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Some Nutritional Composition and Functional Properties of *Prosopis Africana*

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Abstract

The nutritional composition and functional properties of *Prosopis Africana* were studied using standard analytical techniques. The results gave proximate composition as follows: moisture, total ash, ether extract, crude protein, crude fibre and carbohydrate were 1.9, 4.4, 12.8, 23.6, 3.3 and 54.0g % respectively. The predominant mineral was K (617.5mg/100g sample) followed in the highest rank by Mg (420.1mg/10g sample). Other minerals such as Na, Ca, P, Mn, Cu, Zn, Fe and Cr were 110.7, 362.5, 196.4, 36.2, 46.2, 22.4, 15.5 and 0.2mg/100g sample respectively while Cd and Pb were not detected. Amino acid analysis revealed that the sample contained nutritionally useful quantities of most of the essential amino acids. The first limiting amino acid was Thr and predicted isoelectric point was 5.4. Functional properties results were: foaming capacity, 3.9 %, foaming stability 96.2 %; water absorption capacity, 340.0; oil absorption capacity, 120.0 %; emulsion capacity 30.0 mLg^{-1}; emulsion stability 38.4 mLg^{-1}; least gelation capacity, 16.0 % and bulk density 0.5268 mLg^{-1}. The protein solubility of the *P. Africana* was found to have minimum solubility at pH 4.5.

Key words : Nutritional composition, functional properties, *Prosopis Africana*

Introduction

Prosopis Africana (P. Africana) is a *Leguminosae* belonging to the family of Fabaceae. It reaches 4-20m in height; has an open crown and slightly rounded buttresses; bark is very dark, scaly, slash, orange to red-brown with white streaks. It was once said that *P. Africana* is the only tropical *Africana Prosopis* species, occurring from Senegal to Ethiopia in the zone between the Sahel and savannah forests. Due to extensive overex ploitation, it has disappeared from extensive parts of the Southern Sahel and the adjavent Sudan savannahs (Von May Dell *et al.*, 1986 and Vogt, 1995). The trees of P. Africana are common in the Middle belt and Northern parts of Nigeria. The local names are “Kiriya’’ and “Okpehe’’ in Hausa and Idoma/Tiv languages in Nigeria respectively. In many areas where the trees are grown/available, the fermented seeds of *P.*

Africana are used as a food condiment. Other traditional processing of *P. Africana* are well known but very little on the nutritional evaluation and functional properties as an ingredient in foods formulation. Therefore, the present study aims at finding the nutritive values as well as functional properties of *P. Africana.*

Materials and Methods

Collection and treatment of sample

Seeds of *P. Africana* were purchased from Markurdi market in Benue State, Nigeria. The seeds were sorted to remove stones and bad ones. Boiling water was added to the seeds, left for seven days and the seeds dehulled, dried in the oven at 40^{O} C and freely ground with Kenwood food blender. The flour was kept in a refrigerator at 4^{O} C prior to use.

Proximate analysis

Proximate analysis of the sample flour for moisture, ash, fat and crude fiber were carried out in at least triplicate using the methods described by Pearson (Pearson, 1976). Nitrogen was determined by the micro-Kjeldahl method described by AOAC (OAC, 1990), and the percentage nitrogen was converted to crude protein by multiplying with the factor - 6.25. Carbohydrate was determined by calculating the difference.

Mineral analysis

The minerals were analyzed from solutions obtained by fitst dry-ashing the seed flour at 550^{O} C. The ash obtained was boiled with 15ml 15ml of 20 % hydrochloric acid in a beaker, filtered into a 100ml standard flask and made up to the mark with distilled water. Sodium and potassium were determined by using a flame photometer (Pearson, 1976); phosphorus by using colorimeter (Aremu, *et al.*, 2005) and other metals AAS (Techtron, 1975). All determinations were done in triplicate.

Amino acid analysis

About 2.0g sample flour was defatted with chloroform/methanol mixture Between 30-35mg of defatted sample was put in glass ampoule. Seven milliliter of 6M HCI was added and oxygen expelled by passing nitrogen into the ampoule. The sealed ampoule was put in an oven at 105 ± 5^{O} C for 22h and later allowed to cool before the content was filtered. The filtrate was then evaporated to dryness at 40^{O} C under vacuum in a rotary evaporator. Residue was dissolved with 5ml acetate buffer (pH=2.0). Amino acid analysis was done by Ion Exchange chromatography (IEC) (Pearson, 1976) using the Technicon Sequential Multisample Amino Acid Analyzer (TSM) (Technicon Instruments Corporation, New York). The amino acid score was determined by the following formula (FAO/WHO, 1973) -

$$\text{Amino acid score} = \frac{\text{mg of amino acid per g of test - protein}}{\text{mg of amino acid per g protein in reference pattern}}$$

Predicted iso-electric point (p1) was estimated by applying the equation (Olaofe and Akintayo, 2000) -

p

Where pIm is the isoelectric point of the mixture of amino acids, Pli, is the iso-electric point of the i^{th} amino acid in the mixture and X_i is the mass or mole fraction of the i^{th} amion acid in the mixture and there are n amino acids in the mixture (Graham Solomons, 1984).

Functional properties

The variation of protein solubility with pH was determined as described by Olaofe, (1994) and Akintayo *et al.*(2002). The protein of the supernatant was determined using the micro-Kjeldahl method (OAC, 1990) and exoressed as mg protein per mikkiliter, the water and oil absorption; and emulsion capacities were determined as reported by Beuchat (1977) using Executive Chef Oil with density of 0.98g/ml. The foaming capacity and stability and least gelation concentration were determined using the procedure of Coffman and Garcia (1977). Bulk density of the seed flour was determined using the procedure of Wand and Kinsella (1976) modified by Akpapunam and Markakis (1981); and Narayana and Narasinga Rao (1984). All chemicals used were of analytical (Analar) grade.

Results and Discussion

Proximate composition

Table I presents the proximate composition of *P. Africana* flour. The percentage of moisture (1.9±0.3%) was low but comparable to rear cowpea (1.8±01.25%), cranberry bean (1.7±0.51%) and kersting's groundnut (1.7±0.12%) as reported by Aremu *et al.* (2006); and this value is within the range expected to be present in most legumes (Olaofe and Sanni, 1988; and Oyenuga, 1968). The low moisture content will afford a long shelf for *P. Africana*. The value of crude fat (12.8±1.2%) was higher as compared with

Table I. Proximate composition (g %) of *P. Africana* flour

Parameter	Concentration[a]
Moisture	1.9 ± 0.3
Total ash	4.4 ± 0.1
Other extrat	12.8 ±1.2
Crude protein	23.6 ± 1.5
Crude fibre	3.3 ± 0.0
Carbohydrate by difference	54.0 ± 0.8
Energy (KJ/100g)[b]	1792.8

[a]Values are mean ± standard deviation of triplicate determinations

[b]calculated metbolisble energy (KJ.100g) : (protein x17 ± fat x 37± carbohydrate x 17)

the values reported for two varieties of bambara groundnut (4.10 and 6.72%) (Aremu, 2006), and pear millet and quinoa (7.6 and 6.3%) (Oshodi, *et al.* 1999) but lower than soybean (23.5%) (Paul and Southgate, 1985), C. vulgaris (47.7%) (Ige *et al.* 1984), pumkin (49.2%) (Fagbemi and Oshodi, 1991) and T. occidentalis (54.4) (Olaofe *et al.* 1994). This is an indication that *P. Africana* cannot be grouped as part of oil-rich legume seed. The quantity of crude protein (23.6±1.5%) was high compared with crude proteins in protein-rich foods such as soybeans, cowpeas and pigeon pea (Olofe, *et al.* 1993) and Kersting's groundnut (Aremu, *et al.*, 2006). The crude fibre (3.3±0.0%) is comparable with most legumes such as pigeon pea and cowpea (Aletor, *et al.* 1989); P. coccineus (Aremu *et al.* 2006) and oil seeds (Olaofe, *et al.* 1994). There is evidence that dietary fibre has a number of beneficial effects related to its indigestibility in the small intestine (Asp, 1996). The calculated metabolisable energy value of 1792.8KJ/100g sample shows that *P. Africana* is favourably comparable to cereals (Brain and Allan, 1977) in terms of its energy values.

Table II. Mineral composition (mg/100g) of *P. Africana* flour

Mieneral	Concentration[a]
Na	110.7±0.1
K	617.5±0.1
Mg	1420.1±0.1
Ca	362.5±0.2
P	196.4±0.1
Mn	36.2±0.4
Cd	ND
Cu	46.2±0.7
Zn	22.4±0.0
Pb	ND
Fe	15.5±0.4
Cr	0.2±0.5
Na/K	0.18
Ca/P	3.76
Ca/Mg	0.86

Values are mean ± standard deviation of triplicate determinations

ND = not detected

Mineral composition

Mineral content of *P. Africana* is presented in Table II. Potassium was found to be the most abundant mineral. This is in close agreement with the observation of Olaofe and Sanni (1988) that potassium was the most predominant mineral in Nigerian agricultural products. Magnesium was found to be the next highest mineral component amounting to about 420.1±0. 1mg/100g sample. It has been reported that magnesium is an activator of many enzyme systems and maintains the electrical protential in nerves (Ferrao, *et al.* 1987). The seed was rich in potassium, magnesium, calcium and phosphorus while the values of copper, zinc, irpn and manganese were low. It is to be noted that cadmium and lead were not in the detectable range. The mineral content in the flour is favourably comparable with that of soybean and cowpea (Olaofe and Sanni, 1988), African yam bean

(Adeyeye, 1989) and Bilphia sapida (Akintayo, *et al.* 2002) and Triticum durum (Adeyeye and Aye, 2005). This indicates that *P. Africana* is good for feed supplement. The ratio of sodium to potassium, Na/K, in the body is of great concern for prevention of high blood pressure. Na/K ratio less than one is recommended (Nieman, *et al.* 1992). The Na/K value of 0.18 (Table II) which is less than one indicates that *P. Africana* would probably save the capacity to reduce high blood pressure. The Ca/P and Ca/Mg ratios were 3.76 and 0.86 respectively. The value of Ca/Mg is very close the recommended value of 1.0 (National Research Council, 1989). Food is considered 'good' if the Ca/P ratio in the present study (3.76), provides an indication *P. Africana* would serve as good source of minerals for bone formation.

Amino acid composition

The result of amino acid composition is shown in Table III. Asp and Glu were found to be the most abundant as expected to be present in legumes. Asp and Glu together make upto 23.3mg/100g protein with a percentage of 31.3%. This value is in close agreement with the report of Olaofe and Akintayo (2000); Kuri *et al.* (1991); Oshodi *el. al* (1998); Aremu *et al.* (2006) and Adeyeye (2004) who had observed that Asp and Glu were the most abundant in legumes and nuts. Leu was also found to be in abundance with value of 6.4mg/100g protein. Table IV depicts the essential, non-essential acidic, neutral and sulphur containing amino acids. The total essential amino acids (TEAA) (with His) was 34.3mg/100g protein which represents 46.1%. This is comparable with values obtained for selected oil seeds (Olaofe, 1994), varieties of V. subterranean and *P. coccineus* (Aremu, *et al.* 2006). Pellet and young (1977) reported that the nutritive value of a protein depends primatily in its capacity to satisfy the needs for nitrogen and essential amino acid. Therefore *P. Africana* can be considered as good diets that can provide the required essential amino acid. The

Table III. Amino acid composition (g/100g protein) of *P. Africana* flour

Amino acid	Concentration
Lysine (Lys)[a]	4.2
Histidine (His)[a]	2.5
Arginine (Arg)[a]	5.0
Aspartic acid (Asp)	10.0
Threonine (Thr)[a]	2.2
Serine (Ser)	3.2
Glutamic acid (Glu)	13.3
Proline (Pro)	3.0
Glycine (Gly)	3.3
Alanine (Ala)	2.8
Cyctine (Cys)	1.3
Valine (Val)[a]	4.2
Methionine (Met)[a]	1.4
Isoleucine (Ile)[a]	3.7
Leucine (Leu)[a]	6.4
Tyrosine (Tyr)	3.2
Phenylanine (Phe)[a]	4.7
lso-electric point (pl)	5.4

[a]Essential amino acids

Table IV. Classification of amino acid composition (g/100g protein) of *P. Africana* flour

Classification	Concentration
Total amino acid (TAA)	74.4
Total non-essential amino acid (TNEAA)	40.1
% TNEAA	53.9
Total essentoal amino acid (TEAA)	
-with histidine	34.3
-without histidine	31.8
% TEAA	
-with histidine	46.1
-Without histidine	42.2
Essential alphatic amino acid (EAAA)	16.5
Essential aromatic amino acid (EArAA)	4.7
Total neutral amino acid (TNAA)	39.4
% TNAA	53.0
Total acidic amino acid (TAAA)	23.3
% TAAA	31.3
Total basic amino acid (TBAA)	11.7
%TBAA	15.7
Total sulphur amino acid (TSAA)	2.7
% cystine in TSAA	48.1

observed value 16.5g/100g protein for essential aliphatic amino acid (EAAA) which constitute the hydrophobic region of protein indicates that *P. Africana* may have better emulsification properties. The total acidic amino acid (TEAA) (31.3g%) was found to be greater than the total basic amino acid (TBAA) (15.7g%). This indicates that its protein is probably acidic in nature. The scoring table (Table V) reveals that first and second limiting amino acids were Thr (0.55) and Lys (0.76) respectively. Apart from Lys, other EAA that have been described as the limiting AA are Met (and/or Cys) and Try (Bender, 1992). Try was not determined. The predicted iso-electric point (p1) of 5.4 (Table III) is a good starting point in predicting the pl for *P. Africana* protein in order to enhance a quick precipitation of protein isolate from biological samples (Olaofe and Akintayo, 2000).

Functional properties

Fig. 1 shows the *P. Africana* protein solubility as a function of pH. This Provides a good index of the potential or limitation of a protein as a functional ingredient. The minimum

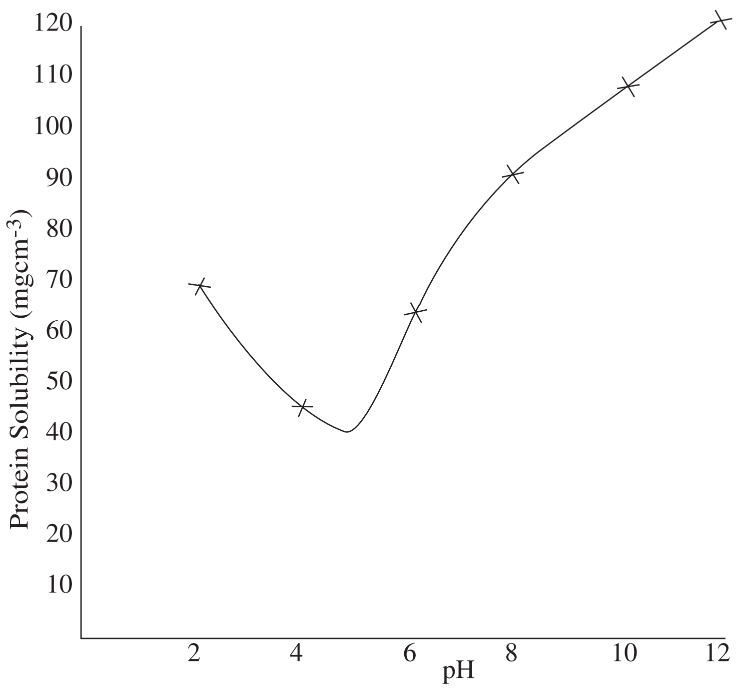

Fig. 1. Variation of protein solubility of *P. Africana* flour

Table V. Amino acid scores of *P. Africana* flour

AAC	PAAESP[a] (g/100g protein)	EAAC	AAS
Ile	4.0	3.7	0.93
Leu	7.0	6.4	0.91
Lus	5.5	4.2	0.76
Met + Cys (TSAA)	3.5	2.7	0.77
Phe + Tyr	6.0	7.9	1.32
Thr	4.0	2.2	0.55
Try	1.0	nd	na
Val	5.0	4.2	0.84
Total	36.0	31.3	6.08

[a]Source: Belshant *et al*[53] (1975)

nd = Not determined and na = Not available

AAC = Amino acid composition;

PAAESP = Provisional amino acid (Egg) scoring pattern;

EAAC = Essential amino acid composition (See Table III) and

AAS = Amino acid scores.

solubility occurred at 4.5. The observed value is in excellent agreement with the melon seed protein's minimum solubility at pH 4.5 reported by Ige *et al.* (1984). The enhanced solubility of the flour protein in acid region indicates that the protein may be useful in the formulation of acid foods such as protein rich carbonated beverages.

The results of foaming capacity and stability are presented in Table VI. *P. Africana* produced thin foams with medium size air cells and its foaming capacity (FC) of 3.92±0.7 % was very low when compared with benni seed (18.0 %), pearl millet and quinoa (19.0 %) reported by Oshodi *et al.* (1999); selected sea foods (6 - 14 %) (Ogunlade, *et al.* 2005); varieties of legume seeds (7.9 - 155%) (Aremu, *et al*. 2006); soybean (66 %) (Lin, *et al.* 1974); great Northern bean (32 %) (Sathe, *et al.* 1982); and varieties of African yam bean (54.0-55.0 %) (Oshodi, *et al.* 1997). Foaming stability recorded after 12hrs was 96.2±0.5%. Water absorption capacity, WAC (340 + 0.0%) (Table VI) is higher than that of sun flower (107 %) and soy bean (130 %) reported by Lin *et al* (1974); Z. variegatus (127.5 %) (Olaofe *et al.* 1998) and various liman bean (130 - 142 %) (Oshodi and Experigin, 1989). The high WAC recorded in this report suggested that *P. Africana* may be used in the formulation of some foods such as soups or baked products (Olaofe *et al.* 1998). The oil absorption capacity (OAC) is also presented in Table VI. The value is lower than those of varieties of legume seeds (127.8-172.0 %) (Aremu, *et al.* 2006) and cowpeas (281-310 %) (Olofe, *et al.* 1993); Z. variegatus (46.7 %) (Olaofe, *et al.* 1998), pigeon pea (89.7 %) (Oshodi and Ekperigin, 1989). OAC is important as oil acts as a flavour retainer and improves the mouth feel of foods. *P. Africana* will be good in these respects. For emulsifying activity; *P. Africana* has a low percentage of emulsion capacity, 30.0±1.4mLg-1 (Table VI) in comparison with benni seed, pear millet and quinoa (63.0, 89.0 and 104.0 %) (Lin, *et al.* 1974) but higher than values reported for soybean (18%) (Lin, *et al.* 1974) and pigeon peas (7-11%) (Oshodi and Ekperigin, 1989). This indicates that *P. Africana* might be useful in the production of sausages, soups and cakes (Kinsella, 1979). Table VI still depicts the emulsion stability after 24hrs, which is

Table VI. Functional properties of *P. Africana* Flour[a]

Property	Value
Foaming capacity (FC) %	3.9 ± 0.7
Foaming stability (FS) %	96.2 ± 0.5
Water absorption capacity (WAC) %	340.0 ± 0.0
Oil absorption capacity (OAC) %	120.0 ± 1.2
Emulsion capacity (EC) mLg^{-1}	30.0 ± 1.4
Emulsion stability (ES) mLg^{-1}	38.4 ± 2.0
Least gelation concentration (LGC) %	16.0 ± 0.0
Bulk density (BD)gmL^{-1}	0.5268 ± 0.3

[a]Values are mean ± standard deviation of triplicate determinations

the volume of water separated. The value obtained for *P. Africana* (38.4 ± 20mLg^{-1}) is close to pear millet (34.0%) (Oshodi, *et al*. 1999), The least gelation concentration (16 %) which is also shown in Table VI is higher than the values reported for some legumes e.g. pigeon pea (10 %) (Oshodi and Ekperigin, 1989), cowpea (10 %) (Attschul and Wileke, 1985) and lupin seed (14 %). The ability of protein to form gels and provide a structural matrix for holding water, flavours, sugars and food ingredients is useful in food application and in new product development, thereby providing an added dimension to protein functionality (Padmashree and Shashilala, 1987). The bulk density (BD) was 0.5268±0.3 gmL^{-1} (Table VI). This value is higher than the values reported for various samples of extrusion texturized soya products with varied protein and soluble sugar contents (0.2382-0.4460gmL^{-1}) (Adeyeye and Adamu, 2003).

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