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THE CHEMICAL COMPOSITION AND FUNCTIONAL PROPERTIES OF JACK BEAN FLOUR (*CANAVALIA ENSIFORMIS*)

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Jack bean (*Canavalia ensiformis*) was processed into flour and evaluated for its proximate and mineral composition. Some functional properties of the flour were also determined. The results showed that the flour contained 30.1% protein, 8.5% moisture, 3.6% fat, 3.8% ash, 2.7% crude fibre and 51.3% carbohydrates by difference. The mineral composition of the flour in mg/kg is: Ca (2160), Mg (1800), K (8600), Na (1700), P (3541), Mn (15), Cu (12), Fe (70) and Zn (26). The functional properties of the flour showed that it has least gelation concentration of 10% (w/v), emulsion capacity of 20%, oil absorption capacity of 105.6%, water absorption capacity of 160% and foaming stability of 4.9% after 2 hrs. The foaming capacity of the flour increases with increasing flour concentration while its protein showed a minimum solubility at pH_4.

Key words: Chemical composition, Functional properties, Jack bean flour.

Introduction

Jack bean (*Canavalia ensiformis*) is widely cultivated in humid tropics of Africa, Asia, Mexico and India [1,2]. It has various vernacular names in Nigeria; 'Awuje' and 'Pakala' in Yoruba, 'Wake' in Hausa and 'Agba' in Igbo. It is a robust plant with high yield (4,600 kg/ha) and with nutritious pods and protein-rich seeds [1]. It is among the largest domestic legumes in size [1]. Jack bean can tolerate a wider range of soil texture and fertility. Among pulses, only Jack bean grows nearly well on the highly leached, nutrient depleted low land tropical soils as well as an acid soil [3]. Although it is widely eaten particularly in Asia and some parts of Africa, its full potential is limited by growth inhibiting proteins that must be carefully detoxified before the seeds are edible [1,4]. The mature dry seeds require extensive boiling with one or two changes of cooking water and dehulling to make it edible. The full grown but still green, moist and soft seeds are eaten as cooked vegetable. The seed is also being detoxified by fermenting to tempeh [5]. The flour is often made into deep fried cake 'akara balls' or steamed cakes 'moinmoin' in Nigeria.

Much of the work on Jack bean is under study. Liener[7] reported that the bean contained free amino acids which is of metabolic interest because of its chemical similarity to arginine. Some of the proximate composition of the bean [1, 8, 9] showed that it contained higher protein than cowpea [3] and *Cajanus cajan* [10]. Similarly, Jack bean has shown to contain more essential and non-essential amino acids than cowpea [11] which is widely consumed in Nigeria. The ultimate success of utilising plant protein in food formulation depends largely upon the functional properties [11]. There is no information on the functional properties of Jack bean and its mineral composition [12] hence, this work is aimed at studying both the functional properties as well as its valuable mineral composition in order to exploit its possible food uses.

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Materials and Methods

The matured and dried Jack beans (*Canavalia ensiformis*) were purchaced from local market and village settlements around Ado-Ekiti, Nigeria. The seeds were blanched, dehulled and dried in air oven at 50°. The dried beans were ground into fine flour, sieved to pass through mesh size of 425μM and packed in the polyethylene bottle and stored at 25° in a dry place until use.

The proximate composition of the flour, moisture content, crude fat, crude protein, ash and fibre content were determined as described by Pearson [13] and determinations were made at least in triplicate.

The functional properties of the flour were determined as follows: the least gelation property of the flour was determined as described by Coffmann and Garcia [14] while emulsion capacity of the flour was determined by modifying the procedure of Kinsella [15] and Ige *et al.* [16]. Two grams of the flour was made into slurry in 40 cm^3 of distilled water in an elenmeyer flask and stirred at 1,000 rpm for 15 mins with a magnetic bar of 3.8cm. 10cm^3 of 'Avop' vegetable oil with density of 0.88g cm^{-3} was then added while stirring over a period of 5 mins. The slurry was transferred into a graduated centrifuge tube and put inside a water bath at 85° for 15 mins with occassional stirring. It was then removed and cooled for 15 mins in cold water at room temperature. The material was then centrifuged at 3,500 rpm for 30 mins to obtain a stable

emulsion. The results were expressed as percentage of oil that separated from the emulsion layer. The water and oil absorption capacity of the flour was determined as described by Beuchat [17] while the foaming capacity and stability as well as the effect of flour concentration on foaming capacity were carried out according to Lin *et al.* [18]. The solubility of the flour protein as a function of pH was also determined as described by Oshodi *et al.* [10] and Ige *et al.* [16] and the result expressed as Mg protein cm^{-3}.

The mineral composition of the flour was determined by dry ashing 5 g of the flour and dissolving the ash in deionized water (100 cm^3) with few drops of concentrated HCl [19]. Corning flame photometer was used to determine Na and K, while atomic absorption spectrophotometer PYE Unicorn SP 9 was used to determine Ca, Mg, P, Fe, Cu, Mn and Zn. Similarly, 10 g of the flour was wet oxidised [20] and the above minerals determined using atomic absorption spectrophotometer model 703. The mean values of each element were determined and their errors estimated as standard errors. All determinations were made at least in triplicate.

Results and Discussion

The results of proximate composition of the Jack bean flour (Table 1) obtained in this investigation showed that the bean is rich in protein (30.1%) and carbohydrate (51.3%). The value (29%) is similar to those reported earlier [9]. Though the protein content of Jack bean flour is lower than that of soybean flour (41.6%) [21] and winged bean flour (40%) [22]; it is however, higher than that of cowpea (*Vigna unguiculata*) (24.5%) [11], Lima beans (*Phaseolus vulgaris*) 21.4% and Pigeon pea (*Cajanus cajan*) flour (22.4%) [10]. Hence, Jack bean may be a good substitute to cowpea and pigeon pea in supplying protein to human diet. The average daily protein requirement [23] of 54 g i. e. (safe level for an adult man) can be met by consuming about 225g of the flour including allowance of 25% for the limiting sulphur amino acids and antinutritional factors. This can be met without any dietary stress. Methionine is the limiting amino acid in most legumes and ranges between 0.5g/100g total a.a. (*Lupinus albus*) to 1.4g/100g total a.a. (soybean) [26].

It is observed from Table 2 that Jack bean flour is high in some essential minerals like phosphorous, magnesium and iron, and is comparable to the value obtained for other beans [4]. The daily nutritional requirements of these elements can be met without dietary stress. The K/Na ratio of the flour is higher than 1. This is desirable as it can level up to the required 1:1 ratio by normal addition of table salt during food preparations.

Table 3 shows the results of functional properties of the Jack bean flour obtained in this investigation. The water absorption capacity (160%) is higher than that of soybean flour (130%) [18], cowpea flour (130%) [11] pigeon pea flour (138%) [10] but is lower than the value reported for winged bean flour (228%) [22]. The flour is thus a good substitute to other beans in providing body for liquid/semi liquid foods [18]. The oil absorption capacity of Jack bean flour (105.6%) is lower than that of soy flour (156%) [18], winged bean flour (203%) [2] but higher than cowpea flour (50%) and pigeon pea flour (89.7%) [11, 10]. The emulsion capacity of the Jack bean flour (20%) is higher than that of wheat flour (7-11%), soybean flour (18%) [18] but lower than the value reported for pigeon pea (49.4%) and winged bean flour (7,110%) [10, 22]. This implied that Jack bean protein can aid the formation and

TABLE 1. PROXIMATE COMPOSITION OF JACK BEAN FLOUR (*CANAVALIS ENSIFORMIS*).

Constituent	Content g $100g^{-1}$(dry flour)*
Water	8.5 ± 0.05
Crude protein	30.1 ± 0.1
Fat	3.6 ± 0.2
Ash	3.8 ± 0.15
Crude fibre	2.7 ± 0.1
Carbohydrate (by difference)	51.3 ± 0.05

* Mean ± standard error.

TABLE 2. MINERAL COMPOSITION OF JACK BEAN FLOUR.

Mineral	Mg/kg*
Ca	2160 ± 0.5
Mg	1800 ± 0.2
K	8600 ± 0.1
Na	1700 ± 0.1
P	3541 ± 0.2
Mn	15 ± 0.01
Fe	70 ± 0.01
Cu	12 ± 0.02
Zn	26 ± 0.05

* Mean ± standard error

TABLE 3. FUNCTIONAL PROPERTIES OF JACK BEAN FLOUR (*CANAVALIA ENSIFORMIS*).

Functional properties examined	Percentage(%)
Water absorption capacity	160 ± 0.2
Oil absorption capacity	105.6 ± 0.05
Least gelation concentration	10 ± 0.1 (w/v)
Emulsion capacity	20 ± 0.2
Foaming capacity	5.9 ± 0.1
Foaming stability (after 2 hours)	4.9 ± 0.1

*Mean ± standard error.

stabilization of emulsion in preparation like milk and frozen desserts as well as in the formulation of meat extenders and additives [16].

The least gelation concentration of Jack bean flour was 10% w/v, this is similar to the value reported for cowpea 10% w/v [11]. It is comparable to the value obtained for pigeon pea 12% w/v [10] but lower than that of winged bean flour 18% wv [12] respecitvely. Jack bean flour has low foaming capacity and stability compared with other beans. This may be due to the nature of protein predominant in the bean [22]. Foaming was observed to increase with increase in flour concentration (Table 4). Maximum foaming was observed at 10% w/v which is similar to that observed for winged bean flour [22].

Figure 1 shows that the protein solubility of Jack bean flour indicates a minimum value at pH_4. Both the shape of the curve and the isoelectric pH are similar to the observations of other beans i.e. cowpea $pH_{4.5}$, lupid seed pH_4, winged bean pH_4 [11, 22, 25].

TABLE 4. EFFECT OF CONCENTRATION AND TIME ON FOAMING STABILITY OF JACK BEAN FLOUR.

Concentrations %(w/v)	2	4	6	8	10		
Time (hr)	102	104	106	108	110	Initial	Vol. cm^3
0	108	111	115	118	122		
0.5	106	109	113	116	118		
1.0	104	108	112	114	116		
1.5	103	106	110	113	114		
2.0	103	105	108	112	113		
3.0	102	104	107	110	112		
4.0	102	104	107	110	111		

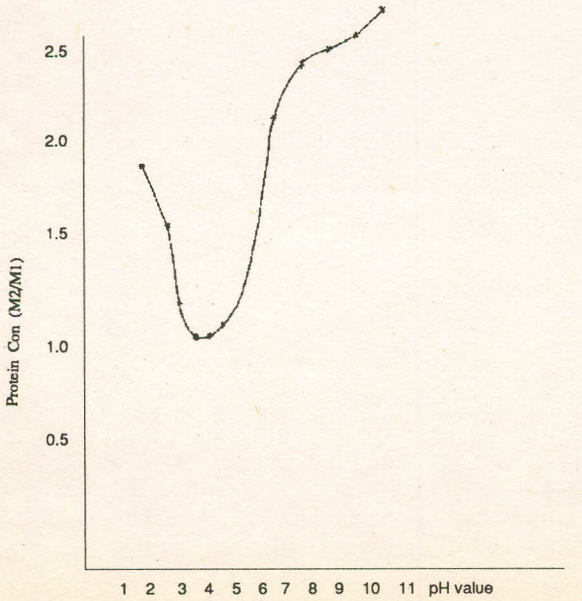

Fig. 1. Effect of the pH on protein solubility of Jack bean flower.

Conclusion

Jack bean flour has 30.1% protein. The protein of the flour has minimum solubility at pH_4. The least gelation concentration of the flour is 10% w/v; the water and oil absorption capacities are 160, and 105.6% respectively. The flour protein has low foaming property and foaming capacity increases with increase in flour concentration. The flour is a good source of some essential minerals. Considering the above results, Jack bean will be an effective substitute to cowpea, pigeon pea and soybean flours as a protein source, food ingredient formulations, binders, extenders and good source of some essential minerals. Research attention should be shifted towards breeding jack bean varieties with less nutrient inhibitory factors in order to allow the bean to contribute more effectively to human diet.

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