absorption and bile acid metabolism (Cheecke, 1996). The concentrations of saponin for this seed is 3.27% which is in close agreement with that of mucuna seeds which ranges from 0.52 to 3.0 (Adebowale *et al*., 2003) but higher than that of sesbania seeds 0.50-1.46% (Hossain and Becker, 2001).

Table 3: Concentration of Ca, Zn, phytate and calculated Phy: Zn, Ca: phy and [Ca][Phy]/[Zn] mole rations of Baobab (*Adansonia digitata*) seed

Mineral/antinutrient	Concentration
Phytin phosphorus pP%	0.62
Ca (mg/100 g)	242
Zn (mg/100 g)	3.40
P (mg/100 g)	480
Phytate (g/100 g)	6.66
[a] Phy :Zn	0.19
[b] Ca: Phy	604
[c][Ca][Phy]/[Zn]	0.011
pP/p	0.13
Ca/P	0.50
Ca/Mg	0.69

[a]: (Mg of Phy/MW (molecular weight) of Phy: Mg of Zn /MW of Zn); [b]: (Mg of Ca/MW of Ca:Mg of Phy/MW of Phy); [c]: (Mol/Kg of Ca) (Mol/kg Phy) / (Mol/kg Zn)

It has been known for a long time that a wide variety of plants are potentially toxic because they contain glycosides from which hydrogen cyanide may be released by hydrolysis (Conn, 1979). Hydrolysis occurs quite rapidly when the ground plant is cooked in water, and most of the liberated hydrogen cyanide is lost by volatilization. The concentration of cyanide in the seed is 0.42% which is lower than the values for kidney bean 2.0% and garden pea 2.3% (Montgomery, 1969). This result shows that Baobab seed contain minimum levels of antinutritional factors which the body can accommodate and these can also be reduced by boiling. According to Fagbemi *et al*. (2005), processing especially boiling can effectively reduce the antinutritional factors.

Table 3 presents the results of Ca, Zn, phytate (phy), phy: Zn, Ca: phy, phytinphosphorus and Ca x Phy/Zn. Obelease and Harland (1981) showed that foods with a molar ratio of phy:Zn less than 10 showed adequate availability of Zn and problems were encountered when the value was greater than 15. In Table 3, the phy:Zn ratios is shown for the seed flour, the values is less than 10 which indicate adequate availability of Zn.

Also phytic acid has been observed to have markedly decreased Ca bioavailability and the Ca: Phy molar ratio has been proposed as an indicator of Ca bioavailability. The critical molar ratio of Ca:Phy is reported to be 6.1 (Oladimeji, 2000). The molar ratio of Ca:Phy obtained for Baobab (*Adansonia digitata*) is 604. This value is much, much greater than reported critical molar ratio of Ca:Phy, indicating that absorption of calcium would not be affected by phytate in the seed's flour.

Ellis *et al.* (1987) and Davies and Warrignton (1986) indicated that the ratio of Ca x Phy/Zn is a better predictor of Zn availability and that if the values were greater than 0.5 mol/kg, there would be interferences with the availability of Zn. For Baobab seed flour the Ca x phy/Zn value is less than 0.5, which means that there would not be interferences in the availability of Zn. Ekpedeme *et al.* (2000) reported that high levels of anti-nutrients, such as oxalate, phytic acid and HCN, are known to be very poisonous to humans. Since the results indicated that the seed flour has low amount of phytates, (0.62% phytin phoshorus), the bioavailability of essential dietary minerals, especially calcium and zinc were assured.

The total phosphorus of *Adansonia digitata* 480 mg/100 g is higher than that of Chinese bottle gourd (*Lagenaria siceraria*) 451 mg/100 g (Olaofe and Adeyeye, 2009). Also the value of phytinphosphorus 0.62 for the seed flour is lower than that of Chinese bottle gourd. This means that only 0.62 total phosphorus were linked to phytin for *Adansonia digitata*. The nutritional implication of high phytin phosphorus rests on the fact that monogastric animals lack phytase, which can break down the phytin to release phosphorus for utilization (Olaofe and Adeyeye, 2009). It means that with the low values of phytinphosphorus in this seed's flour, monogastric animal taking it will have the phosphorus released for utilization.

CONCLUSION

In conclusion, it shows that the seed baobab, contains low amount of antinutritional factors and excellent calcium, zinc and phytate interrelationship which will make it useful in the food production.

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