

# Chemical and Functional Characterization of Baobab (*Adansonia Digitata L.*) Seed Protein Concentrate using Alcohol Extraction Method

Adenekan M.K.<sup>1</sup>, Fadimu G.J.<sup>2,3\*</sup>, Odunmbaku L.A.<sup>1</sup>, Nupo S.S.<sup>1</sup>, Oguntinyinbo S.I.<sup>1</sup>, Oke E.K.<sup>2</sup>

<sup>1</sup>Department of Food Technology, Moshood Abiola Polytechnic, Nigeria

<sup>2</sup>Department of Food Science and Technology, Federal University of Agriculture, Nigeria

<sup>3</sup>Department of Food Science and Human Nutrition, King Saud University, Saudi Arabia

**Abstract**— This study investigated the characteristics of baobab protein concentrate prepared using alcohol extraction method. Baobab fruit and the seeds were washed out, cleaned to remove dirt, sundried for three days and finally ground in an electric mill, sieved and stored. The flour was defatted with hexane under constant magnetic stirring for 3hrs. The slurry was vacuum filtered through filter paper and the residue was used for subsequent extraction. The result obtained showed that alcohol extraction method significantly ( $p < 0.05$ ) affected the chemical composition and functional properties of the baobab protein isolate. Result of functional properties shows that the alcohol extracted baobab protein concentrate displayed higher solubility index and emulsifying capacity. Baobab protein concentrate can be considered as potential functional food ingredient.

**Keywords**— Baobab, protein concentrate, alcohol, chemical composition, functional properties.

## I. INTRODUCTION

Intense efforts are currently made in the search of cheap protein sources with good nutritional and functional properties, to attenuate the problem of protein malnutrition widely spread in developing countries [1]. Plant proteins play significant roles in human nutrition particularly in developing countries where average protein intake is less than that required. Plant protein products are gaining increased interest as ingredients in food systems throughout many parts of the world and the final success of utilizing plant proteins as additives depends greatly upon the characteristics they impart to foods.

Baobab (*Adansonia digitata L.*), locally called kuka (hausa) and luru (yoruba) is a very long lived tree with multipurpose uses [2]. Baobab is a high yielding, draught resistant and all season plant belonging to the Malvaceae family, it is widely spread throughout the hot, drier regions of tropical Africa [3]. The vernacular name for

baobab means “fruit with many seeds” [4]. The seeds are eaten raw or roasted and have a pleasant nutty flavor [5].

Murray *et al.* [6] reported that baobab seed flour is an important source of energy and protein. The nutritious seed have high values for proteins (33.7%), fats (30.6%), fibre (16.9%) and most minerals. Protein extracts have superior functional properties and are more effectively used in the formulation of foods as compared to seed flours [7].

The acceptability and optimal utilization of baobab seed as a protein source may be limited by the presence of antinutritional factors such as tannins, oxalate and phytate [8]. Nevertheless, techniques employed for extracting protein there from are known to be effective in the elimination of the above antinutrients [9].

Since oilseeds are valuable sources of lipids as well as proteins, numerous studies on protein functionality of major and minor oilseeds such as soybean [10], peanut [11], rapeseed [12], sunflower [13], almond [14], winged bean [15], groundnut [16], have been reported. The chemical and functional characterization of baobab protein concentrate is scarce. The main objective of this present study is to investigate the properties of protein concentrate from baobab which is produced using alcohol precipitation method in order to establish the potentials application.

## II. MATERIALS AND METHODS

### Materials

Baobab fruits were collected from Anigbado village, Ayepe, Abeokuta, Ogun State, Nigeria.

### Methods

#### Preparation of Baobab Seed Flour

Baobab seed flour was prepared according to the method described by Nkafamiya *et al.* [17]. The dried pulp was scraped from the baobab fruit and the seeds were washed out, cleaned to remove dirt, sundried for three days and

finally ground in an electric mill. It was then passed through a 40 mesh sieve and stored for use

### Preparation of Defatted Baobab Flour

Defatted baobab flour was prepared according to the method described by Xiaoying and Yufei, [18]. The flour was defatted with hexane (flour/hexane ratio of 1:10 w/v) under constant magnetic stirring for 3hrs. The slurry was vacuum filtered through filter paper and the residue was used for subsequent extraction. Hexane extractions were repeated until the filtrate was clear. Residue from the last extraction and filtration step was air-dried. Defatted baobab flour (DBF) was ground to 150 meshes for further use.

### Preparation of Baobab Protein Concentrate (Alcohol extraction method)

Baobab protein concentrate was prepared according to the method described by Wolf [19] with minor modifications. Defatted baobab flour was mixed with 95% aqueous alcohol (1:10 w/v) and stirred for 1hr at ambient temperature (about 25°C). The suspension was filtered and the residues were dispersed in de-ionized water (1:10 w/v) at room temperature and stirred for 1hr. The suspension was finely filtered and the pH of the filtrate was adjusted to 4.5 by addition of 1NHCl (to precipitate out the protein). The slurry was then centrifuged (3500rpm, 15min, 36°C). The supernatants were discarded and the precipitates (protein concentrate) dried in a conventional oven. The protein concentrate was pulverized into a powdered form and stored for subsequent analysis.

### Protein Recovery and Chemical Composition Analysis

The chemical composition of baobab meal protein concentrate were determined according to AOAC standard method [20]. The carbohydrate content was estimated by subtracting the sum of percentage of moisture, crude fat, crude protein and ash content from 100% the protein recovery was as follows

$$\text{Protein Recovery (\%)} = \frac{\text{weight (g) of BPC} \times \text{protein content (\% of BPC)} \times 100}{\text{weight (g) of DPC} \times \text{protein content (\% of DPC)}}$$

### Determination of Functional Properties

#### Determination of Protein Solubility (PS)

Baobab protein concentrate solution (20 % w/v) were prepared with dispersing powdered protein into distilled water, adjusted to pH 3 to 9. The protein solutions were stirred with a magnetic stirrer at 4°C overnight, centrifuged at 2,500rpm for 30min. The protein sample was directly solubilized by 0.5m NaOH for determination of total protein. The protein content of the content of the

supernatants was determined by the (Biuret method 1940) using bovine serum albumin (BSA) as a protein standard. Protein solubility was calculated as :

$$\text{Ps (\%)} = 100 \times \text{Ps} / \text{Pt}$$

where Ps is the protein content in the supernatant after centrifugation and filtration and PT is the total protein content present in the protein sample.

### Determination of Water Holding Capacity (WHC) and Fat Absorption Capacity (FAC)

WHC and FAC of Baobab protein concentrate (BPC) were determined by the method of Gandhi and Srivastara [21].

### Determination of Emulsifying activity and Emulsifying stability Index

Emulsifying activity index (EAI) and Emulsion stability index (ESI) of baobab protein flour were measured by the method described by Lopez *et al.* [22].

### Determination of Foaming Capacity and Foaming Stability

Foaming capacity and foaming stability were determined by the method described by Khalid *et al.* [23].

### Determination of Anti nutritional Factors

The tannin content of the sample was determined by the method described by Swain [24], while Phytate and oxalate in the sample was determined by the method describe by Onwuka [25].

### Statistical Analysis

Data obtained were subjected to statistical analysis. Means, Analysis of variance (ANOVA) were determined using SPSS Version 21.0 and the differences between the mean values were evaluated at  $p \leq 0.05$  using Duncan's multiple range test.

## III. RESULT AND DISCUSSION

Result of chemical composition of alcohol extracted baobab protein concentrate is shown in Table 1. The percentage yield of baobab protein concentrate was 51.74%, this agrees with the findings of Arnold *et al.* [5] that the nutritious seeds have high values for proteins, fats (oils), fibre and most minerals. The result indicates that the protein concentrate contains 8.16% moisture, 90.36% protein, 1% crude-fibre and very low/insignificant levels of fat, ash and carbohydrate of 0.13%, 0.20% and 0.13% respectively. The protein content which is the major concern and important constituent (90.36%) was high and compared favourably with 90.05% reported for walnut protein isolate by Xiaoying and Yufei [18] and this value

is higher than 85%, 83% and 70% reported for roasted peanut protein concentrate [26], sesame protein concentrate [27] and bambara bean protein concentrate [28] respectively. Low percentages recorded for other constituents of the cellular matrix as presented in Table 1 is an indication of purity of the protein concentrate obtained and the efficiency of the alcohol extraction method adopted.

Table.1: Chemical properties of baobab protein concentrate

Chemical properties (%)	Composition
Protein yield	51.74±0.12
Moisture	8.16±0.15
Protein	90.36±0.00
Fat	0.13±0.05
Ash	0.20±0.10
Crude Fibre	1.00±0.10
Carbohydrate	0.13±0.05

Mean values with different superscripts within the same column are significantly different (p <0.05)

Result of functional properties of alcohol extracted baobab protein concentrate is presented in Table 2. The foaming capacity of baobab protein concentrate obtained in the present study was 67.36% and it compared favourably with 59% in sesame protein concentrate [27] and higher than 38% in walnut protein concentrate [18]. The foaming capacity was enhanced by high protein concentration, as high protein concentration increases the formation of a multilayer, cohesive protein film at the interface [29]. The high foaming stability in this study (44.86%) shows that baobab has enough flexible protein structure in aqueous solutions and interacted strongly with the air-water interface to form more stable foam. The water absorption capacity of the alcohol extracted baobab protein concentrate recorded was 130%. However, 220% and 610% were reported for the water absorption capacity of cashew nut protein concentrate [30] and sesame protein concentrate [27] respectively. Aletor *et al.* [31] reported that water absorption capacity of the range of values from 149% to 472% is considered critical in viscous food. The oil absorption capacity was 150% and this compared better than 102% reported for bambara groundnut protein isolate [32], but lower than 294% and 306% in sesame protein concentrate [33] and lupin protein isolate [34] respectively. Elnasri and Eltmay [35] reported that high protein content shows high fat absorption capacity. Kinsella [36] also reported that the ability of protein to bind fat is very important for such applications as meat replacement and extenders principally because it enhances flavor retention and improve mouthfeel. Therefore baobab protein concentrate may be used as thickener and binder in food system. The solubility of the

alcohol extracted baobab protein concentrate at the isoelectric point of the protein was 97.26%.The emulsifying capacity of the alcohol extracted baobab protein concentrate was 14.66%. This value compared favourably with 14% reported for sesame protein concentrate [27] but higher than 5% reported for soy protein isolate [27] but lower than 27% reported for walnut protein concentrate [18].

Table.2: Functional properties of baobab protein concentrate obtained through alcohol extraction method

Functional properties (%)	Composition
Foaming capacity	67.36±0.25
Foam stability	44.86±0.05
Water absorption capacity	130.0±5.00
Oil absorption capacity	150.0±5.00
Solubility	97.26±0.15
Emulsifying capacity	14.66±0.15

Mean values with different superscripts within the same column are significantly different (p <0.05)

Table 3 shows the protein solubility and emulsifying capacity of the alcohol extracted baobab protein concentrate as affected by different pH as shown in Table 3. The mean values for the solubility index at pH<sub>5</sub>, pH<sub>6</sub>, pH<sub>7</sub> and pH<sub>8</sub> are 90.46%, 93%, 97.73% and 98.63% respectively. These solubility index compared significantly (p≤0.05) higher than 83% and 47% reported for sesame protein concentrate [27] and walnut protein concentrate [18]. These solubility indexes ensure the usefulness of the baobab protein concentrate in applications such as in beverages. It was observed that as the pH increases, the solubility index and emulsifying capacity were also increasing. This indicates that both solubility and emulsification are pH dependent. Similar observation was reported for Bambara groundnut protein concentrate [32].

Table.3: Solubility and emulsifying capacity of baobab protein concentrate obtain at different pH

Sample pH	Solubility	Emulsifying capacity
pH <sub>5</sub>	90.46±0.15	10.80±0.30
pH <sub>6</sub>	93.00±0.26	12.33±0.15
pH <sub>7</sub>	97.73±0.11	14.76±0.15
pH <sub>8</sub>	98.63±0.15	17.53±0.15

Mean values with different superscripts within the same column are significantly different (p <0.05)

The result of the antinutritional properties is presented in Table 4. This shows that the oxalate, phytate and tannin were undetectable in the baobab protein concentrate. This may be due to the earlier report of Mwasaru *et al.* [9] that

the techniques employed for extracting protein from baobab seeds are known to be effective in the elimination of the above antinutrients.

Table.4: Antinutritional properties of baobab protein concentrate

Antinutritional factors	Baobab concentrate
Oxalate	ND
Phytate	ND
Tannins	ND

ND= Not detected.

#### IV. CONCLUSION

The result obtained from this present study indicates the efficiency of the alcohol extraction method adopted as high purity of the protein concentrate was obtained and the oxalate, phytate and tannin content of the protein concentrate were at undetectable level. The functional properties of the protein concentrate compared favourably with other legumes especially with significantly higher solubility index and emulsifying capacity at different pH. This suggested that the baobab protein concentrate can find useful application in food systems.

#### REFERENCES

- [1] Siddhuraju P. K., Vijayakumari. and Janardhanan, K. (1996), Chemical composition and nutritional evaluation of an underexploited legume, *Acacia nilotica* (L.) Del. *Food Chemistry*, 57, pp. 385-391.
- [2] Igboeli, L.C., Addy, E.O.H. and Salami, L.I. (1997), Effects of some processing techniques on the antinutrient contents of baobab seeds (*Adansonia digitata*). *Bioresource Technology*, 59, pp. 29-31.
- [3] FAO (1988), *Traditional food plants. Food agriculture organization of the United Nations*, Rome, 24, pp. 63-67.
- [4] Ajayi, I.A., Dawodi, F.A., Oderinde, R.A. (2003), Fatty acid composition and metal content of *Adansonia digitata* seeds and seed oil. *La Rivista Italiana delle Sostanze Grasse*, 80, 41-43.
- [5] Arnold, T.H., Wells, M.J. and Wehmeyer, A.S. (1985), *Khoisan food plants: taxa with potential for future economic exploitation*. In: Plants for Arid Lands, Wickens, G.E.; Goodin, J.R.; Field, D.V. (eds.), Allen and Unwin, London, UK, pp. 69-86.
- [6] Murray, S.S., Schoeninger, M.J., Bunn, H.T., Pickering, T.R. and Marlett, J.A. (2001), Nutritional composition of some wild plant foods and honey used by hadza foragers of Tanzania. *Journal of Food Composition and Analysis*, 14, pp. 3-13
- [7] Neto, V.Q., Narain, N., Silva, J.B. and Bora, P.S. (2001), Functional properties of raw and heat processed cashew nut (*Anacardium occidentale* L.) kernel protein isolate. *Nah./Food*, 45, pp. 258-262.
- [8] Proll, J., Petske, K.J., Ezeagu, I.E. and Metges, C.C. (1998), Low nutritional quality of unconventional tropical crop seeds in rats. *Journal of Nutrition*, 128, pp. 2014-2022.
- [9] Mwasaru, M.A., Muhammad, K., Bakar, J. and Cheman, Y.B (1999), Effects of isolation techniques and conditions on the extractability, physicochemical and functional properties of pigeon pea (*Cajanus cajan*) and cowpea (*Vigna unguiculata*) protein isolates. *Food chemistry*, 67, pp.435-443.
- [10] Molina Ortiz S.E., Puppo M.C. and Wagner J.R. (2004), Relationship between structural changes and functional properties of soy protein isolates Carrageenan systems. *Food hydrocolloid*, 18, pp.1045-1053.
- [11] Yu, J., Ahmedna, M. and Goktepe, I. (2007), Peanut protein concentrate: production and functional properties as affected by processing. *Food chemistry*, 103, pp.121-129
- [12] Yoshie-stark, Y., Wada, Y. and Wasche, A. (2008), Chemical composition, functional properties and bioactivities of rape seed protein isolates. *Food chemistry*, 107, pp.32-39.
- [13] Gonzalez-Perez, S. and Vereijken J.M. (2007), Sunflower proteins: overview of their physicochemical, structural and functional properties. *Journal of Food Science and Agriculture*, 87, pp. 2173-2191.
- [14] Sze-Tao, K.W.C. and Sather, S.K (2000), Functional properties and invitro digestibility of almond (*Prunus dukis* L.) protein isolate. *Food Chemistry*, 69, pp. 153-160
- [15] Igene, F., Oboh, S. and Aletor, V. (2005), Effects of some processing techniques on the functional properties of winged bean seed flours. *Journal of Food, Agriculture and Environment*, 3, pp. 28-31.
- [16] Lawal, O., Adebawale, K. and Adebawale, Y. (2007), Functional properties of native and chemically modified protein concentrates from bambara groundnut. *Food research International*, 40, pp. 1003-1011.
- [17] Nkafamiya, I.I., Osemeahon, S.A., Dahiru, D. and Umaru, H.A. (2007), Studies on the chemical composition and physicochemical properties of the seeds of baobab (*Adansonia digitata*). *African Journal of Biotechnology*, 6, pp. 756-759.
- [18] Xiaoying, M.A.O and Yufei, H. (2012), Composition, structure and functional properties of protein concentrates and isolates produced from walnut (*Juglans regia* L.). *International Journal of molecular Science*, 13, pp. 1561-1581.



- [19] Wolf, W.J. (1970), Soybean proteins; their functional, chemical and physical properties. *Journal of Agriculture and Food chemistry*, 18, pp. 969-976.
- [20] AOAC. (2000), *Official methods of analysis*. 17th edn., The Association of Official Analytical Chemists, Virginia.
- [21] Gandhi A.P. and Srivastava J. (2007), Studies on the production of protein isolates from defatted sesame seed (*Sesamum indicum*) flour and their nutritional profile. *ASEAN Food Journal*, 14(3), pp. 175-180.
- [22] Lopez, G., Ros, G., Rincon, F., Periago, M., Martinez, M. and Ortuno, J. (1996). Relationship between physical and hydration properties of soluble and insoluble fiber of artichoke. *Journal of the Agricultural and Food Chemistry* 44, pp. 2773–2778
- [23] Khalid, E.K., Babiker, E.E. and El Tinay, A.H. (2003). Solubility and functional properties of sesame seed proteins influenced by pH and /or salt concentration. *Food Chemistry*, 82, pp. 361-366
- [24] Swain, T. (1979). *Tannins and Lignins*. In Rosenthal, G.A., Jansen, D.H (ed) *Herbivores, their interaction with secondary plant metabolites*. Academic Press, New York, pp. 6574
- [25] Onwuka, G.I. (2005). *Food Analysis and Instrument (theory and practice)*. Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike, Nigeria.
- [26] Jianmei Yu., Mohamed Ahmedna. and Ipek Goktepe (2007), Peanut protein concentrate: production and functional properties as affected by processing. *Food chemistry*, 103, pp.121-129.
- [27] Onsaard, E., Pomsamud, P. and Audtum P (2010). Functional Properties of sesame protein concentrates from sesame meal. *Asian Journal of Food Agro Industry*, 3(04), pp. 420-431.
- [28] Martin Alain M.M., Samuel R.M., Israel L.M. and Etoa, F.X. (2011), Nutritional potential of bambara bean protein concentrate. *Pakistan Journal of Nutrition*, 10(2), pp. 112-119.
- [29] Damodaran, S. (1997), *Food proteins: An overview*. Damodaran, S. and Paraf, A. Mercel (eds.) *Food proteins and their applications* US: CRC Press. pp.22
- [30] Ogunwolu, S.O., Henshaw, F.O., Mock, H., Santos, A. and Awonorin S.O. (2009), Functional properties of protein concentrates and isolates produced from cashew (*Anacardium occidentale* L.) nut. *Food Chemistry*, 115, pp.852 – 858.
- [31] Aletor, O., Oshodi, A.A. and Ipinmoroti, K. (2002), Chemical composition of common leafy vegetables and functional properties of their leaf protein concentrates. *Food Chemistry*, 78(1), pp. 63-68.
- [32] Eltayeb, A.R.S.M., Ali, A.O., Abou-Arab, A.A. and Abu-Salem, F.M (2011), Chemical Composition and functional properties of flour and protein isolate extracted from bambara groundnut (*Vigna subterranean* ). *African Journal of Food Science*, 5 (2), pp. 82 – 90.
- [33] Tomotake, H., Shimaoka, I., Kayashita, J. Nakajoh, M. and Kato, N. (2002), Physicochemical and functional properties of buck wheat protein product. *Journal of Agriculture and Food Chemistry*, 50(7), pp.2125 – 2129.
- [34] Lqari, H., Vioque, J., Pedroche, J. and Millan, F. (2002), Lupinus angustifolius protein isolates: chemical composition, functional properties and protein characterization. *Food Chemistry*, 76, 349-356.
- [35] ElNasri N.A. and ElTinay A.H. (2007), Functional properties of fenugreek (*Trigonella foenum-graecum*) protein concentrate. *Food chemistry*, 103, pp. 582-589
- [36] Kinsella, J.E. (1979), Functional Properties of Soy proteins. *Journal of American Oil Chemist Society*, 56, pp. 242-258.