PHYSICO-CHEMICAL ANALYSIS OF THE FRUIT OF ADANSONIA DIGITATA (BAOBAB) IN GHANA

W. Affo and S. S. Akande
Department of Chemistry, University of Ghana, Legon, Ghana

ABSTRACT

Ten samples of Adansonia digitata fruit were obtained from a farm in Adidome in the Volta Region of Ghana in December 2010. The study was carried out to extract and characterize the seed oil as well as to analyze the nutritional (proximate) composition and elemental make-up of the seed and pulp of Adansonia digitata by standard methods. The L-ascorbic acid (Vitamin C) content of the pulp was also determined titrimetrically using indophenol dye. The seed oil obtained was subjected to a series of chemical tests to determine some useful parameters of the oil such as the iodine value, peroxide value, specific gravity and refractive index etc. Light yellow seed oil which gave a yield of 15.5±0.06% was extracted from the seed using n-hexane. The physico-chemical properties of this oil gave the following results: Iodine value (82.39±0.02), Peroxide value (13.5±0.3), Acid Value (6.8±0.3), Refractive Index (1.4791±0.0001) and Specific gravity (0.95 at 28^{0}C). The seed was found to contain carbohydrate (60.48%), crude protein (7.08%) and fat (oil) (15.5±0.06%). The pulp also contained high amounts of carbohydrate (82.84±0.01%), crude fibre (4.16±0.07%), and very high ascorbic acid content (124mg/100g). Analysis of the pulp revealed that it did not contain any oil. Elemental analysis of both components of the fruit showed that Magnesium(Mg) was in highest quantity (5287mg/100g-seed, 1257mg/100g- pulp) followed by Potassium(K) (1257 mg/100g-seed, 1890 mg/100g- pulp) and Calcium (Ca) and Sodium (Na) having (398mg/100g-seed, 555mg/100g-pulp) and (320mg/100g-seed, 360mg/100g-pulp) concentrations respectively. Micronutrients, such as iron (Fe), zinc (Zn), copper (Cu), manganese (Mn) and chromium (Cr) were also detected. The results of the study were compared to similar studies done on the same variety of the fruit in Saudi Arabia, Sudan and Nigeria.

INTRODUCTION

In a world where over 100,000 different fruits exist, very few of them are thoroughly exploited and commercialised. However, the ever rising demand for protein and energy sources to support the world's growing population especially in the arid and semi-arid areas has led researchers to reach farther and explore new and non-conventional sources of food. Due to the widespread availability of *Adansonia digitata* (Baobab) in the tropical parts of the world especially in Africa, it has been a strong point of focus in this regard. Previous studies show that the fruit of *Adansonia digitata* has been underutilized even though it offers amazing opportunities for improvements in the overall nutritional profile of food products. The fruit has even been termed the "super fruit" (Wilkinson, 2007).

The fruit is a large, egg-shaped capsule, covered with yellowish brown hairs and looks like large rats strung by their tails when seen hanging from the tree hence the name "dead rat tree". The seeds are dark brown in colour and are arranged in a pattern of about 8 locules per fruit attached to fibrous strands from the wall of the fruit and embedded in a creamish white powdery pulp. Several seeds ranging from 30 to 150 are contained in a single fruit. It is this pulp that has been found to be rich in ascorbic acid. Some interesting discoveries are the presence of a highly nutritive seed oil and the presence of nutritional components such as protein, carbohydrate, mineral elements and fibre (Osman, 2004; Hankey, 2004). There is also the discovery that the baobab pulp contains large amounts of vitamin C in ranges of approximately five times that of an orange.

Generally *Adansonia digitata* seeds and pulp have been found to be edible. The pulp is commonly chewed, sucked and made into a traditional drink by soaking in water to provide a refreshing taste somewhat reminiscent of lemonade. In some places, the dry fruit pulp is separated from seeds and fibres and is eaten directly or mixed into porridge or milk (Nour *et al*., 1980; Odetokun, 1996). Some useful purposes of the seed oil are moisturising benefits for the treatment of dry and damaged skin, as well as for intensive hair care. Hence it is used for the formulation of lotions and creams and hair conditioners. The advantage of Baobab seed oil over other oils is its stability during storage. It stores longer than other unrefined oils and blends easily with other essential and fixed oils. It is used in the cosmetics industry, and is edible. All parts of the baobab tree are reported to have medicinal properties according to traditional folklore and research has confirmed this to be true. The local drink made from the pulp of *Adansonia digitata* is a highly potent natural antioxidant mixture due to its high Vitamin C content (Davey *et al.*, 2000). Its marked antioxidant capability helps prevent and combat the formation of free radicals. Free radical oxidative stress is implicated in the pathogenesis of a variety of human diseases such as atherosclerosis, respiratory disorders, cancer, cardiac diseases, diabetes and others (Manfredini, 2002; Mcgregor *et al*., 2006).

The Baobab fruit pulp is used in certain African countries as an effective anti-diarrhea product. A study conducted on 160 children, of the medium age of eight months, demonstrated that an aqueous solution of the Baobab fruit pulp is significantly more effective than the traditional "WHO solution" for rehydration of children affected with diarrhoea (Galil, 1996). The main constituents responsible for this activity are believed to be tannins (astringent effect), mucilage's (absorbents), cellulose, citric acid and other typical constituents of the fruit pulp. Decoctions or milk suspensions have been successfully used for oral treatment of diarrhea and dysentery (Sidibe *et al*., 1996).

MATERIALS AND METHODS

Sampling and pulverization

Ten fruit samples were obtained from baobab trees at a farm in Adidome in the Volta Region. The fruits were opened by breaking and the pulp and seeds were separated from the fruits using a knife. The seeds were then washed in water and dried in the sun for 12 hours (not to a constant weight) before being pounded in a mortar. The powder was subsequently blended and passed through a metallic mesh of size no. 40 after which it was stored in an air tight jar at room temperature. The pulp was grounded using a laboratory ceramic mortar and pestle and also stored in a closed jar at room temperature. Both samples were stored for a period of two weeks before analyses was done.

Extraction of seed oil

Two different approaches were used in the extraction of the seed oil. First, cold extraction was done by weighing (50.0942±0.0001)g of the powdered seed sample into a large reagent bottle. 150ml of solvent (n-hexane) was added to the sample. The bottle was then tightly cocked and vigorously shaken for 10-15mins before it was allowed to stand for a period of 48 hours. The mixture was shaken periodically within the time period after which it was filtered off into a 250ml beaker using a large Whatman filter paper. The solution obtained was transferred into a round-bottomed flask and concentrated using a rotary evaporator to obtain the oil. The percentage yield of the oil was determined and recorded. The oil was stored in a refrigerator at 5^{o}C for further analysis. Alternatively soxhlet extraction was done by placing (49.8943±0.0001)g of the grounded seed sample into a soxhlet apparatus. 500ml of the required solvent (n-hexane) was added to the sample. The apparatus was heated and pure oil was obtained. The percentage yield of oil was determined as

$$\frac{\text{mass of oil}}{\text{mass of seed sample}} \times 100\%.$$

The oil was stored in a refrigerator at 5^{0}C for further analysis. The physico-chemical properties namely iodine value, acid value, peroxide value and specific gravity of the seed oil were determined by using standard AOAC methods (AOAC, 1990; Horowitz, 1975). The refractive index of the oil was determined using a refractometer, Model ABBE REFRACTOMETER 98.490.

Proximate Composition

Proximate composition (carbohydrate, crude protein, crude fibre, moisture) of seed and pulp were determined as follows. Crude protein content was determined using Kjedhal method for nitrogen analysis. (Cox, 1962; Zamora, 2005)
% Protein = Nitrogen × 6.25

Crude fibre content was determined using the Weende method which involves acid hydrolysis followed by alkaline hydrolysis and then ashing the sample in a muffle oven at 550^{o}C for 12 hours (Anderson *et al*., 2011). Total ash was determined by ashing in a furnace at 5500C for 2 hours. Moisture content was determined by drying the sample to constant weight at 2000C for 12 hours. Carbohydrate was determined by difference, that is, % Carbohydrate = 100% – (%Protein + % Moisture + %Crude Fibre + % Fat + %Ash).

Total energy content was calculated as follows: 1g carbohydrate = 4 kcal/g, 1g protein = 4 kcal/g, and 1g fat = 9kcal/g

The Fibre content was not considered (Osborne, 1978).

Elemental Analysis

Elemental analysis of the seed and pulp were determined using a Flame Photometer MODEL Jenway PFP-7 for the elements Sodium (Na) and Potassium (K). Iron (Fe), Copper (Cu), Zinc (Zn), Calcium (Ca), Magnesium (Mg), Lead (Pb), Cadmium (Cd) and Manganese (Mn) were determined using AAS Model Perkin Elmer A Analyst 400. Phosphorus (P) was determined using a spectrometer MODEL Perkin Elmer Lambda 45 UV Vis Spectrometer.

Vitamin C content

Vitamin C (L-ascorbic acid) was determined titrimetrically using indophenol dye. The dye was reduced to 2,6 dichlorophenol indophenols dye (colourless leuco-base) in the presence of the acid while the ascorbic acid was oxidized to dehydroascorbic acid.

Equation for the reaction:
$H_2C_6H_6O_6$(vitamin C) + $HC_{12}H_6C_{12}O_2N$
(indophenol) →→$C_6H_6O_6$ + $HC_{12}H_8C_{12}O_2N$

The physical properties determined for the seeds and fruit of *Adansonia digitata* recorded a length of 19.3±0.1cm and a width of 7.4±0.1cm (Table 1) which were similar to values reported by Nour *et al.,* (1980); 17.1±1.9 cm for fruit length and 8.0±0.5 cm for fruit width. The colour and nature of the seeds and pulp were also similar to descriptions made by Nour *et al.,* (1980).

Table 2 shows the physico-chemical properties of the seed oil extracted. However, the pulp did

Table 1: Physical properties of *Adansonia digitata* fruit

Property	Mean ± Mean deviation
Length of fruit(cm)	19.3±0.1
Width of fruit(cm)	7.4±0.1
Length (mm) of seed	10.26±0.01
Width (mm) of seed	6.62±0.01
Weight(g) of seed	0.500±0.001
No. of seeds per fruit	93±1
Colour	Dark Brown

not contain any oil. The percentage yield of oil from the seed was 15.5±0.6% which was similar to values reported by Osman (2004) who recorded 12.2% and Odetokun (1996) 17.51%. Values obtained for the physico-chemical properties of the oil were comparable to values for some commercial vegetable oils such as cotton seed oil thus making it viable for commercial purposes (FAO, 1968).

The iodine value measures the relative degree of unsaturation of the oil. A fairly low iodine value indicates good stability of the oil implying that the oil is not too prone to oxidative rancidity. Iodine value for the seed oil was found to be 82.39±0.02 which was consistent with 82.41 reported by Odetokun (1996) and 88.0 by Nour *et al*., (1980). Additionally, the value obtained from this study, 82.39±0.02, being fairly low indicates good stability of the oil which is a desirable property for commercially produced oils. Values for specific gravity (0.95±0.01) and refractive index (1.4791 ± 0.0001) were comparable to those reported by Odetokun (1996) (0.937 and 1.4573) and Osman (2004) (0.9 and 1.500) respectively.

The peroxide value obtained was 13.5±0.3. This exceeded the 5.14 value reported by Odetokun (1996). This value fell out of the range of the standard FAO/WHO value of ≤10 for virgin oils. Generally, because peroxide values increase with increase storage time of the seed oil. This increase obtained could therefore be attributed to the long storage period of the seed oil (4 months). Also the rate of peroxidation is greatly affected by the mode of storage. Storage of the oil was done at 40^{o}C for the entire period except during analysis when it was exposed to room temperatures and to light.

The acid value recorded 6.8±0.3 and was comparable to the 7.79 recorded by Odetokun (1996). However, this value fell outside the codex standard (FAO) value of 4.0 for edible virgin fats and oil (Adelaja, 2006). This is also attributed to the storage time (2 months) as the amounts of free fatty acids in oils tend to increase during storage.

The proximate composition of the nutritive contents of the seed and pulp are shown in Tables 3 and 4 respectively. Chemical analysis of

Table 2: Physico-chemical properties of *Adansonia digitata* seed oil

Physico-chemical Property	This study	Nigeria (Odetokun, 1996)	Saudi Arabia (Osman, 2004)
Acid value	6.8 ± 0.3	7.79	-
Iodine number	82.39 ± 0.02	82.41	88
Peroxide value	13.5 ± 0.3	5.14	-
Specific gravity	0.95 at 28^{0}C	-	0.90
Refractive index	1.4791 ±0.0001	1.4573	1.500
Colour	Light Yellow		

both components showed that the total nutritive value (energy content) of the seed was higher (409.74kCal) than that of the pulp (336.28kCal). The high caloric content is due to the abundance of carbohydrate (60.48%) and fat (15.5%) in the seed. In addition, the seed is a good source of crude protein (7.08%) and crude fiber (6.57%). The crude protein and crude fibre contents showed significant difference from the crude protein-of 21.42% and crude fibre-7.15% values reported by Odetokun (1996) and Nour *et al*., (1980) who recorded crude protein-2.6% and crude fibre-5.7%. Variations in climate and soils in places where the fruits were obtained may be contributing factors to some of these differences. Crude fibre content in the seed was generally the same for all studies (Table 3).

Table 3: Proximate composition of seed of *Adansonia digitata*

Constituents	This study	Saudi Arabia (Osman, 2004)	Nigeria (Odetokun, 1996)	Sudan (Nour A. A. *et al*., 1980)
% Moisture	6.47±0.01	4.3	6.21	6.7
% Carbohydrate	60.48±0.01	45.1	37.16	-
% Crude protein	7.8±0.1	18.4	21.42	2.6
% Crude fibre	6.57±0.05	16.2	7.15	5.7
% Ash	3.9±0.3	3.8	2.15	5.3
% Oil	15.5±0.6	12.2	17.51	
Total energy content (kcal/100g)	409.7	363.8	760.41	

Table 4: Proximate composition of pulp of *Adansonia digitata*

Constituents	This study	Saudi Arabia (Osman, 2004)	Nigeria (Odetokun, 1996)	Sudan (Nour A. A. *et al*., 1980)
% Moisture	7.47±0.01	10.4	6.21	6.7
% Carbohydrate	82.84±0.01	76.2	45.21	
% Crude protein	1.23±0.04	3.2	10.90	2.6
% Crude fibre	4.16±0.07	5.4	6.21	5.7
% Ash	4.1±0.1	4.5	1.98	5.3
% Oil	-	0.3	4.28	0.2
Total energy content (kcal/100g)	336.28	320.3	820.47	

Table 5: Vitamin C content of pulp of *Adansonia digitata*

Vitamin C content	Pulp(mg/100g)	Orange(mg/100g)
Vitamin c (L-Ascorbic acid) content	124.0±0.6	74

Table 6: Elemental analysis of *Adansonia digitata*

Element	Seed (mg/100g)	Pulp (mg/100g)
Potassium (K)	990	1890
Sodium (Na)	320	360
Calcium (Ca)	398	555
Magnesium (Mg)	5287	1257
Iron (Fe)	13.2	17.1
Zinc (Zn)	23	31.2
Phosphorus (P)	15.1	4.4
Lead (Pb)	441	395
Cadmium (Cd)	92	92
Manganese (Mn)	66	69

The pulp gave a high (82.84±0.01%) carbohydrate content the highest value recorded in comparison with other studies (Table 4). Crude fiber content was found to be 4.16±0.07% indicating that both the seed and pulp are good sources of carbohydrate and fibre. Analysis of the pulp showed that it contained no oil and as such oil can only be obtained from the seed. This study shows that the pulp is a poor source of crude protein (1.23±0.04%). The low moisture content of both the seed (6.47±0.01%) and pulp (7.47±0.01%) is an index of stability, quality, and long shelf life.

Elemental analysis (Table 6) revealed that both seed and pulp are excellent sources of calcium (Ca), potassium (K), sodium (Na) and magnesium (Mg). The highest concentration recorded was that of Mg (5287mg/100g-seed, 1257mg/100g - pulp) followed by potassium (K) (1257 mg/100g -seed, 1890 mg/100g – pulp). Na and K take part in ionic balance of the human body and maintain tissue excitability. Na plays an important role in the transport of metabolites and K is important for its diuretic nature. The ratio of K/Na in any food is an important factor in prevention of hypertension and arteriosclerosis, with K depressing and Na enhancing blood pressure (Saupi *et al*., 2009).

An interesting observation is the presence of lead (Pb) concentrations of (441mg/100g in seed and 395mg/100g in the pulp (Table 5). This is undesirable since it leads to Pb poisoning if bioavailable to the human body. Since the samples were collected from a farm, the Pb could have seeped into the soil through the use of fertilizers and other agricultural processes. Generally, the results obtained for all the elements analyzed were comparatively higher than those reported for some seed oils. The most striking feature of the pulp was its high content of ascorbic acid (vitamin C) recorded as 124mg/100g. This value measures up to more than twice the ascorbic acid content in an orange making it an excellent source of vitamin C. Thus it could be harnessed for use in the pharmaceutical and nutraceutical industries.

CONCLUSION

The data presented in this study suggests that Adansonia digitata is a good source of seed oil with yield of about 15.5% and their physicochemical properties makes it potentially usefulness in the vegetable oil industry. The overall proximate composition for both the seed and the pulp also make the fruit a good alternative energy source in diets. It could also be used in making supplements for feed formulations for livestock.

The high fibre content contained in the fruit make it of great benefit in balanced diets as this will help in lowering blood cholesterol, control of blood sugar levels and the absorption of nutrients in the digestive tract. The high concentrations of some of the valuable elements will go a long way to resolve problems relating to nutrition and health.

The results of the study also show that the pulp of Adansonia digitata contains high amounts of Vitamin C (L-ascorbic acid) implying a high antioxidant activity. Being a very vital element that humans are unable to synthesize, we are entirely dependent upon dietary sources for it. Because of its many benefits as a vitamin, this pulp can therefore be utilized in the production of beverages and nutritional supplement for export purposes and consumption.

REFERENCES

Adelaja, J. O. (2006). *Evaluation of mineral constituents and Physico-chemical properties of some oil seed.* M.Sc. Industrial Chemistry, University of Ibadan, Ibadan.

Anderson, J. M., Ingram, J. S. I., (1989). TSBF: *A Handbook of Methods of Analysi*s. CAB International pp. 39.

Anderson, J., Perryman, S., Young, L., Prior, S. (2011). *Dietary Fibre*, Colorado State University Extension

Cox, H. E., Pearson, D. (1962). *The Chemical Analysis of Foods* Chemical Publishing Co Inc New York pp. 420.

Davey, M. W., Montagu, M. V., Inze, D. (2000). Plant L-ascorbic acid: chemistry, function, metabolism, bioavailability and effects of processing. *J Sci Food Agric* 80: 825-860.

FAO United Nations Food and Agriculture Organization (1968) *Food Composition Table for use in Africa Rome*, Italy.

Galil, N. E. (1996). Evaluation of Baobab (Gonglase) solution for home management of diarrhoea in Sudanese children. PhD Thesis in Agriculture, Khartoum University, Sudan pp. 152.

Lee, K., Gillatt, P. N., Rossell, J. B. (1994). Authenticity of edible oils and fats. Part XX. Determination of maize oil purity by stable carbon isotope ratio analysis (SCIRA). Research Report No. 719, Leatherhead, Surrey, UK, Leatherhead Food Research Association.

Hankey, A. (2004). *Adansonia digitata.* S. A National Biodiversity International

Harris, L. J., Ray, S.N. (1935). Diagnosis of Vitamin C Sub-nutrition by Urine Analysis, *Lancet 1:* **71.**

Horowitz, W. (1975). *Official Methods of Analysis of AOAC* Association of Official Analytical Chemists Washington 12th Ed pp. 490.

Manfredini, S. (2002). The Health Properties of Baobab, (*Adansonia digitata*), Verona 6 University of Ferrara.

Marangonim, A., Alli I. (1988). Composition of the seeds and pods of the tree legume*Prosopis Juliflora. J. Sci. of Food and Agric*. 99-110.

Maynard, A. J. (*Ed*) (1970). *Methods in Food Analysis* Academic Press New York pp. 176.

McGregor, G. P., Biesalski, H. K. (2006). "Rationale and impact of vitamin C in clinical nutrition" *Current opinion in Clinical Nutrition and Metabolic Care* 9(6): 697 –703.

AOAC (Association of Official Analytical Chemists). (1990). *Official Methods of Analysis.* 15th Edition.

Nour, A. A., Magbour, B. I., Kheiri, N. H. (1980). *Chemical Composition of Baobab Fruit* (*Adansonia digitata l*) *Tropical Science,* 22: 385.

Osman, M. A. (2004). Chemical and Nutrient Analysis of Baobab. *Plant Foods for Human Nutrition*, 29-33.

Odetokun, S. M. (1996). The nutritive value of Baobab Fruit La Rivista Italiano Delle Sostanze Grass Vol. LXXII AGOSTO (Nigeria).

Osborne, D. R., Voogt, P. (1978). Calculations of caloric value in the analysis of nutrients in foods. Academic Press NY. pp. 239-240.

Sadasivam S. and Theymdli B. (1987). In: *Practical Manual in Biochemistry* Tamil Nadu Agricultural University Coimbatore pp. 14.

Sidibe, M., Tembley, D. (1996). *Baobab-Home Grown Vitamin C for Africa*.

Saupi, N., Zakaria M. H. and Bujang J. S. (2009). *Analytic chemical composition and mineral content of yellow velvetleaf* (*Limnocharis flava* L. Buchenau)'s edible parts. *J. Applied Sci*. 9: 2969-2974.

Wilkinson, J., Hall, M. (2007) *Baobab Fruit*: Botanicals ASAP Publishing Ltd, pp. 26.

Young, G. (2011). *Importance of Dietary Fibre*, EzineArticles.com.

Zamora, A. (2005). *Proteins*: Scientific Psychic.